ICAMPAM 2017

Oral Session & Poster Abstracts

ICAMPAM

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Pre-conference Workshops **June 20**

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ICAMPAM 2017 Oral Abstracts

Wednesday, June 21, 2017

9:00 – 10:00 Keynote Presentation

Bjoern Eskofier, Friedrich-Alexander Univeristat Erlangen- Nürnberg, Germany

Smart Shoes Reach the Clinic: Wearable Sensor-Based instrumented Gait Analysis for Movement Disorders

The fast-growing costs of acute care are pushing the healthcare systems worldwide to a limit. A fast-growing interest exists for wearable and pervasive computing systems and ambient assistive technology that aim at ubiquitous health support for individuals in the home and community settings. The talk will focus on such an assistive technology: the eGaIT (embedded gait analysis using information technology) project. Here, we implemented smart sensors in shoes and employed machine learning algorithms to provide accurate information to patients and caregivers in movement disorders. As a model disease, Parkinson's disease (PD) will be presented. Routinely assessed by observation, the disease's symptoms are rated as part of semiquantitative clinical scores. Using eGaIT, we demonstrated the feasibility and applicability of more objective sensor-based gait measurement in PD for clinical studies and individual patient care.

10:00 – 11:00 Speakers and Abstracts

Kirschstein Auditorium: Incorporating Place-Based Data
Session Chair: Sylvia Spengler (National Science Foundation)

Activity-Aware Smart Homes for Health Assessment and Intervention
Diane Cook (Invited Speaker) Washington State University, USA

Combining GPS and activity monitoring to understand the context, location, volume and intensity of physical activity

Danny Rafferty[1], Catriona Dolan[1], Malcolm Granat[2]
[1]Glasgow Caledonian University, [2]University of Salford

Background: Physical activity (PA) monitors provides information on the volume, normally the number of steps taken, and intensity, the cadence of those steps. However it provides no information as to the location or context in which these occur. By combining PA monitoring with GPS we can start to understand how the location and context influence or PA. Objective: To establish the context and location of PA undertaken by those attending a place of work. Method: A convenience sample of participants that considered they had a non-manual occupation was recruited. The activPAL activity monitor (PALtechnologies Ltd, Glasgow, UK) was used to measure the number of steps taken and the cadence of those steps of participants. A Cadence of greater than 109 steps per minute was considered

moderate to vigorous PA (MVPA). GPS was used to identify the geographical locations of where the PA was undertaken. The data from the two devices were synchronised allowing location, context, volume and intensity of PA to be explored. Both devices were worn for seven consecutive days and 5 work days extracted for analysis. Results: Twenty-six office workers [17F; mean age 38 (range23-65)] were recruited. The number of steps taken per day on average for the group was 11,008 (SD ± 2,999) with time spent in MVPA per day being 32.7 (SD ± 17.1) minutes. The commute accounted for 32% or 3,550 (SD ±1664) of the steps taken and 68% or 22.0 (SD ±14.1) minutes of MVPA. (Figure 1) Conclusion: this work demonstrates that through combining activity monitor with GPS data not only can volume and intensity of PA be explored but importantly also the context and location. Hopefully combining the technologies will inform strategies to increase PA.

Home Based Measuring of Physical Activity and Sleep in the eWALL Platform

Harm op den Akker[1], Miriam Cabrita[2], Hermie Hermens[1]
[1]Roessingh Research and Development, [2]University of Twente

Background: The eWALL is a home-based eHealth platform that brings health and wellbeing applications into the homes of older adults. A professional cloud infrastructure supports data storage, service provisioning, and data analysis. The eWALL Home Device, including a large 40" touch screen, gives access to a host of health applications, presented through an easy to use skeomorphic UI. The eWALL was designed and developed in the context of the European FP7 project eWALL (610658) and targeted at older users suffering from Chronic Obstructive Pulmonary Disease, Mild Cognitive Impairments or functional decline. A major development focus was put on developing services to support physical activity (PA) and sleep. Methods: PA and sleep applications within eWALL were designed in multiple user-centered design iterations. A commercial tracker (Fitbit Charge HR) was used to assess PA and sleep continuously in daily life. In order to personalize to the needs of the elderly users, specific focus was put in algorithms for deriving personal long-term trends. For PA, trend data was used to calculate and set tailored daily goals. A virtual, motivational agent provided tailored advice based on the models defined in [1]. Daily and weekly sleep data was accessible in the sleep application and compared to sleep trend data. The eWALL was evaluated in four countries (the Netherlands, Italy, Denmark and Austria) with 48 users for an average period of 24.2 (±10.0) days. Results and Discussion: The evaluation showed that out of a total of 11 applications, the sleep application (ranked first) and the physical activity applications (ranked second) were the most popular apps. The ability to register sleep and physical activity was also mentioned as positive experiences by many participants in semi-structured post-evaluation interviews. Based on the successful evaluation, eWALL will be commercialized with a focus on PA and Sleep functionalities. References: [1] op den Akker et al., 2015

Auditorium A: Analytic Approaches for 24 Hour Data

Session Chair: Chuck Matthews (National Institute of Health)

Multilevel functional methods for modeling actigraphy data and its application to predicting mortality in the US population

Vadim Zipunnikov[1]
[1]Johns Hopkins Bloomberg School of Public Health

We will present the results of analysis of physical activity data collected with accelerometers on 10000+ subjects in National Health and Nutrition Examination Survey (NHANES), a nationally representative sample of the US population. The data have been analyzed with recently developed multilevel functional data analysis approaches that focus on modeling variability in 24-hour diurnal patterns by i) separating and quantifying the systematic and random circadian patterns of physical activity, and ii) modeling those patterns as functions of age, gender, and dominant comorbidities. We will demonstrate that these patterns are accurate predictors of the follow-up mortality in NHANES 2003-2006 cohorts.

The Isotemporal Substitution Paradigm: Opportunities and Limitations for Estimating 'Replacement' Effects in 24 Hour Sensor Data

Matthew Buman

Compositional Analysis of 24 hours Activity Data potential and limitations

Sebastien Chastin[1], Javier Palarea[2]
[1]Glasgow Caledonian University, [2]BioSS

Purpose: To introduce compositional analysis techniques for analysing physical activity data. Methods: Compositional analysis is a branch of statistics that deals with data which sum to a finite whole. This is the case of activity data when dealt with in the time domain. An increasing number of studies utilise 24 hours collection protocol. Compositional data analysis provides a mathematical framework to deal with some of the issue presented by this type of data such a collinearity, but also provide novel analytic potential. Results: We present results of compositional analysis of data from NHANES, the Canadian Health Survey, the Health Survey England and Ausdiab study, to show different types of application of compositional analysis and highlight benefits and limitations. Conclusions: Compositional analysis has the potential to provide more accurate models accounting for the whole day and help us understand the interaction between physical activity, sedentary behaviour and sleep.

Isotemporal Substitution Modeling versus Compositional Data Analysis

John Staudenmayer (Invited Speaker)

Modern devices and innovative recall instruments allow the possibility of using the percentage of time in a twenty-four hour day that a person spends in different categories of activity or inactivity as covariates in regression models. This must be done carefully since the covariates add up to a constant, and two approaches are prevalent in the literature: isotemporal substitution modeling and compositional data analysis. This short talk will describe the two methods and present results from a simulation study that contrasts their effectiveness in different situations.

Auditorium B: Physical Activity and Associated Outcomes

Session Chair: Catrine Tudor-Locke (University of Massachusetts Amherst)

Combining Accelerometry and Magnetic Resonance Imaging data: Associations between non-exercise activity and brain grey matter volume

Markus Reichert[1], Heike Tost[2], Urs Braun[2], Hans-Joachim Salize[2], Alexander Zipf[3], Andreas Meyer-Lindenberg[2], Ulrich Ebner-Priemer[4]

[1]Central Institute of Mental Health (CIMH) / Karlsruhe Institute of Technology (KIT), [2]Central Institute of Mental Health (CIMH), [3]Heidelberg University, [4]Karlsruhe Institute of Technology (KIT)

There is emerging evidence for beneficial effects of physical activity on brain structure and function in humans. However, in most existing studies physical activity data is based on questionnaire assessment, which is subject to retrospective biases. Moreover, these investigations focused on the impacts of exercise (such as jogging) on brain structures and functions within children and elderly's. Unfortunately, there's only few research on the influence of non-exercise activity (unstructured physical activity in everyday life, e.g., climbing stairs) on neural correlates in adults. We aimed to contribute closing the gap of research on the influence of non-exercise activity on brain functioning in adults and, especially, to overcome limitations of existing studies with regards to the non-exercise activity assessment through combining Ambulatory Assessment with Magnetic Resonance Imaging (MRI) measures. Therefore, applying a baseline and a one-year follow-up measurement, we assessed non-exercise activity objectively via accelerometers in the everyday life of adults (n=75) across 7 days. Thereafter, we acquired anatomical MRI data to assess changes in brain grey matter volume. All participants were recruited at the Psychiatric-Epidemiological Center (PEZ), Central Institute of Mental Health, Germany. Preliminary analyses show a significant positive correlation between non-exercise activity and grey matter volume in prefrontal areas (peak voxel at x = -3, y = 50, z = -8; T = 5.68, p = 0.012 FWE-corrected for multiple comparisons across the whole brain) after controlling for exercise, wear-time and body-mass-index. We will present detailed data revealing the strengths of combining Ambulatory Assessment with MRI data.

Sedentary time and higher intensity physical activity versus cardio respiratory fitness - what is more important for cardio-metabolic health for adults aged 40-75?

Annemarie Koster[1], Jeroen van der Velde[1], Coen Stehouwer[1], Carla van der Kallen[1], Pieter Dagnelie[1], Miranda Schram[1], Ronald Henry[1], Simone Sep[1], Simone Eussen[1], Martien van Dongen[1], Nicolaas Schaper[1], Hans Savelberg[1]
[1]Maastricht University

Purpose: To examine the combined associations of sedentary time (ST), high intensity physical activity (HPA), and cardio-respiratory fitness (CRF) with metabolic syndrome (MetS) and glucose metabolism status. Methods: From 1,933 men and women (aged 40-75 years) of The Maastricht Study, ST and HPA were measured with the activPAL3 activity monitor. CRF was assessed with a sub-maximal cycle-ergometer test. MetS was defined according to the ATPIII guidelines. Glucose metabolism status (normal, prediabetes, type 2 diabetes (T2DM)) was determined from an oral glucose tolerance test. For the combined associations, sex-specific tertiles of ST and CRF, and HPA and CRF were cross-tabulated into 9 subgroups. Results: Higher ST, lower HPA and lower CRF were each independently associated with a greater likelihood of having MetS and T2DM. Compared to persons with a high CRF and high HPA, the odds of having MetS and T2DM was significantly increased in groups with a lower CRF regardless of their HPA levels (Figure 1). Persons with a low CRF and low HPA levels had a particularly high odds for MetS (OR:5.73, 95%CI:3.84-8.56) and T2DM (OR:6.42, 95%CI:3.95-10.45). Similarly, compared to persons with high CRF and low ST, those with a medium or low CRF had higher odds for MetS, prediabetes and T2DM, irrespective of ST. In persons with a high CRF, high ST was associated with a significantly high odds for MetS (OR:2.93, 95%CI:1.72-4.99) and T2DM (OR:2.21, 95%CI:1.17-4.17). The highest odds of MetS, prediabetes and T2DM was found in persons with a low CRF and high ST; (OR-MetS:9.22, 95%CI:5.74-

14.80), (OR-prediabetes:3.44, 95%CI:1.89-6.26), (OR-T2DM:8.38, 95%CI:4.83-14.55). Conclusion: ST, HPA and CRF were all independently from each other associated with MetS and T2DM. The combination of low CRF and low HPA and the combination of low CRF and high ST were associated with a particularly high risk of having MetS and T2DM.

At least 10-min physical activity bouts and breaks in sedentary behavior are associated with diabetes/elevated blood glucose

Pauliina Husu[1], Kari Tokola[1], Jaana Suni[1], Henri Vähä-Ypyä[1], Harri Sievänen[1], Tommi Vasankari[1]
[1]The UKK Institute for Health Promotion Research

Background Diabetes is an increasing public health challenge. Based on self-reports, physical activity (PA) decreases and sedentary behaviour (SB) increases the risk for diabetes. This study investigated associations of objectively measured PA/SB with diagnosed diabetes/elevated blood glucose. Methods Participants (n=1183) were 30-75-year-old men and women from PA and fitness sub-sample of the Health 2011 Study, having sufficient (≥4days, ≥10h/day) accelerometer data (Hookie AM20, Traxmeet Ltd, Espoo, Finland) and data on diagnosed diabetes/elevated (>7 mmol/l) blood glucose. PA-parameters were based on mean amplitude deviation of acceleration analyzed in 1min exponential moving average (epoch length 6s). SB (e.g. sitting and laying down) was based on the angle of postural estimation. Parameters of SB and PA were total daily time of SB, standing still, light PA and moderate-to-vigorous PA (MVPA), number and accumulated time of different bouts (5,10,15,30 min), maximum daily value of metabolic equivalent (MET) of different bouts (1min-2h, whole day), mean of these bouts during the week, number of daily breaks in SB and number of daily steps. Multivariable logistic regression analysis was conducted between diabetes/elevated blood glucose and PA/SB adjusted for age, sex and fitness (6-minute walk test result). Results Participants with diabetes had on average more SB and less PA than healthy counterparts. When parameters of PA and SB were analyzed independently, higher daily MET-value and time accumulated from at least 10-minute MVPA-bouts decreased the odds for diabetes. In multivariable analysis at least 10-minute MVPA-bouts and mean number of breaks in SB were associated with lower odds of diabetes. Discussion and conclusions At least 10-minute MVPA-bouts and breaks in SB were more strongly associated with diabetes than shorter MVPA-bouts, MET-values or SB-parameters. Prospective studies are needed to assess causality of this association.

Physical activity and sedentary behaviour in patients with inflammatory joint disease: a cross sectional study.

Kirsty Bell[1], Danny Rafferty[1], Gordon Hendry[1], Martijn Steultjens[1]
[1]Glasgow Caledonian University

Background: Physical activity (PA) has been shown to be of great benefit to patients with inflammatory joint disease (IJD) without having any harmful effects. However, people with IJD are often very inactive and spend more time in sedentary behaviours. Therefore investigation into what determines PA levels in these patients is crucial. Objectives: To determine whether patients with IJD meet the current Government Guidelines on PA; to determine what factors are associated with their PA levels; and to determine what factors are associated with their SB. Method: Cross-sectional study of 50 patients with a medical diagnosis of an IJD prior to commencing a UK National Health Service inflammatory arthritis exercise programme. PA and SB were measured objectively using a physical activity monitor for 7 consecutive days. Activity levels were analysed against the current Government Guidelines on PA using

descriptive statistics. Time spent in SB, low physical activity and moderate to vigorous physical activity were analysed against possible determinants such as disease specific factors, physical condition and health related quality of life (HRQoL) using a Pearson?s or Spearman?s correlation depending on the distribution characteristics of the data. Results: 5% of patients with IJD meet the current Government Guidelines on PA. Patients on average spend 10 hours a day in SB. High levels of PA were associated with higher HRQoL (rs=0.517, P<0.001), higher levels of fitness (rs=0.493, P=0.001), lower body mass index (rs=-0.385, P=0.010) and enhanced exercise attitudes and beliefs (rs=0.34, P=0.024). High levels of SB were associated with lower HRQoL (r=-0.476, P=0.001). Conclusions: Significant correlations have been found between possible determinants of PA and SB. These correlations may help inform interventions and strategies to reduce SB and increase PA in patients with IJD.

Auditorium C: Taking a 'Step' Forward

Session Chair: Jeffrey Hausdorff (Tel Aviv Sourasky Medical Center)

The detection of purposeful stepping using a wrist worn accelerometer

Ben Stansfield[1], Stefan Teufl[1], Jenny Preston[2], Frederike van Wijck[1]
[1]Glasgow Caledonian University, [2]Douglas Grant Rehabilitation Centre, Ayrshire Central Hospital

The detection of purposeful stepping using a wrist worn accelerometer Introduction Physical activity measurement using wrist worn monitors provides a participant friendly alternative to waist or thigh monitors. However, the evidence to support the use of the wrist as a site to measure stepping activity under free-living conditions with acceptable validity is limited (Urbanek et al 2015). Aim To detect purposeful stepping using a wrist worn accelerometer. Methods Healthy adults (18-65y) were asked to wear both an activPAL thigh worn monitor (v6.4.1 Pal Technologies Ltd.) (reference standard for stepping) and a wrist worn Axivity (Axivity Ltd.) triaxial accelerometer for 24 hours under free-living conditions. Purposeful stepping was defined as sustained stepping for a period of time (T: 5,10,15s). Using frequency analysis (FFT, 2s windows, 50% overlap) lower (Freq-Low: 1.5-1.9Hz) and upper (Freq-High: 2.6-3.2Hz) limits were set for stepping detection from the wrist monitor. To allow small breaks in a stepping bout, yet to still classify purposeful stepping a defined error margin was used: Percentage of time stepping detected within a bout (T%). Step detection using the wrist worn device was optimized. Results and Discussion Twenty four hour records of the free-living activity of ten participants were used to optimize purposeful stepping detection. Optimal settings were T=10s, Freq-Low=1.7Hz, Freq-High=3.1Hz, activPAL T% = 92.5, Axivity T% = 70. Wrist monitor purposeful stepping time outcomes were 9.23% (SD 24.25) lower than activPAL (Table 1). This study suggests that there is sufficient cyclical movement in the upper limb to allow purposeful stepping detection in some people. Despite the adaption of the algorithm to incorporate an element of error it was not possible to detect all stepping bouts for all people and in some cases stepping was substantially underestimated. Stepping detection at the wrist under free-living conditions remains challenging.

Slow but Sure: The Accurate Measurement of Slow Stepping

Nicholas Smith[1], Andy Kerr[2], David Loudon[3]
[1]University of Strathclyde and PAL Technologies Inc., [2]University of Strathclyde, [3]PAL Technologies Inc.

Step counting has long since been the fundamental backbone of physical activity monitoring. It offers the advantage of providing a powerful insight into the free-living behaviour of a person through their

daily pattern of step accumulation, while also providing a step count - a simple single figure for each day that is clinically significant and readily understood by the wider population. To correctly reflect an individual's ambulatory activity, it is vital to capture all steps, including those that are slow or shuffled. However, existing approaches fail to accurately capture slower stepping (e.g. pedometers, consumer wearables, and even research-focused devices). These devices detect stepping from the large acceleration peaks generated by the heel strike which are absent in the short step length typical of slow stepping. This undercounting of slow stepping is further compounded by the small number of steps taken in pathological populations (e.g. amputees, frail elderly and neurologically impaired). We have shown that sensor placement is fundamental to the accurate capture of slow stepping (figure 1). The subtle impact forces observed during slow or shuffled gait are attenuated through the body. Additionally, a wrist worn sensor is readily affected by the upper-limb movements of everyday living. The thigh signal was found to have a peak magnitude of 30% of that of the foot, while the trunk signal was below the resolution of the sensor. Therefore, we present a shank worn device. Shank placement offers minimal impact force dissipation (54% of foot), while also providing dynamic angular data allowing pathological segment orientation to be determined, not available with foot mounting.

Free-living dynamic skeletal loading estimation using tri-axial accelerometers

Emma Fortune[1], Kenton Kaufman[1]
[1]Mayo Clinic

Hip bone mineral density (BMD) is an important biomarker of fracture risk, but as a standalone measure it lacks information on modifiable causal factors. The relationship between hip BMD and physical activity (PA)-based skeletal loading estimates could provide a biomarker for prescribing PA changes in high risk patients. Ten older women (age: 78.1 (8.1) yrs, BMI: 25.4 (3.8) kg/m-2) each performed 21 to 38 walking trials in the lab at slow, normal, and fast self-selected speeds (0.5-1.7 m/s) while wearing bilateral ankle activity monitors (AMs) (ActiGraph; 100 Hz). Ground reaction force (GRF) data were collected at 600 Hz for one to five steps per trial using five force plates and video data were collected at 60 Hz. Participants received DXA scans to measure total hip BMD and wore the AMs for 4 days in their free-living environments. Mean step count agreement was 94% with video and peak vertical GRF had a moderate significant correlation with acceleration (Fig 1). In this study, we observed a much smaller RMS error of 0.073 body weight (BW) for GRF estimations compared to 0.185 BW with the NASA GRF AM [1]. The peak vertical GRF of each step detected in the free-living environment was estimated from the peak impact vertical acceleration using a general GRF equation developed from the lab data (Fig 1). The mean (SD) daily step counts across participants were 10257 (3942). A bone density index (BDI) was calculated for each participant as the mean daily cumulative sum of each step's estimated GRF. BMD had a high significant correlation with BDI. Data is currently being collected on an additional 70 participants for further algorithm development and validation. Future work will determine if this ankle acceleration-based BDI tool can be used to predict BMD changes. [1] Bowley and Whalen, Ortho Res Soc, 2001.

The distribution of activPAL postural and stepping classifications within ActiGraph activity classifications

Alexandra Clarke-Cornwell[1], Penny Cook[1], Malcolm Granat[1]
[1]The University of Salford

Objective: Guidelines of physical activity (PA) and sedentary behaviour (SB) are dependent on how we define and quantify physical behaviour. It is therefore important to understand the validity of objective measures of PA and SB. This study aimed to evaluate the activity classifications of the ActiGraph GT3X+ (AG), using activPAL3 (AP) postural and stepping classifications as a criterion reference, in a free-living environment. Methods: A convenience sample of 30 university employees (females (66.67%); age 40.47±10.95 years; BMI 23.93±2.46 kg/m^2) were asked to wear the AG and AP simultaneously during waking hours for 7 days. Data were downloaded in 1-minute epochs and non-wear time was removed, using information from activity diaries and the Troiano algorithm for AG counts. The data were categorised using the Freedson activity cut-points for sedentary, light, moderate, and vigorous physical activity (≤99, 100-1951, 1952-5724, ≥5725): for each of these categories, the percentage of activity (sitting/lying, standing and stepping) from the AP was calculated for each AG category. Results: After data reduction, participants provided on average 11h 58 min of data per day. The majority of these minutes (64.4%) were classified as SB from the AG, 30.5% light physical activity (LPA), and 5.1% moderate to vigorous physical activity (MVPA). The AG count distribution, median (interquartile range:range), for AP minutes that were wholly classified as sedentary was, 1 (0-30:0-9808); standing, 5 (0-39:0-4452); stepping, 3990 (2968-4882:0-13247). The AG sedentary category contained 16.8% standing; LPA contained 35.9% sitting/lying; (85.4%) of MVPA categories were accumulated in steps (figure). Conclusions: The misclassification of standing within the AG sedentary classification, and the high percentage of sitting/lying within the AG LPA category, supports recent evidence that the 100 cut-point for SB can over or under estimate sedentary time depending on the underlying population.

11:15 – 12:15 Speakers and Abstracts

Kirschstein Auditorium: Clinical Applications of Monitoring Devices

Session Chair: Alison Cernich (National Institutes of Health)

Physical Performance Monitoring and Clinical Applications in Orthopedics

Matthew Smuck (Invited Speaker) Stanford University, USA

Objective ambulatory activity better describes the function of patients with hip deformities

Wilshaw Stevens Jr[1], Kirsten Tulchin-Francis[1], Adriana DeLaRocha[1], David Podeszwa[1]
[1]Texas Scottish Rite Hospital for Children

Subjective activity measures have been used to describe patient outcomes following treatment for hip deformity and weak correlations have been shown between subjective and objective measures. Nevertheless, subjective activity measures are widely reported. To compare the activity levels measured subjectively and objectively, across patients treated for various hip deformities. 48 patients (31 f, avg age 22.2 years) who, 1) underwent hip preservation surgery (including surgical hip dislocation (SHD) or periacetabular osteotomy (PAO)), 2) underwent a total hip arthroplasty (THA), or 3) had a diagnosis of coxa vara (CCV) were prospectively enrolled in an IRB approved study. The UCLA and Marx activity scale were completed by the patient to assess (subjective) activity levels. Objective ambulatory activity was measured using a StepWatch Activity Monitor for at least 1 week. Step (stride x 2) data were processed to identify the intensity /duration of ambulatory activity bouts along with the total steps and total ambulatory time (TAT). A Mann-Whitney test (α=0.05) compared measures across all patient groups and

a control cohort (n=31) was included for comparison of the objective measures. While across all patient groups there were no significant differences in subjective measures, there was a significant difference in the objective ambulatory activity measures of TAT ($p<0.05$), Easy/Short ($p<0.01$), and Moderate+/Intermediate ($p<0.001$). Patients who had undergone a SHD had significantly higher TAT compared to controls ($p<0.01$) and spent significantly less time in Moderate+/Intermediate ($p<0.01$). Patients who had undergone a THA spent significantly higher time in Easy/Short ($p<0.01$) and significantly less time in Moderate+/Intermediate ($p<0.01$) compared to controls. Objective measures of ambulatory activity showed a reduction in the amount of time spent in high intensity ambulation and increased time in low intensity ambulation not identified by the self-reported activity.

Objective diagnosis and outcome assessment of shoulder pathologies is clinically feasible using inertial activity monitors to derive asymmetry of intense upper arm movements.

Bernd Grimm[1], Stijn Martens[2], Matthijs Lipperts[3], Ralph Walbeehm[1], Steven Samijo[1]
[1]Zuyderland Medical Center, [2]University of Maastricht, [3]St. Anna Hospital

Introduction Ambulant assessment of shoulder activity could be highly valuable for clinical diagnosis or objective outcome assessment as patient self-reported questionnaires (e.g. DASH, SST) perform poorly. This study investigates if movement asymmetry between contralateral shoulders during activities of daily living (ADL) produces parameters useful for clinical diagnosis or assessment. Methods 24 patients (age: 53.3±10.5, f/m = 9/15) with typical unilateral shoulder pathologies (e.g. cuff tear, impingement) were measured and compared with 28 measurements in 23 matched healthy controls (age: 54.4±6.2, f/m = 10/13). Shoulder activity was recorded for during waking hours (mean ±SD: 11.2±2.7 hours) of one day by adhesively taping a wearable 9D inertial measurement unit (IMU, m=25g, size: 56.1x39.4x15.2mm, f=50Hz, ±16g, ±2000deg/sec) to the Hueter triangle of both upper arms. Via signal post-processing (Matlab) high intensity events were counted as the amount of 0.5s intervals in which the 3D acceleration vector exceeded >0.1g, >0.5g or the 3D angular rate vector was >150deg/s. Relative event count asymmetry (%) between contralateral shoulders, (affected/un-affected, dominant/non-dominant sides) were calculated as outcome parameters. Groups were compared using (non-) parametric statistics after testing data distributions ($p<0.05$). Results High intensity asymmetry scores for the 0.1g, 0.5g and 150deg/s event thresholds were positive and sign. higher for healthy controls (3.22% ±2.29, 0.90% ±1.18, 0.57% ±1.01) than shoulder patients with negative mean asymmetry (-0.66% ±3.22, -0.13% ±0.93 and -0.11% ±0.62; $p<0.006$). Negative asymmetry (<-0.1%) was nearly absent in healthy controls (1/84 values) but common in patients (34/72 values). Discussion & Conclusion Ambulant assessment of shoulder activity during ADL is feasible with IMU's and simple algorithms. Intensity event count asymmetry produce parameters suitable to diagnose or objectively assess shoulder function.

Auditorium A: Accelerometer Wear-Time and Activity Analysis

Session Chair: Ulrich Ebner-Priemer (Karlsruhe Institute of Technology)

Comparing methods for creating an overall physical activity estimate from multiple accelerometer days

Eric Shiroma[1], Osorio Meirelles[1], Lenore Launer[1], Tamara Harris[1]
[1]National Institute on Aging

Background: Accelerometers provide an objective assessment of physical activity and are frequently deployed for at least multiple days. However, it is unclear how to summarize multiple days into one overall physical activity estimate, particularly in the presence of missing data. This study compared summarization method prediction and precision, and the effect of summarization choice on the association of physical activity and mortality. Methods: Data were from NHANES adults (2003-2006) with mortality follow-up through 2013. Overall activity estimates were calculated under different methods: random day, median, mean (natural scale), mean (log transformed), and mixed models adjusting for day of the week and observation day number. To evaluate the summary method prediction and precision, activity estimates were compared to a left-out day using an adjusted R^2 for each summarization method. Summary methods were also evaluated by number of days of observation. To compare the effect of the summarization method on the association of physical activity and mortality, hazard ratios (95% confidence intervals) were calculated using Cox survival analysis. Results: Random day was the poorest predictor of the left-out day (R^2 23.6% - 48.9%). Mixed models, adjusting for day of the week and day order, performed the best (74.6% - 85.4%), particularly among few observation days. However, among 6 or 7 days, medians (66.0% - 68.6%) or means (60.9% - 69.5%) perform adequately. All summary methods showed similar inverse, curvilinear trends between physical activity and mortality (Figure 1). Conclusion: While summarization methods differ in their predictive ability of the left-out day, particularly among few observed days, all methods result in similar conclusions in terms of the association between physical activity and mortality. This provides some evidence that physical activity and mortality studies using various summarization techniques may be able to be directly compared.

More high intensity physical activity in the population with new method to process ActiGraph accelerometer data

Daniel Arvidsson[1], Jan Brønd[2], Elias Johannesson[1], Lars Bo Andersen[3], Örjan Ekblom[4], Elin Ekblom Bak[4], Göran Bergström[1], Mats Börjesson[1]
[1]University of Gothenburg, [2]University of Southern Denmark, [3]Western Norway University of Applied Sciences, [4]The Swedish School of Sport and Health Sciences

Introduction: Our research group has developed the processing of raw acceleration data to ActiGraph counts for improved assessment of high intensity physical activity. The aim of the present study was to apply this new processing method to large population data and investigate the effect on physical activity compared to the original ActiGraph method. Methods: Cross-sectional data collected in the Swedish population (SCAPIS Gothenburg and LIV) were used including 1094 individuals 20-65 years old. The sample was categorized into a younger (20-49 yrs) and older (50-65 yrs) group. ActiGraph accelerometer data was collected over seven days and different physical activity measures, their combinations and patterns were generated and investigated using the original and new processing method to generate activity counts. Results: There was a clear increase in high intensity physical activity with the new processing method, especially in younger individuals and in males. For example, the proportion of young males with high intensity physical activity changed from 27% with the original method to 46% with the new method (p=0.03), and from 27% to 35% in young females (p=0.29). The corresponding changes in older individuals were from 10% to 14% in males (p=0.09) and from 8% to 10% in females (p=0.37). Conclusions: The new processing of ActiGraph acceleration data captures more high intensity physical activity in the population. The importance of this development depends on the specific population investigated and the distribution of the physical activity intensity level.

How many days are enough for measuring physical behavior with the ActivPAL in working adults?

Nicolas Aguilar-Farias[1], Nicolas Salom-Díaz[1], Pía Martino-Fuentealba[1]
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Introduction: Activity patterns are highly variable within and between subjects. Therefore, data extraction protocols are needed for different devices to achieve valid measures. The purpose of this study was to determine the number of monitoring days needed to achieve reliable estimates of sitting, standing, walking and transitions with the ActivPAL (AP) monitor in working adults. Methods: Participants (90 adults (51.1% men); age= 39.1±12.43 years) wore an AP for 7 consecutive days. Mean time spent in sedentary, standing and walking per day, and mean number of transitions from sitting to standing per day were calculated for each participant using 7 days of monitoring (reference). Estimates for these activities were also derived from a combination of randomly selected days (from 1 to 6 days), and randomly selected weekdays and weekend days, and compared with the reference using ANOVA, correlation coefficients and Bland-Altman Method. Spearman-Brown Prophecy Formula based on Intraclass correlation of 0.8 was used to predict the minimum number of days needed to represent mean total sitting, standing, walking and transitions per day. Results: Mean total time spent in different activities was 554.9±130.15 min/day for sitting, 297.8±85.43 min/day for standing, and 126.1±42.99 min/day for walking. The mean number of transitions per day was 74.9±27. Five or more days of monitoring were necessary to achieve a reliability of 0.8 for all postures and transitions. Comparisons between combinations of days and the reference for all postures are shown in Table 1. When using a combination of weekdays and weekend days mean biases were like those shown by any combination of days, but 95% limits of agreement were narrower. Conclusion: When using AP, a combination of any 5 days was reliable to represent all activities and transitions per week, but it may be preferred to include at least 1 weekend day among these to achieve more accurate estimates.

Utility of ActiGraph wear sensor in assessing wear-time in 24-hour wrist measurement

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There are no standard procedures for identifying wake wear, sleep wear and non-wear time from the 24-h accelerometer recordings. Participant diaries increase participant burden and frequently have missing values. The Choi algorithm identifies 90-min consecutive zero counts as non-wear time, allowing for 2 minutes of non-zero counts, thus possibly ignoring short non-wear bouts and over-estimating non-wear time during sleep. The ActiGraph wActiSleep-BT has a wear sensor which may offer solution for distinguishing between wear and non-wear time. The objective of this study was to compare wake and sleep wear time identified by the sensor to those identified by the Choi algorithm and by participant diaries. In the Finnish Retirement and Aging Study, 477 aging workers (mean age 62, SD 1.2, 18% male) were asked to wear wActiSleep-BT on their non-dominant wrist continuously for 7 days and 6 nights. Sleep and wake time were defined by participant diaries and divided into wear and non-wear time by three methods: participant diaries indicating start and end time of the measurement, Choi algorithm and sensor. The sensor identified significantly less wear time than the other two methods. Mean (SD) minutes of wake and sleep wear time were 804 (263) and 399 (137) by sensor, 903 (179) and 429 (99) by Choi algorithm and 922 (158) and 448 (89) by participant diaries. However, for the majority of participants the correlation of wake wear time identified by Choi algorithm and sensor was very high (Figure 1). The observed discrepancy between Choi algorithm and sensor was mostly due to

underestimation of wear time by the sensor possibly owing to technical errors. In the conference we will present methods to identify those participants for whom sensor works appropriately. In addition, we will present a tool to calculate wear time for those for whom wear sensor does not work.

Auditorium B: Multimodal Assessment

Session Chair: Theresa Cruz (National Institute of Health)

The context of physical activity of older adults in daily life: combining accelerometry and ecological momentary assessment

Miriam Cabrita[1], Harm op den Akker[2], Monique Tabak[2], Miriam Vollenbroek-Hutten[1], Hermie Hermens[2]
[1]University of Twente, [2]Roessingh Research and Development

Background: Despite the overall policies and interventions promoting physical activity (PA), older adults are still not reaching the recommended levels of PA. The guidelines for PA targeting older adults involve not only exercise related activities, but also highlight the importance of everyday activities in reaching an active lifestyle. Multimodal assessment allows to investigate the context of PA in daily life, thereby improving the interventions to promote active lifestyles. Method: During approximately one month, in a study primarily designed to assess the relation between pleasure and PA in daily life [1], 10 community-dwelling older adults (aged 65 to 83) continuously monitored their PA by carrying a hip-worn accelerometer (measuring PA in IMA counts/min). Context of physical activity was assessed by EMA on a smartphone application, approximately every hour from 08h00 to 20h00. Participants were requested to choose from a set of options which activity they were performing, with whom and where. Results: A total of 3994 EMA-events were collected, from which 2301 were used in this analysis. Most of the events were reported at home (73%), alone (57%) and concerned relaxation activities (40%). Significant results include the fact that outside the home environment participants were 58% more active than at home ($p<.0001$), and that participants were significantly more active with friends than while being alone or with the partner. For our older population sample, household activities contributed considerably to the daily PA, similar to the contribution of sport activities. Conclusions: Interesting findings appeared from our study but most importantly, based on our data analysis, we derived a number of critical recommendations for the design of future EMA studies. For example, great care should be taken in the analysis of momentary assessments, as the participants choose their most opportune moment to report their activities.

Associations of real-life mobility with measures of physical, cognitive as well as psychosocial functioning in community-dwelling older adults

Eleftheria Giannouli[1], Otmar Bock[1], Wiebren Zijlstra[1]
[1]German Sport University Cologne

Studies have shown that limited mobility is associated with morbidity, increased fall risk, loss of independence, institutionalization, and increased mortality. To support older people in maintaining independent mobility, it is important to have knowledge of factors that impact on mobility. Although literature demonstrates the multi-dimensionality of mobility, most studies of mobility in older people do not take this into account. This study aims to have a more comprehensive approach to mobility in older people by analyzing the association of life-space and physical activity in daily life with hypothesized mobility determinants. Data were obtained in a sample of over 100 older community dwelling adults.

Life-space mobility and physical activity were assessed based on measurements by smartphone during one week. Life-space variables (life-space, action range and total distance) were calculated from GPS data, and physical activity variables (active and gait time and number of steps) were calculated from inertial sensors in the smartphone. Physical functioning was assessed based on measures of cardio fitness, leg and handgrip strength, balance and gait function; cognitive functioning was assessed based on measures of attention and executive function; in addition psychological (loneliness, perceived ageism and self-efficacy measures) and social determinants (sociableness, perceived help availability and social networks) were assessed. Our results show differential associations between life space, physical activity and the hypothesized mobility determinants which may contribute to a better understanding of mobility limitations and challenges in designing appropriate interventions to enhance mobility in older persons.

Estimating energy expenditure during outdoor level walking using Global Positioning System or accelerometry in patients with peripheral artery disease

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[1]ENS Rennes, [2]Clinical investigation center (CIC) 1414, INSERM

Introduction. Estimating energy expenditure (EE) related to outdoor walking capacity in peripheral artery disease (PAD) patients could allow a better standardization of the assessment of their limitations during free-living outdoor walking. However, there is no data regarding the accuracy of ambulatory methods to perform such estimations. Our aim was to study the accuracy of global positioning system (GPS) and accelerometry for estimating EE during outdoor walking in PAD patients. Methods. Thirteen PAD patients with walking limitations completed a 45-to-60-min outdoor walk (athletic track) while wearing a DG100 GPS receiver (shoulder; 1-Hz), a wGT3X+ accelerometer (hip; 30-Hz) and a K4b2 portable metabolic system. Patients had to walk until pain forces them to stop. Recovery time between walking bouts was free. For each walking bout, total EE (MET-min) was measured using the K4b2. MET-min were estimated using appropriate MET or oxygen uptake equations that incorporated either i) GPS speed and grade or ii) accelerometer counts. The highest measured MET-min values (one value/patient) were compared with the corresponding GPS- or accelerometry-estimated MET-min values. Results. Estimated and measured MET-min were significantly correlated ($r>0.98$, $p\leq0.001$ [all devices and equations]). Mean absolute percentage error ranged from 17 to 21% for GPS and from 18 to 25% for accelerometry according to the equation. One GPS-based equation (ACSM) significantly underestimated MET-min while one accelerometry-based equation (Leenders et al., 2003) significantly overestimated MET-min ($p\leq0.05$). MET-min estimated using the other equations (GPS/accelerometry) were not significantly different from the measured MET-min. Discussion and conclusion. GPS and accelerometry provide acceptable accuracy for estimating EE related to outdoor walking capacity in most PAD patients although large errors are likely to occur in some patients (see figure: patient #2) (support: CHU Rennes-CORECT 2013).

Using Bluetooth proximity sensing to determine location in a workplace.

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Most wearable devices that measure sedentary and active time in workplaces cannot determine the context of that time. The ActiGraph wGT3X-BT and Link models allow users to not only measure movement but the wearer?s location relative to a beacon using Bluetooth proximity detection. This function has yet to be independently validated. Knowing where workers are sitting and moving at work can inform strategies suitable for workplace interventions. Twenty-five office workers (32% men, mean ± SD age 39 ± 11 years) wore a wearable camera (video recording) and the ActiGraph Link, initialised as a receiver, attached to the thigh for one work day (6.2 ± 1.1 hours). Link devices initialised as beacons were placed in the entry (n=1), kitchen (n=1), photocopy room (n=1), corridors (n=2?4), and the wearer?s office (n=2). RSSI signals from all beacons were converted to binary outcomes (1=present, 0=absent). Link-determined location was decided using two methods. Method 1: Presence/absence of signal at a single beacon location. Method 2: Signal presence was summed over a 50 s centred moving window for all beacon locations. A single location was assigned based on majority vote and time-use probabilities. Location determined by each method was checked against camera location for sensitivity, specificity and accuracy. Median sensitivity/specificity/accuracy for the office location was 99%/29%/55% (method 1) and 99%/77%/98% (method 2). The median sensitivity/specificity/accuracy for the other locations ranged from 41%/56%/55% (corridors) to 87%/65%/65% (kitchen) for method 1 and 17%/99%/99% (entry) to 83%/99%/99% (kitchen) for method 2. The ActiGraph proximity detection function shows promise as a tool for determining where workers spend time within office-based work settings. When using multiple beacons, a rolling window algorithm that chooses a single location can improve classification accuracy. This information will be for researchers planning workplace sitting interventions.

Auditorium C: Sleep Classification

Session Chair: Rebecca Spencer (University of Massachusetts, Amherst)

Accuracy of an automated algorithm to detect nocturnal sleep in adults using 24-h waist accelerometry

Tiago Barreira[1], Jessica Redmond[2], John Schuna Jr[3], Catrine Tudor-Locke[4]
[1]Syracuse University, [2]Utica College, [3]Oregon State University, [4]University of Massachusetts Amherst

Purpose: We previously developed and tested the accuracy of an automated algorithm implemented using SAS to detect bed time, wake time, and sleep period time (SPT) in a sample of children. The purpose of this study was to test the accuracy of the algorithm in an adult sample. Methods: 104 adults were asked to log evening bed time and morning wake time and wear an ActiGraph GT3X+ accelerometer at their waist 24 h/days for seven consecutive days, unless coming in contact with water. Data were averaged for each participant before additional analysis. Mean difference (MD) and mean absolute difference (MAD) were computed. Pearson correlations and dependent sample t-tests were used to compare log-based variables of bed time, wake time, and SPT to corresponding accelerometer-determined variables estimated using the automated algorithm. Results: 85 participants (75% female, BMI=23.9±3.8 kg/m², age=23.3±5.6 years), provided 2+ days of valid accelerometer and log data for a total of 369 days. There was no mean difference between log and accelerometer estimates of bed time (11:48pm vs. 11:53pm, t(84)=1.56, p=.12, MD=5min, MAD=25min, r=.92). However, there was a significant mean difference (t(84)=2.53, p=.01) between log and accelerometer estimates of wake time (7:41am vs. 7:49am, MD=8min, MAD=24min, r=.92). Regardless, there was no mean difference (t(84)=0.70, p=.49) between log accelerometer estimates of SPT (473±59 vs. 476±66 min, MD=3min,

MAD=30min, r=.82). Conclusions: The log and automated accelerometer algorithm estimates were highly correlated and relatively small differences were present. Although a significant mean difference was found for wake time, this difference might not be meaningful in practice (i.e., MD=8 min) and did not ultimately contribute to significant differences in SPT. MAD, which gives a better estimate of the expected differences at the individual level, also provided good validity evidence for the automated algorithm use of individual estimates.

Accurate Measurement of Sleep Outcome Variables Using Wrist-Worn Monitors May Require User Input

Daniel Heil[1], Blakely Brown[2], Kari Jo Harris[2], Mike Tryon[3], Wei Zhu[1]
[1]Montana State University, [2]University of Montana, [3]Salish Kootenai College

Wearable electronic devices for the health and wellness consumer market commonly include the ability to assess overnight sleep quality. To do this accurately, these monitors must know exactly when sleep starts (sleep onset time; SOT) and ends (awake time; AT). To help determine both SOT and AT, consumer wearables often have two options: 1) User input feature (e.g., press a button) to approximate both SOT and AT; 2) An objective algorithm that does not require user input. For large intervention-based studies, however, an objective algorithm for determining SOT and AT is desired to reduce subject burden and improve objectivity. The purpose of this study was to determine the feasibility of using a wrist-worn accelerometry-based physical activity monitor (AM) to objectively determine variables associated with sleep quality. Methods: 22 children (10 boys, 12 girls; Mean[SD]: 8[1] yrs) and 18 adults (7 men, 11 women; 34[8] yrs) each wore an Actical AM on the same wrist for 7 consecutive days with locking wristbands. The raw AM data was then processed and analyzed using a collection of analytical steps (algorithm) derived from the research literature to determine both SOT and AT, both of which were compared to Actogram plots for each 24-hr period. Results: Initially, the objective algorithm was unable to detect either SOT, AT, or both for 1 to 7 nights for 15 of 22 children, as well as for all 18 adults. Based upon visual analysis of the Actograms, the algorithm was adjusted to limit the SOT search for after 6:00 and 8:00 PM for the children and adults, respectively. This change improved SOT detection for the children dramatically (only 8 with 1 or more detection errors), while every adult still suffered at least 1 detection error. Conclusions: These results suggest that a completely objective evaluation of sleep quality parameters may not yet be possible with the Actical AM without user input (i.e., press a button) or feedback (i.e., sleep log to record SOT and AT).

Automated sleep scoring algorithms for activity monitors - a comparison to polysomnography in the Raine Study.

Peter Eastwood[1], Ian Dunican[1], Kevin Murray[1], James Slater[1], Kathleen Maddison[1], John Caldwell[2], Leon Straker[3]
[1]University of Western Australia, [2]Coastal Performance Consulting, [3]Curtin University

INTRODUCTION Wrist-activity monitors are widely used to assess sleep and activity. Accurate measurement of time at 'lights out' (LO) is essential for calculation of several activity-derived measures including sleep latency (SL), sleep duration (SD), wake after sleep onset (WASO) and sleep efficiency (SE). To determine LO some devices use subjective reports (sleep diary) and others use automated proprietary scoring algorithms. This study aimed to compare the sleep measures of two such devices to polysomnography (PSG). METHODS A community sample of n=50 parents of participants in the Western

Australian Pregnancy Cohort (Raine) Study, mean age of 57±5 years, underwent an overnight laboratory-based PSG study during which they also wore a Readiband? (v3, Fatigue Science Inc., Canada, analysed using Readiband Sync) (Rb) and an ActiGraph (GTX3+, ActiGraph, FL, USA analyzed using ActiLife) (Act) on the non-dominant wrist. Rb uses an automated proprietary algorithm to determine LO whereas the Act requires participants to complete a diary, noting the time of LO the previous evening. Agreement between devices was assessed by Bland-Altman analyses with limits of agreement (LoA) calculated between PSG, Rb and Act. Differences between devices were assessed using linear mixed models. RESULTS Compared to PSG, Rb underestimated LO by 45mins (LoA±150mins), WASO by 85mins (LoA±115mins) and SL by 14mins (LoA±88mins) and overestimated SD by 73mins (LoA±90mins) and SE by 6% (LoA±31%). Compared to PSG, Act overestimated LO by 3mins (LoA±60mins), SD by 45mins (LoA±122mins), SE by 18% (LoA±26%) and underestimated WASO by 58mins (LoA±100mins) and SL by 21mins (LoA±55mins). CONCLUSION Compared to PSG, both the Rb and Act underestimate WASO and overestimate SD and SE. Act underestimates and Rb overestimate SL. The Act device, using a sleep diary, provides a more accurate estimate of LO, although both devices had wide LoA.

Sleep pattern detection using raw tri-axial wrist and hip actigraphy in the Raine Study

Michelle Trevenen[1], Kevin Murray[1], Berwin Turlach[1], Leon Straker[2], Peter Eastwood[1]
[1]University of Western Australia, [2]Curtin University

Sleep disorders occur in around 20% of the population and are associated with a multitude of serious health implications. Whilst polysomnography is considered the 'gold standard' in assessing sleep patterns, it is intrusive and costly hence actigraphy is increasingly being considered as a viable alternative. Current actigraphic sleep pattern detection algorithms typically use filtered uni-axial actigraphy data with a low sampling rate, measured on a patient's wrist or hip. However, the utility of wrist algorithms are limited due to poor specificity (wakefulness detection) and the ability for hip actigraphy to monitor sleep patterns is relatively unsubstantiated. Using simultaneously measured Actigraph GT3X+ and polysomnography data from 100 healthy young adults (22 years old) in the Western Australian Pregnancy Cohort (Raine) Study we created and validated two sleep/wake identification algorithms. These algorithms utilized raw tri-axial acceleration data from wrist and hip actigraphy. Random forest methodology was used as a form of dimension reduction and subsequent generalized linear mixed models were used to form predictive models. Our final wrist actigraphy algorithm yielded an average accuracy of 74% (SD 17%), sensitivity (sleep detection) of 75% (SD 18%) and specificity of 69% (SD 22%). The final hip actigraphy algorithm yielded an average accuracy of 70% (SD 13%), sensitivity of 71% (SD 15%) and specificity of 65% (SD 22%). These results were superior in specificity and comparable in accuracy and sensitivity to other widely used algorithms, indicating that raw data is suitable for sleep/wake classification. In addition, we found our model derived from hip actigraphy was comparable to the model derived from wrist actigraphy, supporting the notion that hip actigraphy could be an effective tool for sleep/wake identification.

1:45 – 2:45 Symposia

Kirschstein Auditorium – Symposium

Statistical modeling of circadian rhythms of physical activity

Jacek Urbanek[1], Vadim Zipunnikov[1], Jiawei Bai[1], Kathleen Merikangas[2]
[1]Johns Hopkins Bloomberg School of Public Health, [2]National Institute of Mental Health

Purpose: The proposed symposium will introduce novel and intuitive statistical methods for modeling the human circadian rhythm based on data collected using body-worn physical activity monitors. All methods are motivated by and applied to large observational studies. Rationale: Biological rhythms have been under intense methodological development across all disciplines of health research. Data obtained from body-worn physical activity monitors provide a much more complete view of human activity than was previously available. The intensity of human activity combined with its within- and between-day chronotype provide new possibilities for scientific research and raise a host of new challenges for statistical analysis. Objectives: The main objective is to present the potential of physical activity data for studying biological rhythms. We will introduce the methodology for the analysis of daily patterns of activity for large epidemiological studies. Next, we will present exploratory analysis techniques and introduce novel statistical methods for modeling circadian patterns with their application to health research. Summary: We will introduce a new perspective on diurnal patterns of physical activity and their relation to health and demographic outcomes. Format: 1.Jacek Urbanek: Objective accelerometry-derived measures of sleep variability in NHANES 2003-06 2.Vadim Zipunnikov: A real-time accelerometry-derived physical activity score for prediction of heart failure hospital readmissions 3.Jiawei Bai: Multi-stage dynamic models for levels of activity data obtained from wearable devices 4.Kathleen Merikangas: Motor Activity Research Consortium for Health (mMARCH): Standardization of procedures and analyses of mobile technologies in mood disorders and related conditions

Auditorium A - Symposium

The clinical utility of accelerometers in clinical populations

Joanne McVeigh[1], Leon Straker[1], Rebecca Meiring[2], Antonia Wadley[2], Carolyn McIntyre[3]
[1]Curtin University, [2]University of Witwatersrand, [3]Edith Cowan University

We will present novel data about activity accumulation patterns in clinical populations. Pain and other symptoms limit the ability of people with chronic conditions such as Human Immuno-Deficiency Virus (HIV), cancer or a musculoskeletal disorder to move normally, and as a result everyday physical activity (PA) levels are reduced. Information about the activity behaviours in these populations has been gathered from self-report or physician assessed measures. Detailed information about the daily, spontaneous PA patterns in people with chronic conditions is limited. Accelerometry can aid the measurement of debilitating effects of chronic conditions and can detect effects of physical, surgical, or pharmacological interventions outside the laboratory or hospital setting, in community dwelling people. We aim to: summarise current evidence regarding the clinical utility of accelerometry in people living with chronic conditions; extend current evidence concerning the role of PA and sedentary behaviour accumulation patterns in relation to health outcomes in clinical populations; and discuss future research directions for the use of 24 hour accelerometry measurements in clinical populations. Format: Dr Rebecca Meiring will focus on the assessment of functional outcomes in patients with musculoskeletal disorders using accelerometery. Dr Antonia Wadley will discuss the dissociation between chronic pain and PA in people living with HIV. Dr Carolyn McIntyre will demonstrate the utility of accelerometry in malignant pleural disease and its potential role in research and clinical practise for people living with

cancer. Prof Leon Straker will lead the discussion with a summary of the collective evidence of the clinical utility of accelerometry in special populations.

2:45 – 3:45 Speakers and Abstracts

Kirschstein Auditorium: Utility of Consumer Devices

Session Chair: Genevieve Healy (The University of Queensland, School of Public Health)

Measuring Physical Behavior: Insights from Device Manufacturers and Academic Research Laboratories

Kate Lyden (Invited Speaker) KAL Research & Consulting | University of Massachusetts, USA

Which heart rate-based monitor is better: Apple Watch or Fitbit Charge HR?

Yang Bai[1], Gregory Welk[2], Paul Hibbing[3], Konstantinos Mantis[2]
[1]University of Vermont, [2]Iowa State University, [3]University of Tennessee

PURPOSE: The purpose of this investigation was to examine the validity of energy expenditure (EE), steps, and heart rate measured with the Apple Watch series 1 (Apple Watch 1) and Fitbit Charge HR. METHODS: Thirty-nine healthy adults wore the two monitors on the left wrist while completing a semi-structured activity protocol consisting of 20 minutes of sedentary activity, 25 minutes of aerobic exercise, and 25 minutes of light intensity physical activity (5-minute breaks between each session). Criterion measures were obtained from an Oxycon Mobile metabolic system for EE, a pedometer worn on the waistline for steps, and a Polar heart rate strap worn on the chest for heart rate. The participants had the flexibility to self-select the type of activity they performed under each condition. RESULTS: For estimating whole-trial EE, the mean absolute percent error (MAPE) from Fitbit Charge HR (32.9%) was more than twice that of Apple Watch (15.2%). This trend was consistent for the three separate conditions, with the Apple Watch showing lower MAPE (18.2% ~23.4%) than Fitbit Charge HR (34.6% ~61.2%). Both monitors accurately assessed steps during aerobic activity (MAPEApple: 6.2%; MAPEFitbit: 9.4%) but overestimated steps in light physical activity. For heart rate, Fitbit Charge HR produced its smallest MAPE in sedentary behaviors (7.2%), followed by aerobic exercise (8.4%), and light physical activity (10.1%), each of which were statistically equivalent with the Polar heart rate sensor to within 10%. CONCLUSION: The Apple Watch 1 had stronger validity than the Fitbit Charge HR for assessing overall EE and steps during aerobic exercise. The Fitbit Charge HR provided heart rate estimates that were statistically equivalent to Polar heart rate monitor.

Criterion Validity of Consumer and Research Grade Activity Monitors During Brief, Intermittent Walking Bouts

Lindsay Toth[1], Paul Hibbing[1], Susan Park[1], Alvin Morton[1], Whitney Pittman[1], Damla Sarisaltik[1], Andrew Kaplan[1], Scott Crouter[1], David Bassett[1]
[1]The University of Tennessee Knoxville

Introduction: To avoid counting movement artifacts as steps, some activity monitors require several consecutive seconds of stepping before steps are retroactively counted towards the total step accumulation. Purpose: To study how algorithms in different activity monitors affect the number of

steps recorded during brief, intermittent walking bouts when the walking interval or rest interval is manipulated. Methods: Participants (n=21; 19-57 years) wore StepWatches on the ankle, the Fitbit Zip, New Lifestyles Digi-Walker SW-200, Omron HJ-322U, and ActiGraph GT3X on the hip, and the Fitbit Charge, Garmin Vivofit 2, Polar A360, Withings Pulse Ox and ActiGraph GT3X on the wrist. Part A: 5 trials where participants walked 4, 6, 8, 10, or 12 steps followed by 10 s standing rest. Part B: 6 trials where participants walked 4 steps followed by 1, 2, 4, 6, 8, or 10 s standing rest. Cadence was 100 steps/min and each trial lasted 2 min. Hand-counted (HC) steps served as the criterion. The data for each device were reported as percent of actual steps. Results: In Part A, the StepWatch, Digi-Walker SW-200, and ActiGraph GT3X with low frequency extension (LFE) (hip and wrist) were within 6.2% HC steps. The ActiGraph GT3X with moving average vector magnitude (MAVM) (hip and wrist) and Polar A360 required extremely long bouts (>12 steps) of continuous walking, so almost no steps were recorded. All other devices required 6-10 steps to be taken before recording (See Figure 1). In Part B, for most of these devices, even 1-2 s rest was sufficient to break up a walking bout, resulting in a failure to record steps. Conclusion: Some activity monitors use step-counting algorithms that screen out steps taken in short walking bouts. Since brief intermittent walking bouts are common in daily life, the inability of activity monitors to record every step is likely to be a major source of error contributing to the undercounting of steps taken throughout the day.

Auditorium A: Physical Activity Measurement in Youth

Session Chair: Alan Donnelly (University of Limerick)

EASY - An Instrument for Surveillance of Physical Activity in Youth

Russell Pate[1], Kerry McIver[1], Michael Beets[1], Marsha Dowda[1]
[1]University of South Carolina

There is a need for a self-report instrument, with sound psychometric properties, for monitoring compliance with physical activity guidelines in youth. This study aimed to develop such an instrument by applying Item Response Theory as well as traditional methods for assessing validity and reliability. Focus groups, conducted with 162 middle school students, identified 30 forms of physical activity that are highly prevalent in that age group. These activities were incorporated into three preliminary forms of a self-report instrument. The three formats were: yes/no for participation in each activity during the previous seven days; yes/no plus the number of days (1-7) on which the activity was performed; and yes/no, frequency (1-7) and intensity (1-4). Middle school students (n=537) were randomly assigned to complete one of the three instruments. Rasch analysis was applied to the responses to the three formats, and the yes/no plus frequency format was identified as the preferred format. This instrument was completed twice by an independent sample of 342 middle school students at the end of a seven day period during which they had worn an accelerometer. Associations between responses to the individual items and objectively measured moderate to vigorous physical activity (MVPA) resulted in selection of six items for inclusion in the final instrument. Six more items were included on the premise that they should be queried in a surveillance system. Three additional items were included on the basis of a Rasch analysis. This produced a fourteeen item instrument, and responses to this instrument were found to be highly reliable (r=0.91) and demonstrated acceptable concurrent validity when associated with objectively measured MVPA (r=0.33).

Full day arm movement patterns across early infancy

Beth Smith[1], Ivan Trujillo-Priego[1], Joanne Shida[1], Christianne Lane[1]
[1]University of Southern California

Background. Our goal is full day monitoring with wearable sensors to determine quantity, type, and quality of infants' limb movements. This is part of our larger aim to detect deviation from healthy brain function and development in early infancy. Full-day assessment is desirable due to high variability in infant performance and temperament. Here we present preliminary, proof-of-concept results from infants with typical development. Method. Twenty infants with typical development participated, recruited from Los Angeles area healthcare providers. Infants were between 1-7 months of age and participated in 3-6 visits each, monthly, across the development of reaching. We collected a reaching skill assessment and full day arm movement data from wearable sensors (Opals, APDM Inc.), anthropometrics, and the Bayley Scales of Infant Development (3rd edition). We used a custom algorithm to identify the start and stop of each arm movement bout produced across a full day, as well as the duration and average acceleration of each bout. Results. Duration of arm movement bouts (in s, Fig. 2) decreases while number of bouts (Fig. 3) increases linearly and average acceleration (in m/s2, Fig. 4) increases quadratically. Figures 5 and 6 show Bayley composite motor and cognitive scores. Preliminary analyses support that movement characteristics themselves do not predict Bayley scores but that larger change in movement variables across visits is related to higher cognitive development scores at a visit. Discussion and Conclusion. Full-day arm movement characteristics change in an expected way across development, however there is variability in individual infant trajectories and this may be an important feature to consider. This work represents the first step in creating norms for infants with typical development by describing the means and variability of our measures. We will continue to analyze these data and will expand to infants at risk for development delay.

All days, most days or an average: Operationalizing the current physical activity recommendation for children and youth

Rachel Colley[1], Valerie Carson[2], Didier Garriguet[1], Ian Janssen[3], Karen Roberts[4], Mark Tremblay[5]
[1]Statistics Canada, [2]University of Alberta, [3]Queen's University, [4]Public Health Agency of Canada, [5]Children's Hospital of Eastern Ontario Research Institute

Background: Despite between-country consistency in the moderate-to-vigorous physical activity (MVPA) recommendation for children and youth (i.e., 60 min/day), there is variation in how this benchmark is assessed, limiting comparability between studies and across jurisdictions. The aim of this study was to draw attention to the implications of using various operational definitions. Methods: This analysis is based on 4,308 children and youth (aged 6 to 17 years) from the Canadian Health Measures Survey. Participants wore an Actical accelerometer for 7 days. Four definitions of adherence to the 60 min/day MVPA benchmark were compared: all days (accumulating 60 min of MVPA on 4/4, 5/5, 6/6 or 7/7 days per week), at least 6 out of 7 days, most days (accumulating 60 min of MVPA on 70% of valid days), and an average of 60 min of MVPA across valid days. Results: When an operational definition corresponding to all or most days was used, the prevalence of adherence was generally at or below 10% (Fig. 1). When using an average operational definition, the prevalence of adherence ranged between 28 and 41%, depending on the survey cycle. The average daily MVPA of respondents who met the 60-minute MVPA target on all or almost all days ranged between 108 and 122 minutes per day while the average daily MVPA of respondents who met the 60-minute MVPA target on most days or on average ranged between 82-91 minutes per day. About a quarter of children and youth whose average daily MVPA was

greater than or equal to 60 minutes accumulated 60 minutes of MVPA on 7/7 days and > 80% accumulated 60 minutes of MVPA on at least 3 days out of 7. Discussion: Caution should be applied when between-study comparisons are being made unless harmonization in methods and operational definitions is confirmed.

Auditorium B: Ambulation in Older Adults

Session Chair: Jorunn Helbostad (Norwegian University of Science and Technology)

How much does healthy gait change when moving away from a laboratory?

Fabio Storm[1], Fabio Storm[1], Claudia Mazzà[1]
[1]University of Sheffield

It can be hypothesised that moving from a laboratory to a daily life context would change both mechanical and control aspects of gait. These changes, however, have not been fully quantified and normative data to facilitate their understanding are lacking. This study aimed at determining the impact of walking in different environments on various parameters on both upper and lower body movements. Five Inertial measurement units (IMUs, APDM), were located on both ankles, L5, C7 and head of 18 healthy participants (13 males, 28 ± 3 years). Triaxial accelerations and angular velocities were recorded from four walking tasks: straight laboratory and outdoor walking, and unconstrained indoor and community walking. Gait temporal parameters and their variability and upper body movement descriptors (magnitude, smoothness, harmonicity, attenuation, regularity and symmetry) were obtained from validated algorithms and a two-way repeated measures ANOVA (p=0.05) was used to test the effects of walking condition and environment. Mean stride, step, stance, swing and single support durations were not markedly affected by moving from the lab to community (1.3%-3.4% changes), while, as expected, their variability was much higher (32.5%-39.9% increase) when recorded from unconstrained conditions. The ability to control the upper body movements was challenged by unconstrained outdoor walking, for example lower harmonicity (-15.8%) and smoothness (-29.%). These results showed that, even for healthy participants, gait is significantly impacted by condition and environment, with walking quality being reduced in habitual environments. As values obtained from different settings cannot be used interchangeably, normative values about changes in healthy gait provided by this study can help when investigating similar environments and gait conditions. This is critical if free-living gait variables are to be used for biomarkers in pathological populations where differences are likely exacerbated.

Turning at home and during community ambulation in Parkinson's disease: a new measure of fall risk?

Martina Mancini[1], Aner Weiss, Talia Herman, Fay Horak, Jeff Hausdorff
[1]Oregon Health & Science University

Difficulty turning during gait is a common problem in people with Parkinson's disease (PD) and leads to significant disability, falls, and loss of function. We hypothesized that quality, rather than quantity, of turning during daily life would be related to falls in PD. Ninety-five subjects with PD (age: 65±9 yrs; Motor UPDRS ON: 34.2±12.3) wore a DynaPort hybrid sensor (McRoberts) on the lower back for 3 days. An algorithm identified periods of walking (longer than 10 sec) and calculated the following metrics to characterize turning that occurred during walking (mean and coefficient of variation, CV): 1) number of turns in each 30 min period, 2) angle amplitude, 3) duration, 4) angular velocity, 5) medio-lateral (ML)

jerk and 6) ML jerk range. Based on self-report of falls that occurred 12 months after testing, participants were grouped as fallers (two or more falls N=26) or non-fallers (N=69). One-way ANOVA evaluated differences between future fallers and non-fallers. Turning duration and its CV, turn velocity CV, ML jerk and range were positively associated with UPDRS-motor scores (r-values: 0.22 to 0.55, p-values: 0.03 to <0.0001), but number of turns was not. Number of turns (20±10/30min non-fallers, 19±11/30min fallers) was similar, but fallers had a lower mean angle compared to non-fallers (92±5° vs 89±7°, p=0.04). Jerk (0.36±0.03 vs. $m^2/s5$ vs. 0.29±0.01$m^2/s5$, p=0.004) and range (0.29±0.009 m/s^2 vs. 0.27±0.005m/s^2; p=0.02) were higher in the fallers, compared to non-fallers. Interestingly, when correcting for UPDRS-motor scores, only the ML jerk and range still differed between fallers and non-fallers. These findings suggest that continuous monitoring of turning during daily activities among patients with PD is related to disease severity and might be useful in predicting future falls. Although the number of turns was the same, fallers showed an impaired medio-lateral control of turning.

Investigating the intervening effect of hospitalizations on physical activity patterns measured by accelerometry

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The effect of hospitalizations on subsequent patterns of sedentary and total physical activity (TPA) time was examined in older adults participating in a long-term physical activity trial. Participants (79+/-5 years) were randomized to either a physical activity (PA) or health education (HE) intervention. They wore a hip accelerometer at baseline (BL) and 6, 12, and 24 months. Accelerometer patterns were characterized as bouts (defined as consecutive minutes) of sedentary (<100 counts/min; 1+, 10+, 30+, 60+ lengths) and TPA (100+ counts/min; 1+, 2+, 5+, 10+ lengths) time. Each participant was categorized as having no hospitalizations (0 hospital days), a short cumulative hospital duration (1-3 days), and a long cumulative hospital duration (4+ days) within BL-6, 6-12, and 12-24 month intervals. Of 1,341 participants, 358 (27%) experienced at least one hospitalization. Following a hospitalization, both PA and HE participants had more sedentary time as compared with those not hospitalized (8 and 16 minutes/day for short and long durations, respectively, p<0.001). Only long durations were associated with increases in prolonged (10+ minutes) sedentary bouts (+20 to +22 minutes, p<0.05). Short and long hospital durations were negatively associated with TPA bouts <10 minutes (1+: -7 and -16 minutes; 2+: -5 and -11 minutes; 5+: -3 and -4 minutes, p<0.05). The hospitalized PA group had less sedentary time in shorter bouts (<30 minutes, -8 to -10 minutes, p<0.05) and more daily time across all TPA bouts (+3 to +6 minutes, p<0.01) than those hospitalized in HE. Hospitalizations negatively impact subsequent patterns of daily sedentary/TPA time. Activity bouts lasting 10+ minutes were resistant to hospitalizations. Despite a hospitalization, PA participants decreased short sedentary bouts and increased longer activity bouts. Closely monitoring activity patterns may help identify interventions to assist older adults recovering from a hospitalization.

Alterations in Community Stepping and Step Quality among Older Adults with Mild Cognitive Impairment

Jeffrey Hausdorff[1], Shiran Shustak[1], Inbar Hillel[1], Silvia Del Din[2], Esther Bekkers[3], Elisa Pelosin[4], Freek Nieuwhof[5], Anat Mirelman[1], Lynn Rochester[6]

[1]Tel Aviv Sourasky Medical Center, [2]Newcastle University, Newcastle upon Tyne, [3]KU Leuven, [4]University of Genova, [5]Radboud university medical center, [6], Newcastle University, Newcastle upon Tyne

Background: Recent work demonstrated that the gait pattern of people with mild cognitive impairment (MCI) differs from that of age-matched cognitively intact controls (CIC) and, in general, that walking ability, as measured in the clinic, may not reflect actual daily performance. We evaluated if the amount and quality of daily-life walking differs in older adults with MCI, compared to CIC. Methods: The inclusion criteria were (1) age 60-90 years, (2) able to walk at least 5 minutes unassisted, (3) stable medications, and (4) >2 falls in the past 6 months. Subjects with MCI were included if they scored 0.5 on the Clinical Dementia Rating Scale. To assess step quantity and quality, subjects wore a tri-axial accelerometer on the lower-back for 7 days. Results: Age and gender were similar ($p>0.10$) in MCI (n=36, 77.83±6.42 yrs; 27.77% men) and CIC (n=100, 76.01±6.15 yrs; 22% men). As expected, Montreal Cognitive Assessment (MoCA) scores were lower ($p<0.001$) in MCI (21.31±4.05), compared to CIC (25.81±2.64). Steps per day were lower ($p=0.004$) in MCI (6932.11±3571.79), compared to CIC (9225.69±4132.41). Seven-day walking time was also lower ($p=0.003$) in MCI (12.8±5.7 hrs), compared to CIC (16.5±6.5 hrs). Within-bout walking (e.g., stride regularity) was less consistent ($p=0.024$) in MCI (0.51±0.14), compared to CIC (0.58±0.14). Similarly, in the frequency domain, the peak amplitude of the vertical acceleration was smaller ($p=0.015$) in MCI (0.62±0.21g), compared to CIC (0.72±0.21g). After adjusting for MoCA scores, group differences in stepping quantity and quality were no longer significant ($p>0.320$), supporting the idea that cognitive function mediated the group differences. Conclusions: Older adults with MCI walk less and with a more variable walking pattern, as compared to cognitively-intact subjects matched with respect to age and gender. These findings extend previous clinical work and suggest that MCI affects the quantity and quality of community ambulation.

Auditorium C: Physical Activity in Cardiovascular Disease Populations

Session Chair: Mary Evans (National Institutes of Health)

Unfavourable physical behaviour in persons with aneurysmal subarachnoid hemorrhage: in-depth objective measures of physical activity and sedentary behaviour.

Wouter Harmsen[1], Gerard Ribbers[1], Majanka Heijenbrok - Kal[1], Johannes Bussmann[1], Emiel Sneekes[1], Ladbon Khajeh[2], Fop van Kooten[2], Sebastiaan Neggers[2], Rita van den Berg - Emons[1]
[1]Rijndam Rehabilitation Institute, [2]Erasmus MC

BACKGROUND: Aneurysmal subarachnoid hemorrhage (a-SAH) is a potential life-threatening stroke. Those who survive are likely to regain functional independence. However, many cannot resume their previous daily activities, making them at risk for unfavourable physical behaviour. The present study examines measures of physical behaviour, with separate attention for physical activity (PA) and sedentary behaviour (SB), six months post a-SAH. METHODS: Physical behaviour was objectively measured with the VitaMove activity monitor which consists of 3 individual, wirelessly connected accelerometers. The aim was to cover three consecutive weekdays. Total time spent in PA (walking, cycling, running and non-cyclic movement) and in SB (sitting and lying behaviour) was determined. In-depth analyses were done to determine the accumulation and distribution of PA and SB. Binary time series were created from which the mean bout length and fragmentation index were calculated. Measures of PA and SB in patients were compared to that of healthy controls. RESULTS: 33 patients with a-SAH and 18 controls participated. Patients with a-SAH spent 105min/24h being physically active, which

was 35min/24h less than controls (p<0.01). For PA, mean bout length was shorter in patients with a-SAH (12.0s vs. 13.5s, p<0.01), and fragmentation index was higher (0.053 vs. 0.041, p<0.01) compared to controls. Total sedentary time did not differ between groups (514min vs. 474min, p=0.29). For SB, mean bout length was longer in patients (122.3s vs. 80.5s, p<0.05), whereas fragmentation index did not differ from controls (0.0032 vs 0.0036, p=0.40). DISCUSSION: Patients with a-SAH have unfavourable physical behaviour; they are less physically active, they break their PA time into shorter periods, and their SB periods last longer compared to controls. Since unfavourable physical behaviour is a risk factor for poor health, interventions seem necessary, and should target both PA and SB in patients with a-SAH.

Exploring free living physical activity profiles: Beyond step count.

Danny Rafferty[1], Jason Gill[2], Lorna Paul[2]
[1]Glasgow Caledonian University, [2]University of Glasgow

Introduction: It is common in the literature to describe physical activity (PA) as the number of steps taken in an average day. When using accelerometers to objectively measuring free living PA a rich data set is available that goes beyond a simple volume count, allowing a more detailed exploration of PA patterns. Understanding these patterns of PA potentially allows the development of targeted treatment strategies and/or a more detailed exploration of the effects of interventions. Methods: 22 stroke survivors (10 men, age 55.3 ± 9.9 years; 4.2 ± 4.0 years since their stroke) were recruited from local stroke support groups, and 22 controls were matched for sex, age and body mass index. All participants wore an ActivPALTM physical activity monitor for seven days and from these data activity profiles, including the number of steps per day, time spent sedentary and time in different cadence bands, were recorded. Results: Stroke survivors took significantly fewer steps per day than controls (4035 ± 2830 steps/day vs 8394 ± 2941 steps/day, p<0.001) and sedentary time (including sleep time) was significantly higher for stroke participants compared to controls (20.4 ± 2.7 hours vs 17.5 ± 3.8 hours, p<0.001). People living with stroke spent similar amounts of time with cadences between 20 - 79 steps per minute (Sporadic through to slow walking) but significantly less time making incidental movement i.e. with cadences between 1 - 19 steps per minute.(Figure 1). Discussion & Conclusion: These results suggest that specifically targeting incidental movements in this patient group may have merit to increase the amounts of PA undertaken and reduce the amount of sedentary time. Objectively measured PA should be more fully explored to help understand PA behaviours and effectiveness of interventions.

Quantifying the sit-to-stand and stand-to-sit transition from free-living data

Chris Pickford[1], Andy Kerr[2], Malcolm Granat[1]
[1]University of Salford, [2]University of Strathclyde

Background: Standing and sitting are two of the most demanding and common physical manoeuvres that an individual performs and are important for maintaining functional independence. Their deterioration may indicate the onset of frailty, and physical and cognitive decline, as well as acting as a benchmark for rehabilitation. Currently, there is a paucity of reports on robustly quantifying these transitions in free-living conditions. We aimed to quantify sit-to-stand (Si-St) and stand-to-sit (St-Si) transitions using accelerometer data and determine whether healthy volunteers could be distinguished from stroke survivors using peak velocity of the transitions. Methods: Free-living Si-St and St-Si acceleration data were recorded from 21 healthy volunteers and 33 stroke survivors using activPAL3 monitors over a one-week period. Pitch was calculated from raw 3-axis accelerometer data, and the

velocity vector derived. Individual mean velocities were compared between populations using t-tests. Results: A total of 10454 transitions (Si-St and St-Si combined) and 11237 transitions were recorded in healthy volunteers and stroke survivors, respectively. Healthy volunteers had significantly higher overall mean peak velocity for either transition compared with stroke survivors (healthy, ~75 deg/sec versus stroke, ~45 deg/sec; Si-St, $p<0.01$ and St-Si, $p<0.01$). Peak velocity of transition was associated with increased variation in peak velocity across both groups (Figure). Discussion: Si-St and St-Si transitions could be quantified using accelerometer data, and there were significant differences in the peak velocity of each transition between the groups. Furthermore, variation in an individual's peak velocity may be associated with the ability to perform these transitions. This methodology could be used to monitor decline in functional ability and also determine the effectiveness of an intervention.

Identification and measurement of ambulatory activity after stroke using Real Time Location technology

Arshi Iqbal[1], Allison Cooper[2], Przemyslaw Woznowski[3], Claire Butterworth[4], Christopher Rees[5], Alun Preece[6], Robert van Deursen[6]
[1]Royal Bournemouth Hospital, [2]Swansea University, [3]University of Bristol, [4]University Hospital Llandough, [5]University Hospital of Llandough, [6]Cardiff University

Introduction: A new automated system was developed in Cardiff to measure several activities relevant to mobility and rehabilitation. The system reliably provides continuous tracking of a large number of wireless sensors with minimal disruption of clinical routine. The aim of this report was to explore ambulatory activity of patients admitted in the stroke rehabilitation unit. Method: Infra-red room locators were placed in all rooms of a 24-bedded stroke unit. Participants wore generic Radio-Frequency Identification sensors on the unaffected wrist. These sensors were also tied around their walking aids, wheelchairs and other transport equipment. All sensors transmitted their location and movement signals to a computer. Data was analysed using bespoke software. Descriptive statistics are reported here. Results: Data was collected from 47 patients (F= 39, M=8; Mean age=78±11 years) for an average of 58 ±40 days. The median Functional Ambulation Category score was 1 on admission and 3.5 on discharge. Three main types of ambulation were detected: 1) transport with a Sara® Stedy/hoist, 2) wheelchair use and 3) walking with a designated Zimmer frame or stick. Patients using type 1 and 3 in combination (n=21) and those using only type 3 (n=6) seemed to have the longest duration of ambulation (mean= 14minutes/day) followed by those using all 3 types (n=6; mean duration=10 minutes/day). Duration of ambulation for patients using types 1and/or 2 appeared low (n=16; mean≤7minutes/day). Figure 1 shows the variation in the weekly duration and pattern of ambulation for an individual patient from admission to discharge. Discussion: With an increase in the use of wearables, a generic sensor based system utilising information from the wearer in combination with information from their environment is a promising approach to measure activity in a real-world setting. This could further inform rehabilitation research and clinical practice for functional recovery post stroke.

4:00 – 5:00 Keynote Presentation

Jennifer Hicks, Stanford University, CA, USA

Planetary Scale Smartphone Data Reveal Relationships Between Physical Activity, Environment, & Health

The rise of consumer fitness trackers, smartphones, and smart watches offers an unprecedented opportunity to examine physical activity in free-living populations worldwide. The Mobilize Center, an NIH BD2K Center of Excellence at Stanford University, is analyzing movement data from 6 million individuals in over 100 countries around the world using a smartphone app for activity and health tracking. This analysis has revealed new insights about physical activity levels around the world and what factors are predictive of these activity levels. Further, we are developing a new methodological framework for studying health behaviors, like physical activity, using messy, but massive datasets.

Thursday, June 22, 2017

8:30 – 10:00 Keynote Presentations: Devices in Very Large Cohorts

Nick Wareham, Director MRC Epidemiology Unit, University of Cambridge
Measuring physical activity objectively in the UK Biobank study

Technological advances now make it possible to collect and analyse objective physical activity day in very large cohort studies. The UK Biobank study has recruited 500,000 participants to a prospective cohort study. A team selected an approach for objective physical activity measurement and oversaw the implementation of 7-day wrist-worn accelerometery measurement in 103,712 people. In order to assist analyses, a core set of derived variables have been computed focusing on overall activity and intensity distribution. These summary variables are part of the UK Biobank dataset and can be used by researchers as exposures, confounding factors or outcome variables in future analyses.

Heiner Boeing, German Institute of Human Nutrition, Berlin, Germany
7-day accelerometry in the German Health Study (National Cohort)

The German Health Study is a recent (2012) established initiative of German epidemiologist that intend to generate a scientific public resource for epidemiologic and public health research. For this purpose 200,000 study participants will be recruited for a long term cohort study until 2019 and first repeated measurements conducted until 2023. The study protocol consists of questionnaires and physical examinations including bio-banking covering a large range of exposures and functional status. Physical activity is a major exposure and addressed by questionnaires and motion devices. For assessment of movements over 7 complete days the actigraph GT3x was chosen. In this talk, the process how to select the device will be descripted as well the experience with this device in the study conduct including data transfer and management. The results of the quality assurance program will be shared as well the strategy presented how to establish analysis routines for the raw data.

James McClain, National Institute of Health, USA
Participant Technology and Assessment in the All of Us Research Program: Current Status and Future Innovations

10:15 – 11:15 Speakers and Abstracts

Kirschstein Auditorium: Analytic Approaches and Metrics

Session Chair: Søren Brage (University of Cambridge)

Use of Mean Amplitude Deviation as an Approach to Acceleration Data Processing – Experience from Finnish Population Based Studies

Tommi Vasankari (Invited Speaker) UKK-instituutti, Finland

Objective measurements of physical activity in the Norwegian HUNT Study

Paul Jarle Mork[1], Hilde Bårdstu[1], Atle Melleby Kongsvold[1], Astrid Tessem[1], Hans Olav Hessen[1], Helge Langseth[1], Kerstin Bach[1]
[1]Norwegian University of Science and Technology

Background. The Nord-Trøndelag Health Study (the HUNT Study) is one of the largest health studies ever performed. It is a unique database of personal and family medical histories collected over three intensive surveys (HUNT1 in 1984-1986, HUNT2 in 1995- 1997, and HUNT3 in 2006-2008). More than 106,000 adults participated in one or several HUNT surveys. The fourth HUNT survey (HUNT4) -- starting in September 2017 -- will include one week of objective measurement of physical activity in about 50,000 adults (≥20 years) and 10,000 adolescents (13-19 years). Methods. Physical activity will be measured by small, lightweight tri-axial accelerometers placed at the lower back and on the front of the thigh. Heart rate is recorded with a chest-band in a random sub-sample (about 10% of participants). A validation study has been carried out to develop algorithms for detection of different daytime activities such as sitting, standing, walking, running and cycling. These algorithms will be extended to further sub-grouping of activities like moving while standing ("shuffling"), walking stairs and forward bending of upper body while standing. The sensor set up will also allow for identification of body movements and different postures while lying down (prone, supine and on right/left side). A second validation study is currently being carried out to investigate whether nocturnal body movements and/or changes in body position can be used to identify sleep-wake cycles as recorded by polysomnography. Discussion. We envisage that the objective measurements of physical activity in HUNT4 will open for exciting research that will provide new and important insights into the relation between physical activity, health and well-being. The technical solutions, analytic approach and possibilities for research based on the HUNT data material will be presented.

Clustering algorithms for recognition of ADL performed with upper limbs

Arturo Vega-Gonzalez[1], Sergio Parra-Sanchez[1], Juan Manuel Gomez Gonzalez[2], Irais Quintero Ortega[1], Mayra Cuellar-Cruz[3], Birzabith Mendoza-Novelo[1], Jose Jorge Delgado-Garcia[1]
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INTRODUCTION A number of Activities of Daily Living (ADL) are performed with upper limbs, those related to feeding, communication and grooming are parameters of independence. There are studies on ADL in a free-living environment using inertial sensors, but low recognition rate of functional activities is a persistent. Recently, the use of the vertical displacement of the wrist related to the shoulder has

shown better results. Our aim is the evaluation of clustering techniques for the upper-limb functional-activity recognition. The target activities include eating, drinking, talking by phone, write on computer, brushing teeth and combing hair. METHODS Eight healthy subjects wore a sensor able to record the kinematics of the wrist while performed a set of ADL. Data was low-pass filtered (10 Hz). Fourteen statistical and kinematic features were extracted from data and reduced to five by using Principal Components Analysis, pursued by the following clustering techniques: k-means, DBSCAN, normalized and no-normalized spectral clustering (considering full-connected graphs with a Gaussian kernel). Additionally, a random test was done using Monte Carlo considering Fowlkes and Mallows, Rand, Jaccard, separation, cohesion, silhouette and V-measure evaluation coefficients. RESULTS AND DISCUSSION Random test indicates a non-random structure of data for all algorithms (C.I. 95%). The best algorithm was the k-means with recognition score up to 90%. Spectral algorithm showed the lowest score (for the parameters used). DBSCAN showed that data space is density-in-homogeneous. Results suggest that clustering can be used to recognize functional tasks. CONCLUSIONS K-means algorithm can group activities belonging to the same aim making easier the recognition process. The clustering can be used as a pre-processing step. ACKNOWLEDGEMENTS DAIP-UGTO 1146/2016 and PAPIME PE104715.

Auditorium A: Consumer Device Applications in Research

Session Chair: David Bassett (University of Tennessee, Knoxville)

Does Stress Influence the Volume and Pattern of Sedentary Behavior? Group and Person (N of 1) Level Results of a 1-Year Observational Study among Healthy Adults

Keith Diaz[1], Anusorn Thanataveerat[1], Faith Parsons[1], Sunmoo Yoon[2], Ying Kuen Cheung[2], Carmela Alcantara[2], Andrea Duran[1], Ipek Ensari[1], David Krupka[1], Joseph Schwartz[1], Matthew Burg[3], Karina Davidson[1]
[1]Columbia University Medical Center, [2]Columbia University, [3]Yale University School of Medicine

BACKGROUND: Excessive sedentary time is ubiquitous in Westernized societies and is associated with deleterious health outcomes. Few data exist examining the daily determinants of sedentary behavior. Using mobile technologies to collect continuous data over 1-year, the purpose of this study was to examine the association of daily stress with the volume and pattern of objectively-measured sedentary behavior in healthy adults. METHODS: Data were collected from an observational study of healthy adults (N=79; 43% male, mean age: 32±9 years) who were studied for 365 days. Sedentary behavior was objectively measured using a wrist-based Fitbit Flex. The volume (total sedentary time [min/day]) and pattern (mean sedentary bout duration [min/bout], a measure of accumulation of sedentary time in prolonged, uninterrupted bouts) of sedentary behavior were quantified at the day-level. An electronic diary that used the participant's own smartphone was used to assess daily stress (i.e., response to 'overall, how stressful was your day?'; prompt on a 0-10 Likert scale). A random coefficients linear mixed model was used to predict sedentary behavior characteristics from the end-of-day stress rating. RESULTS: The end-of-day stress rating was not associated with the volume (B=0.00, p=0.996) or pattern (B= -0.02, p=0.574) of sedentary behavior. There was, however, a high degree of inter-individual variability in the relationship between end-of-day stress rating and mean sedentary bout duration (p<0.001; see Figure). High end-of-day stress ratings were significantly associated with greater mean sedentary bout duration for some (n=6), with lower mean sedentary bout duration for others (n=8), and was not associated with mean sedentary bout duration for the remainder (n=65). CONCLUSION: The

influence of daily stress on sedentary behavior on a given day varies from person to person. A precision medicine approach may be warranted to target reductions in sedentary time.

Accuracy of consumer physical activity trackers for measuring step counts: comparison against a validated waist-worn pedometer

Charlotte Edwardson[1], Melanie Davies[1], Kamlesh Khunti[1], Tom Yates[1], Alex Rowlands[1]
[1]University of Leicester

Purpose: Research on the accuracy of consumer activity trackers for measuring free-living physical activity is lacking. The aim is to compare the accuracy of consumer wrist-worn activity trackers for measuring steps, when worn on the non-dominant and dominant wrist, against a validated pedometer. Methods: Participants wore six wrist activity trackers (Fitbit Flex, Garmin Vivofit3, Jawbone UP24, Polar Loop, MiBand, Aquarius) and a waist-worn pedometer (New-Lifestyles NL-800) concurrently for two waking days. On day 1, three trackers were worn on the non-dominant (ND) and three on the dominant (D) wrist. On day 2 the trackers were worn on the opposite wrist. At the end of each day the number of steps from each device was recorded. Accuracy of the trackers, relative to the pedometer, was assessed using mean absolute percent error (MAPE), equivalence testing and Bland-Altman limits of agreement. Results: 25 participants were included (64% female, mean age=33.1 (SD=9.1) years, BMI=23.8 (SD=2.5) kg/m^2). MAPEs, in ascending order, were 10.0% (MiBand ND), 10.9% (Fitbit ND), 11.9% (MiBand D), 12.5% (Jawbone ND), 12.7% (Garmin ND), 13.7% (Garmin D), 14.7% (Jawbone D), 15.2% (Fitbit D), 17.4% (Polar Loop ND), 18.6% (Aquarius ND), 24.6% (Polar Loop D), 28.2% (Aquarius D). Equivalence testing showed that none of the tracker 90% CI estimates were completely within the 10% equivalence zone (Figure 1). Bland-Altman analysis revealed that the FitBit ND, Garmin D, MiBand ND and D and Jawbone D all had a low mean bias (<500 steps). However, 95% limits of agreement were wide for all devices, the MiBand ND had the narrowest (difference=4356 steps). Discussion and conclusion: The accuracy of physical activity trackers varied, some overestimated and some underestimated steps. Trackers worn on the non-dominant, rather than dominant, wrist were more accurate. Overall, the MiBand appeared to be the most accurate and the Polar Loop and Aquarius least accurate.

Consumer Wearable Activity Trackers as Behavioural Interventions and Continuous Monitoring of Physical Behaviours - Lessons from ACTIVATE Trial

Nga Nguyen[1], Brigid Lynch[1]
[1]Cancer Council Victoria/University of Melbourne

Commercial wearable activity trackers (WATs) have potential utility as behavioural change devices and for continuously collecting daily physical behaviours in public health research. Here, we describe some issues and challenges related to using WATs to monitor free-living physical behaviours and support behavioural change in an intervention research, the ACTIVATE Trial. ACTIVATE Trial, which commenced recruitment in August 2016, is a randomised control trial of the Garmin Vivofit2, to improve physical activity (PA) among approximately 100 sedentary breast cancer survivors. Women are randomly assigned to either intervention group (receive a WAT and telephone counselling in 12 weeks) or waitlist control group (receive only the WAT after 12 week delay).We are developing a system to continuously monitor daily physical behaviours using the Garmin API service. We also qualitatively collect consumer feedbacks on the WAT usability via phone calls As of 10 January 2017, 42 women have been recruited. 20 have been assigned to wear the fitness band (mean age 59). The average time for WAT wear is 7

weeks. Women generally find the WAT easy to use. 90% of participants reported wearing and syncing the trackers daily. Our 24/7 monitoring system is in testing progress. We can collect the daily summary measurement of type, duration, and overtime pattern of PA and sleep duration. Some key challenges encountered during the trial include: (1) difficulties in getting Garmin to transfer the data to our server due to the upgrade to a new API; (2) limited Garmin technical support; and (3) three participants reported technical problem when syncing the WAT with smartphone. Data storage and effective data management are under development. WATs are perceived as useful and feasible by breast cancer survivors in free-living conditions. Understanding implementation challenges and steps to address them in the ?real world? are essential for effectively integrating WAT into large-scale health research

Auditorium B: From the Lab to Free-Living

Session Chair: Patty Freedson (University of Massachusetts, Amherst)

From bounded to pragmatic data collection: Validity of state-of-the-art activity recognition in daily life context

Hala Abdul Rahman[1], Alexis Le Faucheur[1], Ge Di[2], Guy Carrault[2], Jacques Prioux[1]
[1]Ecole Normale Supérieure - Rennes, [2]Université de Rennes 1

Introduction-Physical activity recognition is an emerging yet challenging research area. One of the critical challenges when monitoring physical activities is data acquisition, which has to be done under unconfined realistic conditions rather than laboratory controlled states (Oscar. 2013). In this context, several works have been carried out reporting high recognition accuracy. However, existing models are all built upon controlled activities only without being analyzed under real-life conditions. To address this limitation, our work highlights a novel data collection protocol that covers various measurement sessions to test the responses of classic recognition system in discriminating real-life activities. Methods-In a triple-sessions based protocol, 5 out of 20 participants (ongoing study) wearing the BioHarness3 chest strap performed 12 different activities (Fig. 1). The standardized and semi-standardized sessions (S1) and (S2) were performed under supervision, while participants in the third session (S3) are left to freely perform their daily-life activities with the no supervisor around. Yet an Autographer camera was worn around the neck to automatically take photos of their environment. Image data were then coded and analyzed in order to extract the performed activities. Time and frequency features were extracted from windowed acceleration data. Results-As a preliminary analysis, the activities of 4 subjects in S1 were used for data training of the recognition model and then the activities segments of each session of the 5th subject were tested accordingly. The K-Nearest Neighbours model was able to correctly classify 81.1 ± 2.3%, 72.9 ± 2.2% and 41.7 ± 11.0% of activities of S1, S2 and S3 respectively. Discussion-Such significant performance degradation from S1 to S3 emphasizes our objective to bridge the gap by implementing new recognition techniques adapted to accurately recognize daily life activities while being performed in their natural environment.

Validity of a Statistical Estimation Framework for Energy Expenditure Estimation of Lab-based and Free-Living Physical Activities from a Wrist-worn Accelerometer

Meynard John Toledo[1], Qiao Wang[1], Alberto Florez Pregonero[1], Barbara Ainsworth[1], Pavan Turaga[1], Matthew Buman[1]
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BACKGROUND: An accurate assessment of sedentary and active behaviors is crucial for public health research. PURPOSE: We aimed to validate a new statistical estimation framework (SEF) to estimate energy expenditure (EE) of lab-based activities and correctly classify free-living activities from a single wrist-worn accelerometer. METHODS: Participants (N= 162) from two datasets [lab-based (n= 142, 48% males, age (mean±SD) = 34.6±9.8 years, BMI= 27.6±4.8 kg/m2) and free-living (n= 20, 50% males, age= 30.3±6.4 years, BMI= 22.7±3.2 kg/m2)] were analyzed. In the lab dataset, participants performed a random set of activities (out of 33 classes) in a 2h lab visit. In the free-living dataset, participants were observed continuously over two 8h periods while simultaneously categorizing their activities (i.e. walking, sitting, running/jogging, lying down, and standing). Lab and free-living participants wore a GENEActiv accelerometer (Activinsights, Kimbolton, UK) on the wrist and lab participants wore a Zephyr BioHarness (Medtronic, MD, USA) for EE criterion measurement. The SEF used statistical estimation theory and a linear activity classifier to estimate EE at 10-sec windows. RESULTS: The new method was more accurate than the conventional linear regression approach (mean bias= -0.012 METs, RMSE= 0.70 vs. mean bias= 0.037 METs, RMSE= 0.80) for the lab-based activities. SEF correctly classified 92.4%, 20.2%, and 83.0% of free-living stationary (i.e. sitting and standing), walking, and jogging/running events, respectively. Figure 1 shows the confusion matrices for categorizing these three types of activities. CONCLUSION: The SEF showed improved capability in estimating EE from lab-based activities and decent accuracy in classifying activity intensities in free-living conditions. The reasons for confusion between walking and stationary categories and the accuracy of this method in estimating EE of free-living activities should be explored in future studies.

What plays the determinant role in persons with dementia and sleep disturbance: Outdoor waking, evening artificial light exposure, or sleep education: A meta-analysis

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Aim: Effectiveness of outdoor waking physical activity; evening artificial light exposure; sleep education on sleep disturbance in dementia. Methods: Data collection included literature searches in data base (MEDLINE, PsycINFO, Pubmed, CINAHL) on 20 January 2016 and checked these articles. Using the terms: Waking, sleephygiene, sleepeducation, light, phototherapy, Actigraphy . Inclusion criteria of diagnosis dementia; Age > 60 years; measuring tools use actigraphy; randomized controlled trial. Excluded criteria that were. MMSE (Mini-Mental State Examination) <4分, total included meta-analysis: four articles. Results: Outdoor walking only showed increase 0.95 % sleep efficiency, reduce number of night awakening (0.78 time/day), however, the meta-analysis showed the difference is no significant. evening artificial light exposure 2,500Lux changed in increase 2.29% sleep efficiency, reduce 12.81 minutes of night awakening time, reduce 0.63 time/day of night awakening, increase 15.27 minutes of total sleep time. Outdoor walking, sleep education combination evening artificial light exposure significantly changed in increase 6.17% sleep efficiency, reduce 33.77 minutes of night awakening time, reduce 3.25 time/day of night awakening, reduce daytime sleepiness 47.79 minutes, increase 34.22 minutes of total sleep time. Conclusions: Low-intensity walking with outdoor (30-minutes) exposure is not enough to improve sleep disturbance on dementia person. Outdoor walking combination evening artificial light exposure before 2-3hour go to habitual bedtime, light intensity 2,500Lux and sleep education, be proved that significant changed their sleep quality; Outdoor walking was confirmed may be mechanism: reduce depression and anxiety; shifting of circadian rhythms; zeitgeber to external cues that synchronise

or entrain the endogenous circadian system; evening artificial light therapy to heal emotional and delay sleep onset time, reduce evening sleepiness, redevelop circadian rhythm.

Auditorium C: Approaches to Estimating Intensity in Accelerometry

Session Chair: Rick Troiano (National Cancer Institute)

Estimating relative intensity physical activity accelerometer cut-points using a maximal graded exercise treadmill test

Juned Siddique[1], David Aaby[1], Whitney Welch[1], Stephen Sidney[2], Bethany Barone Gibbs[3], Jared Reis[4], Patty Freedson[5]
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Background: Physical activity (PA) intensity is defined either in terms of absolute intensity or relative intensity. Absolute intensity refers to the energy required to perform an activity. Relative intensity refers to the level of effort based on how hard an individual is working relative to individual maximum aerobic capacity. Purpose: To develop methods for obtaining relative intensity accelerometer cut-points using data from a maximal graded exercise treadmill test. Methods: 1867 men and women aged 38 to 50 from the CARDIA Fitness Study wore Actigraph 7164 accelerometers during a maximal graded exercise treadmill test and for 1 week of normal activity in 2005-2006. Using mixed-effects regression models we regressed accelerometer counts on heart rate as a percentage of maximum (HRMAX) and on rating of perceived exertion (RPE). Based on these two models, we obtained a moderate intensity count cut-point (64% of max heart rate or an RPE of 12) for each participant. We applied these cut-points to the week of CARDIA accelerometer data. Results: The median moderate-intensity accelerometer cut-point using HRMAX was 1650 (IQR 1103-2348), and these cut-points were significantly correlated with BMI (rho=-0.18), treadmill test duration (rho=0.44), and maximum heart rate (rho=0.17). Median daily minutes of absolute and relative intensity moderate-to-vigorous PA (MVPA) was 27 min/day and 42 min/day, respectively. 33% of participants met MVPA guidelines (30 min/day) on both intensity scales, 31% met MPVA guidelines on a relative intensity scale only, 10% on an absolute intensity scale only, and 26% did not meet guidelines on either intensity scale. Cut-points based on RPE provided similar results to those based on HRMAX. Conclusion: Accelerometer-based relative intensity cut-points may be a useful new PA metric that describes PA adjusted for maximal capacity. Future work will examine the association between relative-intensity PA and incident cardiometabolic disease.

Classification accuracy of cadence cut points for discriminating moderate- and vigorous-intensity ambulation

Elroy Aguiar[1], Ho Han[1], Scott Ducharme[1], Chris Moore[1], John Schuna, Jr[2], Catrine Tudor-Locke[1]
[1]University of Massachusetts Amherst, [2]Oregon State University

BACKGROUND: Previous studies have established the strong correlation between cadence (steps/min) and intensity, with 100 steps/min emerging as a reasonable heuristic value (i.e., evidence-based, practical, rounded cut point) representative of moderate-intensity ambulation. PURPOSE: To determine the classification accuracy of cadence cut points for discriminating moderate- and vigorous-intensity ambulation. METHODS: 77 participants (51% men, mean age 30.4±5.7 years; BMI 24.9±3.4 kg/m^2) were recruited for the Cadence-Adults study (NIH/NIA #5R01AG049024-03). Participants completed a

treadmill walking test comprised of 5-min bouts at incrementally faster speeds (0.5-6 mph) with a 2-min rest between bouts. The test was terminated at the completion of the bout during which the participant began to run, achieved >75% of maximum heart rate, or reported a Borg rating of perceived exertion >13. Cadence was visually observed (steps per bout / 5-min) and intensity was measured using indirect calorimetry (metabolic equivalents, METs). A total of 620 person-bouts were included in these analyses (incomplete bouts excluded). Receiver Operating Characteristic (ROC) analysis was performed to determine the sensitivity, specificity, accuracy and area under the curve (AUC) of cadence cut points. Optimal cut points for moderate- (3 METs) and vigorous-intensity (6 METs) were identified using Youden's index. RESULTS: The optimal cut point for 3 METs was 99 steps/min (Table 1). Classification accuracy was similar for 100 steps/min (heuristic cut point). The optimal cut point for 6 METs was 120 steps/min. CONCLUSION: These results confirm that 100 steps/min is a reasonable heuristic cut point representative of moderate-intensity ambulation. Further, 120 steps/min appears to be a reasonable heuristic cut point for vigorous intensity. These heuristic values may serve as useful guidelines for shaping the intensity of ambulatory behavior and/or as cut points for accelerometer data processing.

Impact of epoch lengths on accelerometer activity intensity estimations for adults

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Introduction: Many decisions in accelerometer data collection and processing can impact physical activity indicators such as activity intensity levels. It is seldom highlighted that intensity cut points are determined at a specific epoch length, and that shorter or longer epoch lengths result in very different estimates of activity intensity. This study compares the impact of epoch length on estimates of time in moderate-to-vigorous physical activity (MVPA), light physical activity (LPA), and sedentary behavior (SB), using both tri-axial and uni-axial cut-points. Methods: The present study used real-life accelerometer data for 159 participants from the RECORD GPS study aged between 35 and 65 years, living in the French capital region, Ile-de-France. The respondents were asked to wear an accelerometer (ActiGraph GT3X) at the right hip for 7 days. Daily activity intensity levels were estimated using four epoch lengths: 1-s, 15-s, 30-s and 60-s. Results: Compared to 60-s epochs, shorter epoch lengths resulted in considerably higher estimates for MVPA and SB duration; and consequently in lower estimates for LPA. The impact of the epoch length was greater for vector magnitude compared to vertical axis indicators; and it was lower for activity duration transport compared to activity duration at the workplace and other places. The impact of epoch length on activity intensity estimates is in most cases larger than the impact of other data processing decisions. Conclusion: The findings support the call for further standardization of the data processing decisions in physical activity research. The authors strongly advice to use intensity cut-points in combination with the data processing decisions used for the respective calibration studies, including epoch length.

Parameterizing and validating existing algorithms for identifying out-of-bed time using hip-worn accelerometer data from older adults

John Bellettiere[1], Yiliang Zhang[2], Vincent Berardi[3], Kelsie Full[1], Andrea LaCroix[1], Chongzhi Di[4]
[1]University of California, San Diego, [2]Peking University, [3]San Diego State University, [4]Fred Hutchinson Cancer Research Center

Continuous 24-hour accelerometer-wear protocols enable the study of interrelations between sleep, sedentary behavior, physical activity and health. Using hip-worn accelerometer data, Tracy et al. (2014) and McVeigh et al. (2016) each developed an algorithm using data from children and adults < 23 years to distinguish in-bed time from out-of-bed time, enabling the differentiation of time in other activities from in-bed time. Broadly speaking, both procedures are decision tree-based routines that use multiple count-per-minute (cpm) thresholds to identify long periods of low activity that are indicative of in-bed time. We adapted both algorithms for older women by identifying optimal cpm thresholds and validated the algorithms using data from a sleep-log assisted visual analysis of accelerometer data. Concurrent GT3X+ and sleep-log data were analyzed for 206 women (mean±SD age 79±6) randomly selected from 6114 participants from the Objective Physical Activity and Cardiovascular Health study. For 104 women, each algorithm was implemented >80 times, each with different combinations of cpm thresholds. The algorithms were optimized by selecting the cpm threshold combination that maximized sensitivity+specificity. Data from the remaining 102 women were used to test the agreement of out-of-bed time, per woman, via measures of percent agreement, sensitivity, specificity, and Cohn's kappa. Data from 1242 days were used. The McVeigh algorithm outperformed the Tracy algorithm. Optimal cpm thresholds for the McVeigh algorithm were similar to original thresholds and results using original thresholds are presented. The McVeigh algorithm agreed with the visual analysis median (25th,75th percentile) 89% (81%,94%) of the time with sensitivity=0.91 (0.80,0.98), specificity=0.89 (0.82,0.95), and kappa=0.75 (0.58,0.85). The original McVeigh algorithm performed well compared to sleep-log assisted visual analysis and is suitable for identification of out-of-bed time among older women.

2:30 – 3:30 Special Presentation (Kirschstein Auditorium)

Deborah Estrin: Using Small Data to Personalize, Sustain and Study Health Behavior

3:30 – 4:30 Keynote Presentation

Karl E. Friedl, University of California, San Francisco, USA
Monitoring of Sleep and Other Neurophysiological Parameters Outside of the Laboratory Setting

4:45 – 6:00 Special Symposium (Kirschstein Auditorium)

Friday, June 23, 2017

8:30 – 9:30 Keynote Presentation

Mike McConnell, Verily Life Sciences, CA, USA
Use of mobile/wearable devices for research and clinical care

9:30 – 11:00 Speakers and Abstracts and Symposia

Kirschstein Auditorium: Estimating Energy Expenditure with ActiGraph

Session Chair: Dana Wolff-Hughes (National Institutes of Health)

Application of the ActiGraph GT9X IMU to Estimate Energy Expenditure

Samuel LaMunion[1], Paul Hibbing[1], David Bassett Jr.[1], Scott Crouter[1]
[1]The University of Tennessee Knoxville

PURPOSE: The newest ActiGraph device (GT9X) now includes a tri-axial gyroscope and magnetometer; however, little research has explored these functions for estimating energy expenditure (EE). Thus, the purpose of this study was to explore the use of the gyroscope and magnetometer data, in addition to the tri-axial accelerometer, for prediction of EE. METHODS: Thirty participants (mean±SD; age, 23.0±2.3 years; BMI, 25.2±3.9 kg/m2) performed 10 activities ranging from sedentary to vigorous intensity. An ActiGraph GT9X accelerometer was worn on the right hip, both wrists, and both ankles. A Cosmed K4b2 was used as the criterion measure of EE. Tri-axial accelerometer (sampled at 80 Hz), gyroscope and magnetometer data (sampled at 100 Hz) were converted to mean data per second. Resulting magnetometer values were transformed to indicate cardinal direction and summed to reflect the number of direction changes within each minute. For each variable, the mean from minutes 3-6 of each activity was used to develop the models. To examine the additive value for estimating EE, three regression models were developed: 1) acceleration only; 2) acceleration + gyroscope; and 3) acceleration + gyroscope + magnetometer. Models were developed on 70% of the sample and cross-validated using a 30% holdout sample. Root mean square error (RMSE) and mean absolute percent error (MAPE) were used to assess each model. RESULTS: In general, the addition of the gyroscope resulted in reduced RMSE and MAPE at all wear locations. For the accelerometer-only models at each wear location, RMSE (range, 1.72-1.98 METs) and MAPE (range, 36.5-43.7%) were reduced after adding the gyroscope into the models (RMSE, range of 1.32-1.55 METs; MAPE, range of 21.2-29.7%). Addition of the magnetometer into the model resulted in a negligible improvement. CONCLUSION: Adding gyroscope data improves the prediction of EE during lifestyle activities, compared to only using a triaxial accelerometer.

ActiGraph Done Six Ways

Charles Matthews[1], Sarah Keadle, Steven Moore[1], Dale Schoeller, Raymond Carroll, Richard Troiano, Joshua Sampson
[1]US NIH/NCI

Purpose. ActiGraph (AG) technology (epoch length, vertical vs. 3-d axes) and calibration methods (study designs, raw data modeling) have evolved over 20 years, but improvements in validity associated with these advances have not been described in large free-living studies. Thus, we evaluated six methods that reflect key advances in AG methodology. Methods. Participants were 683 adults (50-74 y). Criterion measures were: physical activity energy expenditure (PAEE) from doubly labeled water, active time (AT)

and sedentary time (ST) from activPAL. Devices were worn twice for 7-d, 6-months apart. We evaluated 4 methods to estimate PAEE: two PAEE prediction equations derived from 60 s epochs, 3 walk/run activities, and linear regression using vertical axis (Freedson) or vector magnitude (Sasaki); the Crouter 2-regresssion method (10 s epochs, vertical axis, 18 activities, linear regression); and Sojourn 3x (Soj3x; 1 s epochs, 3-d features, ~30 activities, machine learning). We also evaluated AT and ST using Crouter, Soj3x and 2 cut-points (100 vertical axis [100VT], 200 vector magnitude [200VM]). Results. Criterion means for PAEE were 743 kcal/d, AT 6.0 hrs/d and ST 9.8 hrs/d. Compared to criterion, Crouter was most accurate for PAEE (-6%) but least accurate for AT and ST (50%, -30%). 100VT was most accurate for AT and ST (2%, -1%). Freedson and Soj3x accuracy were comparable, and both were more accurate than Sasaki and 200VM. Correlations were r 0.56 for all methods, but were slightly higher for more advanced methods (Crouter, Soj3x) for PAEE (r=0.67-0.68), while those using 3-axes (200VM, Soj3x) were higher for AT and ST (r=0.67-0.70). Improvements in the strength of correlations associated with more advanced methods was greater in women than men. Conclusions. More sophisticated AG data and calibration methods were associated with improved validity, but the increase was often modest, and varied by sex.

Use of the ActiGraph GT9X Inertial Measurement Unit to Predict Energy Expenditure

Scott Crouter[1], Paul Hibbing[1], Samuel LaMunion[1], David Bassett[1]
[1]The University of Tennessee Knoxville

BACKGROUND: ActiGraph's newest device (GT9X) has an inertial measurement unit (IMU) that includes a triaxial gyroscope and magnetometer; however, there is a paucity of data on the impact of using the GT9X IMU to predict energy expenditure (EE). PURPOSE: To examine if using the GT9X IMU data improves EE prediction (METs), compared to using only the raw acceleration data. METHODS: Thirty participants (age, 23±2.3 years; BMI, 25.2±3.9 kg/m²) completed 10 activities for 7-min each while wearing a Cosmed K4b² to measure EE and GT9X monitors on the hip, both wrists, and both ankles. Raw accelerometer data (80 Hz) and IMU data (100 Hz) were averaged over 1-s for each axis. Accelerometer data were expressed for each individual axis and vector magnitude (VM) was calculated. Magnetometer data were expressed as number of direction changes. The data were collapsed so each variable was summarized over each minute using the features chosen by Staudenmayer et al. (i.e. 10th, 25th, 50th, 75th, and 90th percentiles, and lag-one autocorrelation). A holdout sample of 30% was used for cross-validation. Three ANNs were trained for each location: 1) raw acceleration only; 2) model 1 plus gyroscope data; 3) model 2 plus magnetometer data. The performance of each model was evaluated using root mean square error (RMSE). RESULTS: In general, across all wear locations, the best performing models for prediction of EE used only the VM (RMSE range 1.26-2.15 METs), with the ankle location performing the best. The addition of the IMU data did not improve the prediction of EE for the VM model. For the models using the individual accelerometer axes, the addition of the gyroscope improved the prediction of EE, but in general they still performed worse than VM only model (See table 1). CONCLUSION: Using IMU data, in addition to acceleration, did not result in improved estimates of EE. Further work should explore the best feature selection using the IMU to maximize use of the data.

Absolute validity of activity energy expenditure estimates from wrist accelerometry

Thomas White[1], Kate Westgate[1], Patrick Olivier[2], Michelle Venables[1], Nick Wareham[1], Soren Brage[1]
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Introduction Wrist acceleration is now the most widely adopted objective measure of physical activity. In this study, we derived models to estimate activity energy expenditure (AEE) from non-dominant wrist acceleration intensity, then investigated their absolute validity using Doubly Labelled Water (DLW), a gold standard measure of Total Energy Expenditure (TEE) in free-living. Methods The model was derived in a dataset of ~1700 UK adults who wore two devices for six days during free-living; a triaxial accelerometer on the non-dominant wrist (GeneActiv) and a combined heart-rate and chest accelerometer (Actiheart), which was individually-calibrated using a treadmill test. Our validation dataset comprised 100 adults (50% men) who wore triaxial accelerometers on both wrists (Axivity AX3), contemporaneous with a DLW measurement over 9-14 days. Resting energy expenditure (REE) was measured by indirect calorimetry, and diet induced thermogenesis (DIT) was estimated using a Food Frequency Questionnaire. Dominant wrist intensity was crudely harmonised to non-dominant wrist intensity by subtracting 10%, and the prediction models were applied to both 5-minute level acceleration signals. The resulting estimated AEE signals were collapsed to daily averages, and compared against measured AEE by testing for mean bias, 95% limits of agreement, Spearman correlations, and Root Mean Squared Error. Results Mean (SD) AEE measured by DLW was 45.6 (16.7) kJ/kg. Estimated AEE was 46.7 (12.7) kJ/kg from the non-dominant wrist, and 47.4 (12.4) kJ/kg from the dominant wrist; the estimations had a RMSE of 13 kJ/kg and 14 kJ/kg respectively, non-significant mean biases of 0.9 kJ/kg and 1.2 kJ/kg, and both were strongly correlated with the criterion (r=0.6). Conclusion The intensity models, derived exclusively using non-dominant wrist data and a "silver-standard" criterion, translated successfully to a highly accurate and precise estimation of AEE from both wrists.

Which is the best accelerometer-based metric to predict free-living activity energy expenditure?

Jairo Migueles[1], Christine Delisle Nyström[2], Cristina Cadenas-Sanchez[1], Pontus Henriksson[1], Francisco Ortega[1], Marie Löf[2]
[1]University of Granada, [2]Karolinska Institutet

Introduction Accelerometers are widely used to objectively assess daily physical activity in epidemiological and clinical research. Different ways of processing raw acceleration signals have resulted in different summary metrics. This study aimed to evaluate the capacity of different raw- and count-based metrics to estimate activity energy expenditure (AEE) measured using the doubly labelled water method in preschoolers. Methods Cross-sectional data from the MINISTOP obesity prevention trial was used. Forty healthy Swedish preschoolers (5.5±0.5 y/o; 22 boys) wore ActiGraph GT3X+ on their non-dominant wrist during 5-9 days (24 hour-periods). The metrics derived were: Euclidean norm minus one (ENMO), Euclidian norm of the high-pass filtered signals (HFEN), HFEN plus Euclidean norm of low-pass filtered signals minus 1 g (HFEN+), Mean Amplitude Deviation (MAD) of the Euclidean Norm and activity counts from the ActiGraph manufacturer applying normal and low-frequency extension filters (NFCounts and LFECounts). Total energy expenditure (TEE) was assessed using the doubly labelled water method during 14 days. AEE was calculated as (TEE x 0.9) minus predicted basal metabolic rate. Linear regression models were created. Results Alone, ENMO, HFEN+ and MAD explained 36%, 32% and 33% of the variance in AEE respectively (all $p<0.001$). NFCounts and LFECounts showed markedly worse capacity to predict AEE, with both only explaining 19% of the variance (all $p\leq0.006$). Adjusting for body weight and height increased the capacity of the metrics to predict AEE. Thus, ENMO, HFEN, HFEN+ and MAD explained 51-56% of the variance ($p<0.001$), with ENMO explaining the most ($r^2=56\%$). Conclusion Metrics derived from raw acceleration signals (i.e. ENMO, HFEN, HFEN+ and MAD) clearly outperformed those metrics calculated by the ActiGraph manufacturer (i.e. NFCounts and LFECounts). Our results

suggest that predictions of AEE should preferably be based on metrics derived from raw accelerations signals.

Auditorium A: Activity Analysis in Special Populations

Session Chair: Hans Bussmann (Erasmus MC University Medical Center)

Using machine learning and accelerometry to improve energy expenditure prediction in pregnant women

Alexander Montoye[1], Jordana Dahmen[2], Scott Conger[3], Christopher Connolly[2]
[1]Alma College, [2]Washington State University, [3]Boise State University

PURPOSE: To compare energy expenditure (EE) prediction accuracy of a machine learning model developed in pregnant women to models developed in non-pregnant populations. METHODS: Twelve pregnant women (gestational age=22±7 weeks; mean age=29±4) wore an ActiGraph GT9X Link accelerometer on the right hip and a metabolic analyzer (criterion measure for EE [METs]) while sitting quietly for five minutes and treadmill walking at five speeds (1.5, 2.0, 2.5, 3.0, 3.5 mph) for two minutes each. All activity data (steady- and non-steady-state) were used in model development and analyses. Features of the raw (60 Hz) Link data (mean, variance) were extracted from each axis in 30-second windows and used as inputs in two EE-prediction machine learning models. Model 1 was previously validated in a non-pregnant, adult population (n=39, mean age=22±4); Model 2 was developed with the current dataset using a leave-one-out approach. The Freedson 2011 count-based EE prediction model was used for comparison. Model accuracy was determined using correlations, mean absolute error (MAE), and bias. Repeated measures ANOVA was used to compare model accuracy. RESULTS: Correlations (mean ± SD) were significantly higher for Model 2 (0.81±0.24; p=0.04) and Freedson (0.88±0.07; p=0.03) than for Model 1 (0.59±0.39) but were not different between Model 2 and Freedson (p=0.31). MAE for Model 2 (0.50±0.19 METs) was significantly lower than both Model 1 (1.29±0.52 METs; p<0.01) and Freedson (0.87±0.27 METs; p<0.01), and Freedson was significantly lower than Model 1 (p=0.04). Model 2 had no overall bias (0.02±0.28 METs), whereas Model 1 and Freedson systematically overestimated EE (0.70±0.87 and 0.65±0.20 METs, respectively). CONCLUSION: The EE prediction model developed in pregnant women outperformed traditional and machine learning models developed in non-pregnant populations. Studies using accelerometers to assess EE in pregnant women should consider population-specific prediction models.

Calibration of the GENEActiv wrist- and hip-worn accelerometer for prediction of activity-related energy expenditure in preschoolers

Berit Steenbock[1], Norman Wirsik[1], Mirko Brandes[1]
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Objectives: To calibrate and validate activity-related energy expenditure (AEE) prediction of the GENEActiv accelerometer worn on three different locations (dominant vs. non-dominant wrist vs. right hip) via indirect calorimetry in preschoolers. Methods: 44 children (aged 4.8 ± 0.8 years, 115 ± 8cm, 20.2 ± 4.2kg) completed a parcours including resting (lying), sedentary (e. g. drawing), light (e. g. toy blocks), moderate (e. g. climbing) and vigorous (e. g. running) activities. Oxygen consumption and carbon dioxide production was measured continuously and converted to absolute (kJ/min) and relative (J/min/kg) AEE. Accelerometer data measured at 100 Hz was converted to 1s-epochs. The means of AEE and

acceleration, calculated as the vector magnitude (VM) of the three axes, of the last minute of each activity was considered for statistical analysis. Several mixed linear models accounting for repeated measurements were fitted. In order to assess the accuracy of the different models, leave-one-out cross-validation was used to calculate the root-mean-square-error (RMSE). Results: For absolute AEE, the model including weight and VM performed best for the non-dominant wrist (AEE(kJ/min)=0.3771+0.1598*weight+0.0068*VM+0.0060*(weight*VM); RMSE: 2.77, Figure 1), compared to the dominant wrist (RMSE: 2.90) and hip (RMSE: 3.09). For relative AEE, the model including VM performed best for the non-dominant wrist (AEE(J/min/kg)=0.19+0.0064VM; RMSE: 0.13), compared to the dominant wrist (RMSE: 0.14) and hip (0.15). Including additional parameters, e.g. height, age, sex and interactions improved the models only marginally. Conclusion: We recommend a simple model based on acceleration and weight to estimate AEE due to the marginal improvements by adding additional parameters. Between the different locations, the non-dominant wrist showed the best results. Therefore, we recommend choosing the non-dominant wrist for measuring AEE in preschoolers.

Comparability of different accelerometers and sites for activity-related energy expenditure prediction in preschool children

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Background: To compare and validate activity-related energy expenditure (AEE) prediction of three accelerometers at wrist, hip and thigh in three to six year old children against indirect calorimetry. Methods: 44 children (aged 4.8 ± 0.8 years, 115 ± 8cm, 20.2 ± 4.2kg) completed a parcours including resting (lying), sedentary (e. g. drawing), light (e. g. toy blocks), moderate (e. g. climbing) and vigorous (e. g. running) activities. Oxygen consumption and carbon dioxide production was measured continuously and converted to absolute (kJ/min) and relative (J/min/kg) AEE. Accelerometer data measured at 100 Hz (GENEActiv, non-dominant and dominant wrist; Actigraph, right and left hip; all in 1s-epochs) and 20 Hz (Activpal, right thigh, 15s-epochs). The means of AEE and acceleration of the last minute of each activity was considered for statistical analysis. Several mixed linear models accounting for repeated measurements were fitted. Models were computed for the vector magnitude (VM) and the vertical acceleration only. In order to assess the accuracy of the different models, leave-one-out cross-validation was used to calculate the root-mean-square-error. Results: For absolute and relative AEE estimation, activPAL performed superior (RMSE: 2.732 and 0.123, respectively), compared to the GENEactiv at the non-dominant wrist (RMSE: 2.771 and 0.126, respectively) and the Actigraph at the right hip (RMSE: 3.686 and 0.178, respectively). For absolute AEE, the model including weight*VM, for relative AEE the model including VM (activPAL) and VM, age, sex, height and interactions (Actigraph, GENEActiv) performed best. Generally, models based on the VM were superior compared to models based on vertical acceleration (Tab. 1). Conclusion: Due to their similar performance, we recommend estimating AEE by the activPAL and the GENEActiv at the non-dominant wrist in preschoolers. Moreover, an AEE estimation based on the VM should be preferred over utilizing the vertical acceleration.

Using expectile regression and hidden Markov models to assess accelerometer data

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Background: Accelerometers are now widely used in population-based studies to objectively measure physical activity (PA). Simple cutpoints are used to classify recorded impulse counts, i.e. to identify time intervals, so-called bouts, during which the subject remains within one activity range. Here, expectile regression with an applied L0-penalty and hidden Markov models (HMM) are proposed to improve the cutpoint method to accomplish a better identification of the sequence of modes of PA and thereby enhance the measurement of PA. Methods: 1,000 days of accelerometer data for 1 and 5 seconds epochs were simulated based on previously collected labeled data. The cutpoint method is compared with HMMs based on the Gaussian distribution (HMM[Gauss]) and expectile regression (EXPECT) with regard to misclassification rate (MCR), bout detection and computer runtime. Results: For 1 second epochs the cutpoint method had an MCR of about 18%, followed by HMM[Gauss] with 16% and EXPECT with 10%. The average identified number of bouts ranged from 10,300 for the cutpoint method to 2,800 for HMM[Gauss] and 34 bouts for EXPECT, while the mean of the simulated data was 42. For 5 seconds epochs the variance decreased and results for all methods improved. The cutpoint method had an MCR of about 9%, followed by HMM[Gauss] with 6% and EXPECT with less than 2%. Also the mean number of identified bouts decreased to about 1,200 for the cutpoint method, 271 for HMM[Gauss] and 56 for EXPECT. Runtime varied between 0.5-3 seconds (cutpoint), 2.0-10.5 minutes (HMM[Gauss]) and 14.0-70.5 minutes (EXPECT). Conclusions: HMM-based methods as well as expectile regression better classified activity modes than the traditional cutpoint method. Both methods are suitable for modeling accelerometer data. Comparing these new methods, expectile regression showed better performance with regard to all considered quality measures, at the expense of increased runtime.

Fragmentation of Physical Activity and Its Application

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Sedentary behavior is a significant risk factor for a wide range of chronic diseases, comorbidities, and mortality. As people age, daily activities become less fragmented and sedentary behaviors increase. Existing methods of studying sedentary behaviors often rely on quantifying total sedentary volume and ignore the accumulation and temporal distribution of sedentary time. To deal with this inadequacy, we developed a unifying statistical framework to study the fragmentation of physical activity measured with accelerometry by analyzing the distribution functions of sedentary and active bout durations using both parametric and nonparametric approaches. We illustrate the approach by exploring the association of fragmentation of physical activity and mortality in National Health and Nutrition Examination Survey (NHANES) 2003-2006.

Physical activity of frail elderly living at a care facility or at home: Is there a difference?

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Introduction: The senior population keeps rising and with it the medical and health economic challenges to treat frail elderly. Frail seniors may become permanent residents of a care facility or continue living independently at home. The impact of physical activity (PA) on general health and conditions common in frail elderly such as hip fractures, fall risk, dementia or diabetes is increasingly recognized. However, it remains unknown if habitual PA is different between frail elderly living at home or at a care facility. Methods: Habitual PA was monitored in n=75 subjects during 4 days using an ambulant inertial sensor

(GCDC HAM-IMU) worn on the lateral upper leg and analyzed previously validated activity classification algorithms (Matlab). Two groups of elderly diagnosed as frail (e.g. Groninger Frailty Indicator >3) and matched for gender, age and frailty related clinical measures (e.g. GFI, GDS, MMSE, Tinetti, SF12) were compared: Group A living at a care facility (f/m= 10/5, age: 83.6yrs ±6.4)and group B living at home (f/m= 34/26, age: 80.0yrs ±5.5). Results and Discussion: Despite equal demographic, frailty and other clinical measures, care facility residents were significantly less active (daily steps A: 3007±2350 vs B: 5057±2435, -41%, p=0.002) and more sedentary (sitting-bouts >30min: 5.3±1.6 vs 3.9±1.8, +36%, p<0.006) towards thresholds with detrimental health effects (e.g. <3000 steps) than subjects living at home. Comparable qualitative measures such as cadence (76.4±22.5 vs 82.6±14.4 steps/min, p=0.29) or sit-stand-transfer duration (2.60s ±0,59 vs 2.37s ±0,51, p=0.11) confirm the similar physical capacity as clinically scored (e.g. SBBP). Conclusion: In current care facilities, activation programs for frail elderly are not as effective on habitual PA as living independently at home but can leave patients to deleterious PA levels. Improvements are required considering the efforts and costs of care facilities.

Auditorium B: Symposium

Application of Accelerometry to Identify Clinical Trajectories

Tamara Harris[1], Jennifer Schrack[2], Paolo Caserotti[3], Todd Manini[4]
[1]National Institute on Aging, NIH, [2]Johns Hopkins Bloomberg School of Public Health, [3]University of Southern Denmark, [4]University of Florida, Gainesville

PURPOSE: The purpose of this symposium is to identify new opportunities for using accelerometry in the assessment of clinical populations. These presentations will provide an overview of novel applications of accelerometry to capture the trajectory of physical activity and sedentary behavior preceding the onset of clinical illness as well as the trajectory of physical activity most beneficial for recovery from illness. AIMS: To provide information on the clinical utility of accelerometers in: 1) Predicting recovery during in-patient hospitalization; 2) Understanding trajectories of recovery following hospital discharge in community-dwelling older patients; 3) Highlighting pre-hospitalization trajectories of physical activity and sedentary behaviors for patients with congestive heart failure; 4) Discuss the use of accelerometers with very sick patients. We will also discuss the feasibility of use, placement of the device, and the challenge of interpretatng data into clinically meaningful metrics. SUMMARY: Mobility is paramount to recovery from illness, but the current clinical method of assessing mobility via self-report is neither granular nor complete. Accelerometers provide a comprehensive picture of daily movements and are widely used in clinical research, but their clinical utility in the acute care/hospital setting as well as post hospital discharge are not well-defined. The symposium will focus on the use of accelerometry for tracking health and functional status in clinically ill patients, and highlight the benefit of using acceleromters to better understand recovery, reduce hospital length of stay, and adverse events including readmission.

Auditorium C: Symposium

Technology assisted physical activity measurement among children: Attractions and pitfalls

Amy Lu[1], Tom Baranowski[2], Stephen Intille[1], Jungyun Hwang[1], Eldin Dzubur[3]
[1]Northeastern University, [2]Baylor College of Medicine, [3]University of Southern California

Purpose: Recent years saw a plethora of personal wearable sensor technologies and the adoption of ecological momentary assessment (EMA) for physical activity (PA) among children. While their emergence and prevalence offer advantages such as portability, elongated measurement duration, and engagement, the multitude of procedures in data analysis and interpretation, cut-points, measurement environment, and participants' weight status limits their reliability, validity, and comparability. This symposium addresses the need for converging methods to enhance PA measurement among children. Rationale: Children are different from adults in PA amount, intensity, movement and compliance patterns. Four projects present objective and subjective measurement of PA among children, addressing attractions & pitfalls. Objectives: 1. Updated information in child friendly PA measurement devices; 2. Better understanding of the difference between children & adults PA behaviors; 3. Enhanced knowledge in improving PA measurement; 4. Increased familiarity with real-time methods to measure self-reported PA and co-occurring behaviors. Summary: Collectively we show the importance of acknowledging children as special participants in PA measurement. Format: Introduction: Lu 3' Baranowski: Using an all-day camera to assess physical activities among children: Lessons learned 13' Intille: Activity recognition in youth using single accelerometer placed at wrist or ankle 13' Hwang: Wrist or Hip? An exploratory validation study of the placement of accelerometers during active video game play among children 13' Dzubur: Modeling study burden and participant fatigue in ecological momentary (EMA) protocols with subjective self-report & objective survey metadata 13' Comments: Lu 7' Q+A: 12'

11:15 – 12:15 Speakers and Abstracts and Symposia

Kirschstein Auditorium: Approaches to Harmonizing and Standardizing Big Data

Session Chair: Malcolm Granat (University of Salford)

The Role of Interactive Visualisation in the Interpretation of Big Behaviour Data

David Loudon[1], Nikos Mourselas[1], Douglas Maxwell[1]
[1]PAL Technologies Ltd

Long-term physical activity measurement (over several months) has typically been limited to daily accumulations, for example step counts or activity time. Advances in hardware and ubiquitous wireless communication have made feasible the continuous measurement and storage of rich physical behaviour data over extended periods. However, the availability of these big datasets presents new challenges of interpretation and analysis for researchers. In contrast to short duration recordings (1-2 weeks) taken at specific time points across an intervention (e.g. baseline, 3 months and 12 months), continuous data captured over several months magnifies the complexity of analysis due to the size of the dataset, complications of wear time, and variations due to weekend/weekdays, seasons and holiday periods. To interpret and filter the data correctly, and inform the numerical analysis, we argue that effective visualisation of the data is crucial. We have based our approach on long term data from the SitFIT, a pocket-worn physical behaviour intervention device which records and provides feedback to the wearer on their Physical Activity and Sedentary Behaviour over several months. The figure shows an example visualisation of 11 months of data from a single participant using colour-coded spirals. The daily spiral highlights regular patterns of commuting in mornings and at the end of the working day, and more variable activity profiles in the evening. The weekly spiral further uncovers the different distribution of activities between the working week and the weekend. The grey areas show non-wear of the device,

informing which time periods to include in the analysis. Effective visualisation and analysis of long-term, rich data sets will not only provide insight into the mechanism of action of existing interventions but could provide the opportunity to develop precision interventions, dynamically adjusting the intervention based on the individual's daily physical activities.

Motor Activity Research Consortium for Health (mMARCH): Standardization of procedures and analyses of mobile technologies in mood disorders and related conditions.

Kathleen Merikangas[1], Femke Lamers[2], Lihong Cui[1], Haochang Shou[3], Vadim Zipunnikov[4]
[1]National Institute of Mental Health, [2]VU University Medical Center/GGZ inGeest, [3]University of Pennslyvania, [4]Johns Hopkins Bloomberg School of Public Health

Background: There is growing recognition of the role of physical activity in mental disorders, particularly mood disorders of which motor activity is a core feature. Mobile technologies are being increasingly used to track mood fluctuations of both clinical and community samples in real time. There are now about 12 studies that demonstrate differences in activitiy patterns in the bipolar subtype of mood disorders. Aggregation of the findings across studies is complicated by the substantial differences in key study aims, procedures and statistical methods. Aims: In order to address the need for greater coordination across studies in the procedures and analytic methods that can take into account advances in analytic methods we have established an international collaborative effort on actigraphy and mood disorders and symptoms. Methods: This paper describes the aims, methods and approaches of the Motor Activity Research Consortium for Health (mMARCH) that was developed to facilitate coordination of procedures, analyses, and data sharing among research groups collecting actigraphy data to investigate associations between motor activity and mood disorders and a range of other conditions as well as general population samples of adults and youth. Harmonizing ancillary measures using ecological momentary sampling, heart rate monitoring, GPS and other mobile measures also facilitates multi-modal assessment across sites. The core sites include Australia, China, Netherlands, Switzerland, and USA, and the broader network includes sites in the Canada, France, Norway, and the UK. Results: Here we focus on approaches to standardize data collection, measures, and analytic approaches to facilitate integration of findings across studies and cross-site analyses that enhance the generalizability and analytic power. We present findings from multi-site analyses that demonstrate the methods and findings from the mMARCH consortium. We first examine the effects of age, sex, and other dem

Interoperability of data & devices

Joss Langford[1], Matt Reed[2], David Snelling[3], Paul Bruton[4]
[1]Coelition, [2]Unilever Research & Development, [3]Fujitsu Laboratories of Europe, [4]Tessella

Background: Coelition is a non-profit organisation that supports the development of open standards for the measurement of human behaviour. Method: Coelition has worked with commercial organisations in the OASIS technical standard environment to create an open standard specification that allows full interoperability of devices and portability of data. Summary: The OASIS COEL specification provides a privacy-by-design framework for the collection and processing of behavioural data. It is uniquely suited to the transparent use of dynamic data for personalised digital services, IoT applications where devices are collecting information about identifiable individuals and the coding of behavioural data in identity solutions. The specification pseudonymises personal data at source (IDA) and maintains a separation of different data types with clearly defined roles & responsibilities (RPE) for all actors. All behavioural data

are defined as event-based packets (BAP). Every packet is connected directly to an individual and can contain a summary of the consent they provided for the processing of the data. A combination of a taxonomy of all human behaviours (COEL) and the event-based protocol provide a universal template for data portability. Simple interface specifications (MMI & PQI) enforce the separation of roles and provide system-level interoperability. Discussion & conclusion: The OASIS technical committee has allowed commercial, non-profit and academic institutions to work together to create operational infrastructure and public specifications to interact with that infrastructure. The open standards approach provides a method for engaging with global regulators and delivers transparency for data subjects. References: OASIS, https://www.oasis-open.org/committees/coel/ Coelition, https://coelition.org/business/ Reed, M. and Langford, J. (2013). Data to Life. London: Coelition.

Auditorium A: Physical Activity Behavior in Youth

Session Chair: Bronwyn Clark (The University of Queensland)

Objectively measured physical activity and sedentary time and cardio-metabolic biomarkers in young adults: A compositional data analysis approach

Joanne McVeigh[1], Anne Smith[1], Erin Howie[2], Aloke Phatak[1], Simeon Jasper[1], Joanne Jacob[1]
[1]Curtin University, [2]University of Arkansas

The associations between time spent in sleep, sedentary behaviours and physical activity with cardio-metabolic health have traditionally been studied in isolation. Thus little is known about the combined effect of time spent in sleep, SB and physical activity on cardio-metabolic indices. Two studies have used a compositional analysis paradigm to assess the composite relationship between objectively measured activity behaviours and cardio-metabolic outcomes in youth (6-17 yrs) and middle aged adults (32-54 yrs). However, there is a paucity of data examining the composite relationship between activity and cardio-metabolic health in young adults. The aim of this study was to use compositional analysis to assess the combined effect of accelerometer measured physical activity, sedentary behaviour and sleep on 16 markers of cardio-metabolic health in young adults (aged 22 years) from the Raine study. Cross sectional analysis of 24 hour accelerometery data collected from 774 young adults was undertaken using a compositional analysis model. Time spent in sedentary behaviour, light intensity (LIPA) and moderate to vigorous activity (MVPA) was used to form a composition of daily awake time. Within the composition, some significant relationships were detected but they were weak ($R^2<0.19$ for all models). The combined effects of activity behaviours on cardio-metabolic outcomes may not yet be present in these young adults.

Activity Pattern Differences between Obese and Normal Weight children

Ben Stansfield[1], Ceri Sellers[1]
[1]Glasgow Caledonian University

Activity Pattern Differences between Obese and Normal Weight children Introduction Many studies use summary measures such as daily upright time or step count to measure physical activity. This study explored whether aspects of the chronological pattern in which activity was accumulated could be used to supplement these measures in assessing the differences in physical activity between groups of primary school children with different weight status. Methods The thigh-worn activPAL3 tri-axial activity monitor (PALTechnologies Ltd. Glasgow, UK) was used to measure free-living physical activity in 68

primary school children aged 9-11years over a 7-day period. Data for participants recording at least 3 full days was analysed by weight status: Group 1: Underweight, normal, overweight (BMICentile<95), and Group 2: Obese, morbidly obese (BMICentile≥95). Sequences of at least 4 successive rapid (<60s) transitions between sedentary and upright postures (Fig 1) were identified and recorded as "fidget" minutes. 2-sample t-tests were used to compare the group means for week-day upright time, sedentary time, number of upright bouts, step count and fidget minutes. Results Data was analysed for 56 participants, aged 10.6±0.5years: 38 children were in Group1 (BMICentile 59.3±25.2) and 18 in Group 2 (BMICentile 97.9± 1.6). There was no significant difference in age between groups. Mean daily fidget minutes for Group 1 were significantly higher than Group 2 (31.9±12.1;22.0±8.9;p=0.001). Group 1 also had more upright bouts a day than Group 2 (168.5± 32.2;133.6±32.7;p=0.001). No other significant group differences were found. Conclusion Daily fidget minutes and upright bouts were lower for the heavier Group 2, despite there being no significance differences in step count or upright time. While diet was not controlled in this study, there may be aspects of the physical activity patterns that are worth investigating further in relation to weight status.

Auditorium B: Symposium

Using activity monitors to develop, evaluate and refine whole-day interventions

Genevieve Healy[1], Sjaan Gommersall[1], Elisabeth Winkler[1], Matthew Buman[2]
[1]The University of Queensland, [2]The University of Arizona

Purpose: Beyond the advantages of better measurement, the plethora of rich data collected via activity monitors offers exciting possibilities for conducting, evaluating, and refining interventions. Rationale: ICAMPAM?s focus on free-living monitoring makes it ideal for a dialogue on how to make the most of activity monitors in interventions. Some of the methods covered have been used to a limited extent; others not at all in the intervention context, such as compositional data analysis. Objectives: This session aims to showcase and generate discussion on approaches that can help address important concerns to interventionists, including: 1. Using monitors to inform tailored intervention messages 2. The timing and context of activity changes 3. What types of changes are most health enhancing? Summary: The session will cover three cohesive presentations, drawn from two interventions targeting whole-of-day activity change. Firstly, the session will cover how monitor data can be used to motivate behaviour change. Secondly, the session will cover detailed evaluation of when participants make activity changes, illustrating key issues relevant to intervention success (compensation, generalisation, dilution, and critical biological windows). Finally, the session will cover possibilities for refining interventions, based on exploring the types of activity changes most associated with cardio-metabolic biomarker improvements. Format: Using monitors to tailor a text messaging intervention: Sjaan Gomersall Evaluating temporal patterns of activity changes in a workplace intervention: Genevieve Healy Does how sitting is reduced in an intervention dictate its biological impact?: Elisabeth Winkler Discussion led by Matt Buman

ICAMPAM 2017 Poster Abstracts

1-1 Effectiveness of a lateral wedged insole on the levels and patterns of free-living activity.

Yasser Althebaity[1], Malcolm Granat[1], Anmin Liu[1], Richard Jones[1]
[1]University of Salford

Purpose: Knee osteoarthritis (OA) is one of the most common chronic musculoskeletal diseases causing knee pain, disability and reduced levels of activity. The reduction in activity is associated with the majority of health problems and can result in further functional limitations. Abnormal knee loading exists and lateral wedged insoles (LWI) are designed to reduce the knee loading leading to an improved clinical outcome. Given the importance of activity level in individuals with Knee OA, the aim of this study was to determine the effect of the use of the LWI on level and pattern of free-living physical activity. Methods: Individuals with confirmed medial knee OA were randomly allocated to using either a 5˚ LWI or a neutral insole for six weeks. An activPAL monitor was placed on their thigh for 7 consecutive days to measure their activity level at baseline and at week 5. The primary outcome was level of activity and 2x3 mixed ANOVA`s were performed to determine which treatment was more effective. Results: Twenty individuals were randomly assigned into two equal groups. There was no difference between the groups in the characteristics and level of activity at baseline. Compared to baseline the number of steps and stepping time significantly increased in the LWI group (1,525 steps and 17 minutes/day) but not in the control group. The LWI group showed an increase in number of steps taken at a cadence above 90 steps/minute and in continuous stepping bouts of greater than 5 minutes, this was not seen in the control group. Discussion: The group wearing LWIs demonstrated a change in activity profiles after six weeks. Individuals walked more, faster and for a longer time when wearing LWI. Therefore, activity profiles of individuals during interventions give important information and should be collected to complete the profile of individual.

1-3 Comparison between wearable sensors and infra-red cameras-based motion analysis to evaluate gait performance during a simulated ecological task

Einat Kodesh[1], Michal Kafri[2], Tal Krasovsky[1], Tamar, PL Weiss[1], Gabi Zeilig[3], Racheli Kizony[3]
[1]University of Haifa, [2]University of Haifa , [3]Sheba Medical Center

Wearable wireless sensor systems are ideal for analyzing gait patterns during performance of tasks in the real world. However, the reliability and validity of these tools has not been tested during an ecological task (e.g. shopping) that typically includes pauses and a diversity of walking speeds i.e. walking and stopping. The purpose of this study was to test the level of agreement between spatiotemporal data recorded from a wearable sensor system (Mobility Lab, APDM Inc., Portland, OR) and from a 3D infra-red camera-based motion capture system (Vicon, Oxford, UK). Methods: Thirteen adults (aged 21-74 years; 8 men) were tested during a single session. A mall simulation was created and run in the CAREN Integrated Reality System (Motek Medical B.V.) and projected onto a 52" wall-mounted monitor. Participants performed a set of shopping tasks in the mall simulation while walking on a self-paced treadmill and navigating with a joystick. Gait parameters were simultaneously recorded with Mobility Lab and VICON. Gait parameters from both systems were computed using custom-written MATLAB code. Results: Mean time to complete the task was 10.3±4.6 min. Mean gait speed as recorded with the wearable sensors was 0.49±0.17 m/s and with the 3D cameras was 0.48±0.08 m/s. Intraclass Correlation Coefficients were moderate to excellent; .65 for gait speed, .77 for stride length, .97 for

stride time and .95 for cadence. Conclusions: Our findings support the use of wearable sensors in tasks that simulate real life walking, demonstrating their potential for ecological gait research as well as clinical practice.

1-5 Use of wearable sensors to quantify postural stability differences in people with Parkinson's disease with and without freezing of gait

Mahmoud El-Gohary[1], Patricia Carlson-Kuhta[2], Martina Mancini[2], Fay Horak[2], Jessie Huisinga[3]
[1]APDM Inc., [2]Oregon Health & Science University, [3]University of Kansas Medical Center

Objective: To quantify differences in postural responses to perturbations in people with Parkinson's disease (PD) with and without freezing of gait (FOG+, FOG-, resp.), using a manual perturbation and wearable inertial sensors. Background: Clinically, postural responses in people with PD are assessed with the 'pull test' from the motor section of the Unified Parkinson Disease Rating Scale (UPDRS). However the measure is subjective and does not specifically quantify the postural response. We developed a manual Push and Release test as an alternative to provide more sensitive reactive postural-response measures (Horak et al 2009, Smith et al 2014). More recently, we developed new algorithms to quantify the details of the Push and Release using inertial sensors that could be used in a clinical setting. Methods: PD subjects were tested in functional OFF state, 15 PD FOG+ (Motor UPDRS = 50.5±18.8), 54 PD FOG- (UPDRS = 35.2±10.4), and 24 healthy, age-matched control subjects. Subjects wore six Opal triaxial inertial sensors (APDM, Portland, OR) on their chest, lumbar area, wrists, and feet. A reactive postural response was elicited by having subjects lean backward into the hands, placed at shoulder level, of the test administer. The administer leaned the subject backward until the subject s center of mass position was outside of their base of support (posterior to the heels). After three seconds, the administer let go of the subject, who attempted to recover balance by stepping. Results: Mean postural stability sub-score of UPDRS was 1.60±1.35 in PD FOG+ and 0.87±0.95 in PD FOG-. The PD FOG+ and FOG- took more steps to recover, had a shorter step length, and lower step height, compared to the Control group. And PD FOG+ took more steps and had shorter step length than PD FOG- [table1]. Conclusion: Postural responses to the Push and Release test can be quantified in a clinical setting using wearable inertial sensors and is sensitive to PD.

1-8 Variability in physical activity assessed with accelerometer is associated with the disease in elderly with Parkinson´s disease

Maria Hagstromer[1], Eric Rullman[1], Erika Franzèn[1]
[1]Karolinska Institutet

The aim if this study was to explore the relationship between various aspects of physical activity (PA) and physical function, depression, Quality of Life and disease in elderly with Parkinson´s disease (PD). Participants wore an Actigraph GT3x+ accelerometer for one week. PA outcomes were total counts, time spent in various intensities and measures of variability. The analysis focused on episodes with high-recorded activity, which was identified by calculating a rolling mean. From these measures of variability were calculated: skewness, kurtosis and interquartile range (IQR). Disease related outcomes were measured using the Unified Parkinson Disease Rating Scale (UPDRS)-motor and ADL-part. Physical function was measured by means of step length, velocity and cadence and by balance performance (Mini-BESTest). Depressive symptoms were assessed using the Geriatric Depression Scale (GDS) and Health related quality of life using SF-36. Principal components analysis (PCA) of PA variables and clinical

variables were performed on 89 elderly with mild-moderate PD. The PCA revealed a high degree of co-variance, with >60% of the total variance explained by the first two principal components. The PA variables formed three distinct clusters of highly correlated variables, one with skewness, kurtosis and sedentary time, one with various measures of intensity along with high intensity time named as peak activity and a third with measures of total PA. When the clinical variables were superimposed on the PCA of the accelerometer-derived variables disease related outcomes and symptoms of depression co-varied with the accelerometer-derived measures of variability (skewness and kurtosis). In contrast, measures of physical function co-varied with accelerometer-derived variables representing aspects of peak activity. This study showed that novel features of variability of PA derived from accelerometer data were associated with disease related outcomes in elderly with mild-moderate PD.

1-9 The modulation of physical activity by clinical states in bipolar disorder

Holger Hill[1], Esther Mühlbauer[2], Emanuel Severus[2], Iris Reinhard[3], Michael Bauer[2], Ulrich Ebner-Priemer[1]
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Bipolar disorder is (assumed to be) associated with behavioural changes, i.e. higher activities in manic/hypomanic phases and lower activities in depressive phases compared to the euthymic states. Currently, several research groups investigate if objectively measured behavioural changes (i.e. smartphone usage, physical activity) are suited as early warning signs for an upcoming depressive or manic/hypomanic espisode. The detection of an altered behaviour should in turn cue a therapeutic intervention to reduce the negative impact of the upcoming episode. In a pilot study about smartphone useage, we assessed in addition physical activity with hip-worn accelerometers in a subsample of 27 outpatients for up to one year (in total about 3800 measured days). Clinical ratings to assess manic/hypomanic or depressive symptoms were performed every two weeks. Based on the accelerometer raw data (measured as m/s^2) we analysed mean activity (movement acceleration intensity) and movement frequency. The results revealed a lower activity in the depressive state and a higher activity in the manic/hypomanic state. Movement frequency was in general negatively correlated with activity. Circadian rhythmicity revealed an activity peak around 12 h in the depressive state and a biphasic pattern (peaking around 12 h and 17 h) in the manic/hypomanic state. The detection of early warning signs in bipolar disorder can be improved with multiple facets of objectively measured behaviour. The assessment of physical activity should be a valuable contribution to cover different aspects of behaviour.

1-11 Cultural adaptation, translation and validation of the Spanish version of the Past-day Adult's Sedentary Time (PAST) questionnaire in Chilean working adults

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Introduction: Sedentary behavior is highly prevalent across all countries. However, there are limited self-reported instruments for measuring and monitoring SB in Spanish. The aim was to culturally adapt, translate and validate the Past-day Adult´s Sedentary Time (PAST) questionnaire in Chilean working adults using the ActivPAL (AP) accelerometer as reference standard. Methods: A diverse sample of 101 workers (i.e. teachers, taxi drivers, cleaners, health professionals, etc.) were recruited in Temuco, Chile. Participants wore an AP during 1 week and were asked to respond the Spanish version of the PAST

Questionnaire twice in different visits separated by 7 days. The PAST was previously culturally adapted, cross-translated and reviewed by the research team. The PAST asks the time spent in SB in several domains (during work; travel; television viewing; leisure-time computer, internet and electronic games; reading, hobbies and sitting for other purposes) during the previous day. Times reported from the different items were summed to calculate the total time per day spent sitting or lying down. Test-retest reliability for the PAST was assessed with Intraclass correlation (ICC). Concurrent validity for the PAST was examined with Spearman's correlation coefficient and Bland Altman Method and compared with the AP. Results: Ninety participants completed the protocol (51.0% male; age= 39.0±12.39 years; 47.9% overweight, 20.8% obese, mean BMI= 27.2±4.21 kg·m-2). Mean time spent in SB was 9.2±2.16 h/day and 11.5±5.38 h/day as measured with the AP and PAST, respectively. Reliability for the PAST was good (ICC=0.69). However, concurrent validity for the PAST was negligible (r=0.17; male=0.10; female=0.31). Mean bias between the PAST and AP was 1.36 h/day (95% limits of agreement: -10.5 to 13.2 h/day). Conclusions: Although the PAST showed good reliability, the questionnaire may be used with caution in Chilean working population as validation in a diverse sample of workers was negligible.

1-13 Interrelationships among physical activity, body temperature, sleep and lifestyle-related diseases in 1645 community-dwelling people aged 0-100 years: the Nakanojo Study

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This study investigated interrelationships among physical activity, body temperature, sleep and lifestyle-related diseases in 1645 community-living Japanese aged 0-100 years (623 men and 1022 women). Step count and the duration of exercise at an intensity >3 METs were determined by pedometer/accelerometer, 24 h/day for 1 week. During the same period, axillary temperatures were measured twice on rising and twice on going to bed; the averaged temperature in each condition was recorded. Sleep time was calculated from bedtime to the hour of rising, and the efficiency of sleep as hours of sleep (as determined by the validated pedometer/accelerometer algorithm) divided by the time lying in bed. Week-averaged daily step count and daily duration of activity >3 METs peaked in teenagers, and decreased significantly ($p < 0.001$) as age advanced, with changes being greater for duration at >3 METs ($r = -0.418$) than for step count ($r = -0.306$). Week-averaged axillary temperatures showed a gradual decline with aging ($p < 0.001$) both when rising ($r = -0.217$) and when going to bed ($r = -0.410$), the latter change being about twice as great as the former. Both duration and efficiency of sleep showed a small age-dependent reduction ($r = -0.154$ and -0.149, respectively; $p < 0.001$). Age- and sex-adjusted correlation coefficients indicated higher axillary temperatures and better sleep states in more active individuals (particularly in terms of daily duration at >3 METs). After controlling for age and sex, physical activity (both step count and duration at >3 METs) and axillary temperatures on rising were significantly ($p < 0.05$) lower, and the time lying was longer but the efficiency of sleep poorer in individuals >40 years with lifestyle-related diseases (including hypertension, diabetes and hyperlipemia). These results suggest that after adjustment for potential confounders, physical activity, body temperature, sleep and lifestyle-related diseases are interrelated.

1-15 Development of definitions for annotation of physical activity performed by elderly participants recorded using video technology

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With the technological advances of body worn sensor and video recording technology, activities of daily living (ADL) can now be labelled to a higher resolution, which can be synchronized to body-worn inertial sensor systems. However, clear definitions of the beginning and end point of normal physical activities that occur during physical activity protocols recorded using video technology are needed. An iterative process was used to define the beginning and end points of common ADL that occur during trial protocols. Identification and labelling of the participants' movements in 20 minute videos, using the definitions, was completed to a resolution of 0.04s using a team of 7 raters who rated a semi-structured protocol video recorded in a living-lab environment and 9 raters who rated an out-of-lab free-living protocol video. Activity definitions were to describe the transition of the body between the different states in Figure 1. Overall the level of agreement was high, with a percentage of agreement at 88.20% for the In-lab video and 88.61% for the out-of-lab video. The Cohen's Kappa, corrected kappa and the Krippendorff's alpha and Fleiss' kappa were all over 0.84 for both the In-lab and out-of-lab videos. Figure 1. Activity-state transition paradigm. A difficulty with developing such comprehensive definitions for activities is that movement of the upper and lower extremities needs to be described as part of the definitions. Thus certain activities that include short walking bouts and bending of the trunk could be interpreted differently by different raters. In conclusion our developed definitions show high level of agreement for identification of the beginning and end points of physical activity in elderly people recorded in both a first person view and a third person view.

1-17 Where do people spend time sitting, standing and stepping in an office work place?

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Considerable research interest has been generated around workplace sitting and activity. Most studies have examined time spent at the workplace or work hours overall. Knowing whereabouts within workplaces employees spend time, sit and move may help both inform and evaluate strategies for workplace interventions. Thirty office workers (30% men, mean¡ÀSD age 38¡À11 years, 30% with a height-adjustable desk) from a single building in Brisbane, Australia, wore a chest-mounted video camera and a thigh-worn activPAL monitor, for one day during work hours (6.3¡À1.2 h). Each 10 seconds of video recording was coded for key workplace locations for each participant: their office, the corridors, kitchen, photocopy room, entryway of their floor, and ¡°other¡±. For each location, total time, median time to accumulation (w50%), sitting, standing, purposeful walking (stepping ¡Ý30 seconds continuously), and other (incidental) stepping were calculated. On average, participants spent most time in the office (319.2¡À86.3 min) and the least time in the entryway (1.5¡À0.8 min). Half of all office time was accumulated in long continuous periods of ¡Ý50 mins; other locations had shorter accumulations. Sitting was common in the office only (80% sitting). Stepping was limited in the office (2%), highest in the entryway (65%), and intermediate elsewhere (13¨C26%) with the type of stepping being mostly incidental except for the entryway. Standing was most common in the photocopy room (72%) and kitchen (69%). Participants¡¯ own offices accounted for most workplace time and most sitting indicating that the office may be a key location to target sitting reduction. Other spaces that participants occupied more briefly appeared to promote incidental stepping, walking or standing. Strategies consistent with

these workersj¯ patterns may include providing standing/walking options within spaces that participants occupy for long periods (e.g., office) and promoting transitions between spaces.

1-19 Outdoor ambulation post-stroke classified by objective measures of free-living physical behaviour

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Background: The association between self-reported outdoor mobility and accelerometer-measured physical behaviour have previously been found in elderly after hip fracture. No such knowledge however has been found for persons post-stroke. The objective of this study therefore was to explore if self-reported outdoor mobility and measures of free-living physical behaviour are associated in a sample of long-term stroke survivors, and to find thresholds for determining outdoor walking based on an activity monitor. Methods: In this cross-sectional study the primary outcomes were physical behaviour data (upright time and stepping time) derived from the ActivPAL monitor and self-reported outdoor mobility assessed by item 1 from the Nottingham Instrumental Activities of Daily Living questionnaires and items 3 G-I from the RAND 36-item Short Form Health Survey. The association between physical behaviour and outdoor mobility was assessed by Spearman's correlation coefficients, and thresholds for determining outdoor walking will be explored by use of Receiver Operating Characteristic (ROC) curves. Results: 75 persons were tested in average 49 months post-stroke, they were 71 years and 60 percent were males. The sample spent on average 19.4 hours in sitting or lying, and only 1.2 hours of the 4.6 hours upright were spent in walking. 84 percent reported that they could walk outdoors alone, but 34 percent felt that their health were a great limitation if walking more than two kilometres. 12 percent also felt greatly limited when trying to walk one hundred meters. Average upright and stepping time were both significantly correlated with self-reported outdoor walking and limitation in walking distances due to health. Detailed analyses of physical behaviour are still ongoing and complete results will be presented at the ICAMPAM conference. Discussion and Conclusion: As the analyses are not completed we will present the discussion and conclusion at the ICAMPAM conference.

1-21 Interrater reliability of directly-observed stepping and reclining in lower limb amputees in a laboratory setting

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Introduction: Accurate measurement of physical behaviours in adults with lower limb absence is essential to report true patterns of physical behaviour and the effectiveness of interventions. Observation methods are often used for criterion-related validation. Establishing interrater reliability within direct observation methods is an important and necessary precursor to criterion-related validity studies. Purpose: To assess the interrater reliability for quantifying steps and reclining time in simulated lifestyle activities in adults with unilateral lower limb absence. Methods: 15 adults completed three trials of a simulated set of lifestyle activities including kitchen work, sitting and lying and purposeful walking. Trials were video recorded and subsequently analysed independently by three trained raters for three types of behavioural event (incidental stepping, purposeful stepping and reclining). Data were

analysed using oneway intraclass correlation coefficients (ICC) and oneway repeated measures ANOVA and effect sizes (Cohen's d). Results: Reliability was high for the reliability of three raters (ICCs ranged from .98-1.00 for the three types of physical behaviours), and also when adjusted for a single rater (ICCs ranged from .93-.99). Although there were significant ($p < .05$) mean differences among raters for incidental steps, total steps, and reclining time, these corresponded to small effect sizes ($d = 0.08$-0.29). Conclusions: Trained raters are able to consistently judge brief, incidental stepping and more prolonged stepping events as well as sitting and lying events performed by adults with unilateral lower limb absence in controlled laboratory simulations. Multiple raters are not needed in order to obtain reliable data. These data can be used to obtain a reliable record of physical behaviours for criterion-related validation of other measures such as accelerometers.

1-23 The use of accelerometers in cancer survivorship research: A review of data collection and processing methods and quality of reporting

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Background: The use of accelerometers to objectively measure physical activity and sedentary time in cancer survivorship research is becoming increasingly common. Decisions made during the collection and processing of accelerometer data can impact the summary measures obtained (e.g., minutes per day of moderate- and vigorous-intensity physical activity), as well as the associations between those summary measures and health outcomes. It is therefore vital that accelerometer data collection and processing decisions are clearly reported in journal articles arising from accelerometer-based studies. Failure to report this information means that studies are not replicable, and also makes it difficult to determine if discrepant results across studies are 'real' differences or are simply due to measurement and data processing issues. Aim: The aim of this review is to provide an overview of the data collection and processing methods that have been used to date in accelerometer-based studies conducted among cancer patients and/or cancer survivors, and to review the quality of reporting of the components of accelerometer use. Method: A comprehensive MEDLINE search (via OVID) was undertaken to identify relevant studies. In our review we will summarize and rate the quality of reporting of the data collection and data processing components of accelerometer use. This will include monitor used and body positioning, distribution mode, wear protocol, compliance, epoch length, non-wear time definition, criteria for a valid day of wear time, minimum number of valid days required, and the cutpoints used. Results/Discussion: A total of 37 studies have been identified. The majority of studies have used ActiGraph accelerometers and most have been conducted among breast cancer survivors. Few studies have used posture-based devices to measure sedentary time. The full results of this review will be presented at the conference.

1-25 AIRplay: promoting physical activity among children with asthma at school and at home

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BACKGROUND: Asthma is the most common chronic lung disease in childhood. The large majority (70-90%) of asthmatic children is affected by exercise-induced asthma which deters children from participating in regular physical activity or leads to dropping out of play and sports. Children with

asthma should be encouraged to exercise, as physical activity improves asthma symptoms and lung function. OBJECTIVE: To improve self-management of asthma in children (7-9 years old) by means of smart sensing and coaching incorporated in a mobile gaming environment in daily life. METHODS: An interactive playground resembling the known Tag game is installed at school and one class of students is invited to participate. The installation combines floor-projections with tracking and real-time analysis of the movement of the players [1]. Although AIRplay is initially conceptualized targeting children with asthma, all children in the classroom are invited to participate. The game was adapted to require mandatory breaks to all children and in this way, give time to children with asthma to take their medication. Additionally, all children receive a Fitbit Zip and an Android application. A personal physical activity goal is set based on one week of baseline measurement. In the application, the children can see their progress and of their friends towards the physical activity goal, as well as interact with each other. Finally, children with asthma receive tips on how to improve the self-management of asthma. RESULTS: The interactive playground was tested with enthusiasm by children aged 6 to 12 years old. Evaluations in the school environment will take place in April and May 2017. CONCLUSION: The AIRplay system is designed to promote physical activity by engaging children in a fun and exciting game, setting personalized physical activity goals based on the individual physical condition, and promoting a fair competition among children with and without asthma.

1-27 Quantifying the shoulder movement of manual wheelchair users in the real world using an array of inertial sensors

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Shoulder pain is the most common form of musculoskeletal pain in people with spinal cord injuries who use manual wheelchairs. To gain insight into the mechanisms of shoulder overuse injury, shoulder use in the real-world must be quantified. The purpose of this IRB approved study was to develop a methodology to accurately quantify shoulder movement in manual wheelchair users during day-long collections in their natural environment. We secured one inertial sensor each to the trunk and left/right upper arms using elastic straps; each sensor contained a 3-axis accelerometer, angular rate gyro, and magnetometer. Subjects performed alignment movements (a series of static postures and dynamic movements) at the beginning of each data collection, allowing us to deduce body segment-to-sensor alignments in post-processing. Through the use of the calculated body segment-to-sensor alignments (direction cosine matrices) and a Kalman filter, we were able to estimate the orientation of each body segment relative to gravity (i.e., body segment elevation angles). The estimated elevation angles were not subject to drift and did not rely on magnetometer measurements. The Abstract Supplement illustrates the elevation angle versus time as well a probability histogram (bin width = 0.5 degrees) for the right arm of a subject (male, 22 years, T5-T7 injury level, and 1.7 years post-injury) for a 10 hour long data collection. The elevation angles were not normally distributed; instead there were several peaks in the distribution, highlighting that different ranges of elevation angles are required for different tasks throughout the day. This sample data set demonstrates that shoulder movement can be meaningfully quantified using inertial sensors in the real-world, making it possible to understand the demands placed on the shoulders of manual wheelchair users. Future work will utilize the orientations between sensors to resolve shoulder plane of elevation and angle of elevation.

1-29 Using spiral plots to visualise upper limb activity for the assessment of prosthesis use

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A myoelectric prosthetic hand is intended to restore a level of functionality to a person who has experienced loss/absence. When a person with unilateral upper limb absence chooses not to use their prosthesis, they become heavily reliant on their unimpaired arm. Over time this can lead to overuse injuries to the joints and muscles of the upper body (Gambrell, JPO, 2008); nevertheless prosthesis rejection is consistently high with around 30% of users rejecting their prostheses (Biddiss, P&O Int, 2007). To date the main methods of evaluating user performance with a prosthesis have been clinical tests of functionality, and self-reported usage statistics. Activity monitoring offers the potential to quantify use of a prosthesis outside of the clinical environment, however, thus far has not been utilised for this purpose. As part of a larger study, trans-radial myoelectric prosthesis users who reported to be both satisfied and dissatisfied users of their prostheses, were recruited. Participants wore Actigraph GT3X+ monitors on both wrists (anatomical and prosthesis) for a seven day period allowing for comparison of activity between the two arms. In order to visualise patterns in prosthesis use throughout the week, spiral plots were used to show the percentage contribution from each arm during their everyday activities. The figure shows data from a healthy anatomically intact control subject (left) and a trans-radial myoelectric prosthesis user (right). From these graphs it is clear that the myoelectric prosthesis user is heavily reliant on the anatomical arm, unlike the control subject whose behaviour is primarily bilateral. Furthermore, it can be seen that the prosthesis user regularly removed the prosthesis in the evenings. In the past, prosthesis users have complained about battery life and prosthesis comfort. The authors therefore hope to highlight the potential of spiral plots to explore potential causative factors leading to prosthesis usage behaviours.

1-31 Use of Microsoft Bands as an Outcome Measure in Boys with Duchenne Muscular Dystrophy

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Objective: Multi-sensor portable fitness tracking devices (PFTDs), such as the Microsoft Band (MSBand), have the capability to capture important health indicators throughout the day and night. Our objective is to establish the potential of the MSBand as an outcome measure to quantify and detect change in activity patterns in boys with Duchenne Muscular Dystrophy (DMD) during an ongoing clinical trial. Methods: Current PFTDs are restricted in their ability to collect, process and summarize raw data into outcome variables that identify functional and behavioral patterns. To surmount this technical hurdle, our team has implemented a novel app which couples the MSBand to a Wi-Fi phone to collect raw data with control software. To date, 32 boys with DMD, aged 4-15, have worn the MSBand day and night for two weeks, with a 6-month follow-up (n=6). We have also implemented an ancillary project to a NIH-funded first-in-patient drug development study, and are currently collecting daily activity data on DMD clinical trial participants. Results: The MSBand and app are reliable, valid and sensitive to measuring daily activity and sleep patterns in boys with DMD. Longitudinal follow-up demonstrates changes and variations in activity patterns and correlates activity and sleep efficiency ($r2 = 0.299$; $p = 0.001$). Specific clinical measures of function (velocity of stair climbing) collected during the clinical trial correlate with gyrometry ($r = -0.552$; $p = 0.000$). Conclusion: Current research with the MSBand and app is providing pertinent biological and behavioral information regarding activity patterns and changes over time in children with DMD. Systematic data collection, analyses and modeling, as well as interpretation, is

providing valuable information for clinical trials and clinical intervention. Establishing the validity of PFTDs for patients will support the healthcare systems' emphasis on proactive, preventive, evidence-based and person-centered models of care.

1-33 Functional Data Analysis :An Insight into the Circadian Activity Patterns of Middle Aged Men and Women

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Background: Accelerometers can provide an objective measure of physical activity. This data is often reduced to simple summary measures which can mask temporal effects. Functional Data Analysis (FDA) can be used to address this issue and analyse data in a more comprehensive way. Methods: Activity patterns were recorded with a GENEActiv accelerometer in 5 minute epochs for at least five days. Function on scalar regression is applied to this accelerometer data to analyse the effect of a single covariate and multiple covariates on physical activity respectively. These function on scalar models are compared to simple summary measures to highlight the efficiency of FDA to capture temporal information. A Kruskall-Wallis test is utilised as a simple summary measure to test whether average activity is equal amongst groups of a single covariate and a multiple linear regression (MLR) is utilised to assess the impact of multiple covariates on average activity. These methods are used to statistically assess the impact of gender, age, body mass index, smoking status, education, depression and environmental factors on circadian activity patterns of 351 participants aged between 48.9-71.1 years recruited within the Mitchelstown cohort (Ireland). Results: The multiple FOSR identified that age, obesity, smoking, level of education attained, gender and duration of daylight were associated with time specific differences in activity throughout a day. The magnitude of the effect smoking and obesity on activity were on par with the negative impact of ageing on activity. Discussion & Conclusion: Compared with analyses using summary measures (e.g. average activity), FDA reduces information loss about the timing and structure of physical activity. Knowledge of this temporal information is of value and may be used as a guide for targeted interventions. This methodology can be extended to assess the impact of subject specific interventions, subject compliance, environmental effects & social.

1-35 Association between the yearlong physical activity and perceived residential environment: the Nakanojo Study

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INTRODUCTION Our aim was to determine associations between objectively measured physical activity and the perceived neighborhood environment (NE) of elderly individuals. METHODS Subjects were Japanese aged 65-84 years (112 men, 119 women). 24-h pedometer/accelerometer data were collected continuously for 365 days, following a baseline assessment of perceived residential density, mixed land use, safety and street connectivity, using the short version of the Neighborhood Environment Walkability Scale. We examined the association of habitual physical activity with walkability index parameters in terms of levels (the intercept) and the rate of change (linear and quadratic slopes) of physical activity after adjustment of data for appropriate covariates. RESULTS Several NE factors, especially lack of land use mix diversity, poor access to recreational facilities and safety, were associated with a reduced likelihood of taking more than 7000-8000 steps per day or performing more than 15-20

min of physical activity at an intensity >3 METs. Daily step counts and daily duration of habitual activity >3 METs were greatest with a land use mix diversity at 10-15 min walking distance. Above and especially below this distance, physical activity decreased as a quadratic function of land use mix diversity. DISCUSSION AND CONCLUSIONS The daily step count and the duration of habitual physical activity >3 METs are associated with land use mix and environmental safety. Since land use diversity seems a key factor when promoting daily physical activity, city planners should endeavor to improve such diversity.

1-37 Accelerometer measured levels of physical activity and sedentary behavior in children with chronic diseases: a systematic review and meta-analysis

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Moderate-to-vigorous physical activity (MVPA) and sedentary behavior (SB) are important for child health but there is much less information about these behaviours in children with chronic diseases. Objective: To examine accelerometer measured MVPA and SB in children with chronic disease compared with current MVPA recommendations, and with levels in healthy peers. Methods: An extensive search was carried out in Medline, Cochrane library, EMBASE, SPORTDiscus and CINAHL from 2000-2015. Study selection: Studies of accelerometer-measured MVPA and/or SB (at least 3 days and 6 hours/day) in children (0-19 years) with cardiovascular disease, respiratory disease, diabetes, and malignancy who, studied while well and clinically stable. Results: Out of 1505 records, 20 studies were eligible; 11/20 studies included in meta-analysis. 14/20 eligible studies compared levels of MVPA between patients and healthy peers; 11/20 studies provided data on SB. Patient MVPA was below the recommended 60 min/day and SB generally high regardless of the disease condition. Comparison with healthy controls suggested no difference in MVPA between controls and patients with cardiovascular disease (1 study, n=42) and type 1 diabetes (5 studies, n= 400; SMD -0.70, 95% CI -1.89 to 0.48, p=0.25). In children with respiratory disease MVPA was lower than controls (4 studies, n=470; SMD -0.39, 95% CI -0.80, 0.02, p=0.06). Meta-analysis indicated significantly lower MVPA in children with malignancies than in the controls (2 studies, n=90; SMD -2.2, 95% CI -4.08 to - 0.26, p=0.03). SB was fairly consistently higher in the children with chronic diseases but there no marked differences with healthy peers. CONCLUSIONS: MVPA in children with chronic disease appear to be well below recommendations, although comparable with activity levels of their healthy peers except for those with malignancies. Tailored intervention strategies will be needed to increase MVPA and reduce SB in children with chronic disease.

1-39 Effect of three ActiGraph wear-time estimation methods on levels of physical activity and sedentary behavior

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Purpose: To compare estimates of free-living physical activity (PA) and sedentary behavior (SED) using the GT9X during wear-time detected by the monitor's wear-sensor and count-based Troiano-2007 and Choi-2012 algorithms. Methods: Twenty four participants (mean ± SD: age= 22.7 ± 5.0 years, BMI= 23.0 ± 3.5 kg/m2) wore a GT9X on the dominant waist for 2 days while awake (mean wear-time ± SD: 22.6 ± 4.8 hrs.). An independent temperature sensor and self-report was used to derive criterion wear-time.

ActiLife 6 was used compute wear-time using the wear-sensor, and the two count-based algorithms. Proportion of time spent being SED, and in light-intensity (LPA) and moderate-vigorous intensity PA (MVPA) was calculated using Freedson's 2013 VM cut-points. Proportional estimates of PA and SED between the criterion and 3 methods were compared using one-way analyses of variance ($p < 0.05$). Results: Mean wear-time estimates for the criterion, wear-sensor, and the Troiano and Choi algorithms were 15.3 ± 6.4, 15.0 ± 5.8, 15.8 ± 5.3, and 17.4 ± 7.4 hrs/day, respectively. There were no significant inter-method differences in estimating proportions of SED [F (3,69) 0.671, p= 0.573], LPA [F (3,69) 0.625, p= 0.601], or MVPA [F (3,69) 2.503, p= 0.066]. However, Troiano and Choi methods overestimated time spent in MVPA by 17.2 ± 22.6 and 16.3 ± 22.5 min/day, respectively. Conclusions: While there were no differences in proportions of PA and SED when using the three wear-time methods, count-based methods may misclassify non-wear minutes containing motion artifact, as wear-time and thereby, as MVPA when using Freedson VM cut-points. Although the wear-sensor, yielded similar estimates of MVPA as the criterion in this pilot study, similar to advanced methods to detect true PA and SED, future studies may need to comprehensively examine the performance of the wear-sensor and the need for supplemental methods to accurately detect wear-time.

1-41 Detection of risky event during box-lifting

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Introduction sEMG and accelerometry (Acc) enables quantification of exposure during occupational lifting. Using a supervised learning approach, recordings can be divided in training and testing datasets to predict lifting tasks. Aim To detect risky events during a box-lifting. Methods Twenty-six males lifted a box with 16-18-20-22-24 kg in forearm distance and a 16 kg box in 3/4 arm distance, and 8-12-16 kg asymmetrically. sEMGs from shoulders and low back were recorded. Acc were placed on the shoulders, back, and legs. For each lifting task, maximal muscular activity was obtained by calculation of RMS of the sEMG. The forward and sideway inclination of Acc signals were also obtained with respect to a reference position. sEMG signals and Acc data were rendered the feature vector for a linear discriminant analysis to classify the lifting tasks. The classification accuracy was assessed by a 3-fold cross validation approach. Further, to derive a subject-specific threshold for detecting the risky events, the 20 kg lift in forearm distance was used as the reference to define the threshold used for comparison across lifting conditions and the lifts with higher loading or asymmetrical position of trunk considered as risky events. Results After 20 iterations, overall accuracy of the classification based on sEMG RMS values and inclination angles was 21.8%. The use of individual threshold values based on the 20 kg lift in forearm distance resulted in an increased classification rate, i.e. 76.3%. Discussion The use of an individual compared with a global threshold resulted in improved classification accuracy indicating that such approach should be used to detect potentially risky lifts. Conclusion A subject specific thresholding applied to maximal muscle activity and extent of forward and sideway inclination of body segments can be used to discriminate between different lifting loads during box lifting. Funding The Danish Council for Independent Research (DFF - 4092-00320)

1-43 Agreement of activPAL3 with ActiGraph for measuring Moderate to Vigorous Physical Activity

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Purpose: To assess the agreement of published methods of calculating moderate to vigorous physical activity (MVPA) for the activPAL and ActiGraph monitors. Methods: Adults (n=24) wore an activPAL3 and an ActiGraph GT3X concurrently for 1 day. Six published ActiGraph cut-points (epoch length/cut-point/axes used/development population): AG1 (1s/56/vector magnitude (VM)/children); AG5 (5s/167/vertical axis (VT)/children); AG15 (15s/505/VT/older adults); AG1952 (60s/1952/VT/adults); AG2690 (60s/2690/VM/adults); AG3208 (60s/3208/VM/adults); two activPAL methods based on cut-points for sum of acceleration: aP1418 (15s/1418/VT/children); aP2997 (15s/2997/VT/adolescents); and one activPAL method based on a cadence threshold for walking events: aP100 (-/100steps/min/-/adults) were assessed. Agreement of time spent in MVPA was assessed pair-wise using the Bland-Altman technique. Results: Mean time spent in MVPA ranged from 60±32min (aP100) to 145±57min (aP1418); activPAL methods produced both the highest and lowest values. The smallest bias was for aP2997 and AG1, but the limits of agreement (LOA) were wide (Table). The aP100method showed small biases (<6min), and moderate LOAs with four ActiGraph methods. The aP1418 method showed large bias with all ActiGraph methods. Agreement between the ActiGraph methods was excellent between methods using the vertical axis (bias <2min, LOA <6min). Discussion: Objective monitors require interpretation of the output to convert measured acceleration into intensity of activity. Although many validated cut-points exist for the ActiGraph monitor, there is debate concerning which is best. Cut-points should be population specific, but as published activPAL methods were not developed using adults, we compared against ActiGraph cut-points for other populations. MVPA derived from activPAL event-based cadence (aP100) showed the best agreement with the ActiGraph (~6min bias), including the widely-used Freedson cut-points (AG1952).

1-44 Systematic calibration of self-report questionnaires against objective measures of sedentary behaviour in older adults

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Purpose: To systematically calibrate self-report sedentary behaviour (SB) tools against an objective postural measure (activPAL3). Methods: Older adults from 2 existing UK cohorts (LothianBirthCohort1936 aged~79, West of Scotland Twenty07 aged~63; ~83) wore an activPAL3 continuously for 7 days (n=700 analysed), and completed 3 sets of self-report SB questions, before (assessing usual week), and during (assessing previous day and previous week) monitor wear. Each set of questions considered 7 types of SB assessment questions (total sitting time, proportion of day sitting [VAS scale], proxy measures [TV time, screen time], sum of domains, sum of behaviours, pattern). Objective daily sitting time (excluding self-reported sleep) was used to calibrate all self-report measures, by adding a fixed correction factor self-reported SB. Outcomes of correction factor, %overlap of corrected distribution, correlation, and %missing data were used to identify optimal self-report questions. Results: In general, the previous day recall period resulted in less missing data (0.5-5%) than previous week (0.5-16%) or usual week (2-10%). The sum of behaviours (5-16%) and pattern (10-15%) questions had most missing data. Within each recall period, total sitting time (89-96%), TV time (86-90%) or screen time (90-92%) had the best overlap of distribution with the objective measure. However,

proportion of the day spent sitting (VAS scale, 0.30-0.34) and sum of behaviours (0.26-0.33) had the highest correlation with objective measures. Correction factors to calibrate self-report varied from -4.0 to +7.4 hours/day. Conclusions: As originally recorded, none of the self-report measures reported was an accurate measure of self-report sedentary behaviour. Total time spent sitting the previous day (1.2% missing, 96% distribution overlap, +3.53h/day correction) was best for group mean, and proportion of the previous day sitting (0.8% missing, r=0.32) was optimal to rank individuals.

1-47 Cadence cut-point thresholds for moderate-intensity ambulatory activity in children and adolescents: The CADENCE-Kids study

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BACKGROUND: Cadence (steps/min) has been used to infer intensity of adult ambulatory activity, an important constituent of public health physical activity guidelines. PURPOSE: To identify cadence cut-points linking visually observed cadence with absolutely-defined moderate-intensity across in children and adolescents. METHODS: 123 participants between 6-20 yrs (at least 24 per each 3-year age group) were recruited. Participants completed up to ten 5-min treadmill bouts of incrementally faster speeds (from 0.5-5.0 mph in 0.5 mph increments) as tolerated or until running occurred. Cadence was visually observed. In order to calculate Youth metabolic equivalents (METy), resting mass-specific VO2 estimated using the Schofield equation was used for participants between 6-17 yrs, while 3.5 mL/kg/min was used to calculate traditional metabolic equivalents (METs) for participants between 18-20 yrs. Moderate-intensity was defined either as ?4 and <6 or ?3 and <6 for METy and METs, respectively. A total of 848 treadmill bouts were used for analyses after excluding incomplete bouts. Linear mixed-effects regression models with random effects for participants and Receiver Operating Characteristic (ROC) were used to estimate optimal cadence cut-points. RESULTS: In general, an inverse relationship between cadence cut-points and age was observed. Regression-based cut-points consistent with moderate-intensity ranged from 128.4 steps/min for 6-8 yrs to 87.2 steps/min for 18-20 yrs. Comparable ROC-based cut-points ranged from 121.3 to 95.9 steps/min. CONCLUSION: Heuristic values (i.e., evidence-based, practical, rounded cut-points) for cadence associated with moderate-intensity in children and adolescents range from approximately 90 to 125 steps/min, with higher values for younger children. Future research will establish the consistency and utility of these findings in support of measurement and promotion of healthful ambulatory activity in children and adolescents.

1-49 Cross-Validation of Machine Learning Algorithms During Exergaming for Youth

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Machine learning models have been used to create algorithms to estimate energy expenditure across different populations and settings, but few have been cross-validated in a different population. PURPOSE: To cross-validate a machine learning model created for energy expenditure estimation in youth during exergaming. METHODS: Youth, 10-13 years (n=34), wore a portable metabolic analyzer (Oxycon Mobile) and GT3X+ ActiGraph accelerometers on the right hip and wrist for four 15-minute sessions involving 2 of 4 Xbox 360 Kinect exergames (2 games in both single and multi-player modes. For each monitor, mean and variance of the raw data (collected at 30 Hz, reintegrated to 1-sec activity counts) for each axis and vector magnitude were extracted in 15-second epochs. Previously created

machine learning models were used to predict energy expenditure (METs) from the data for the hip, wrist, and a combination of both. Results from the machine learning predictions were compared to measured METs using correlations, root mean square error (RMSE) and bias statistics. Repeated measures ANOVA with post-hoc Bonferroni tests were used to compare model outcomes. RESULTS: Correlations between predicted and measured METs ranged from 0.37 (wrist) to 0.73 (hip; $p<0.05$). RMSE was 2.25 METs for the wrist, 1.77 METs for wrist-hip combined and 1.21 METS for the hip. All between-model comparisons significantly differed ($p<0.05$). Wrist (1.39 METs) and wrist-hip combined (0.87 METs) models significantly overestimated ($p<0.05$). DISCUSSION: The machine learning model for the hip accelerometer outperformed those for the wrist and wrist-hip combined. Correlations for the hip monitor cross-validation were slightly lower than the original validation; however RMSE was similar. Neither the validation nor the cross-validation showed significant bias for the hip monitor. Applying previously-developed machine learning algorithms to similar populations for similar activities may be appropriate.

1-51 A Novel Posture Based Approach To Fall Detection

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BACKGROUND With a growing number of older adults, falls and their associated consequences are an increasing global health problem. It is widely accepted that there is an urgent need for improved automatic detection of falls, as current technology performs poorly and uptake is low. This study introduces a novel posture-based approach to fall detection. METHODS An algorithm was developed to detect falls through monitoring of changes in posture. The design was based on the premise that older adults would most commonly lie when in bed, and would pause in a seated posture as they got into bed. Therefore, any transition from upright to lying without a 'reasonable' period of being in a seated posture would signify a fall. The algorithm had one adjustable parameter, S, the length of time spent sitting before changing to a lying posture. This value was used to discriminate falls from controlled transitions. The algorithm's performance was evaluated using two datasets; 144 simulated falls carried out by 8 healthy adults and 171 days of free-living data from 99 patients in a geriatric rehabilitation ward. The latter dataset contained no known falls. Data were collected using an activPAL3 attached to the thigh. 8-fold cross validation was used to optimise S and test sensitivity and false positive rate. S was optimised using Youden's index for values of S from 0s to 5s in 0.1s increments. RESULTS Through 8-fold cross validation the optimised S was 1.44s ± 0.17 (mean ± SD). The mean sensitivity to detect the simulated falls was 96.5% ± 2.7. In the free-living data set 0.72 ± 0.16 false positives were detected per day. CONCLUSIONS The use of posture change as a method to detect falls shows great potential and the low false positive rate is particularly encouraging. This approach needs to be tested using real-world falls.

1-53 Frequency filtering and the aggregation of raw accelerometry into Actigraph counts

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Introduction: Generating a comparable Actigraph (AG) counts output with alternative accelerometer brands is challenging due to the frequency filtering used in the aggregation. To date, no successful

solution has been obtained. The aim of this study was to investigate a method for generating AG counts using acceleration data from an alternative device and to evaluate alternative frequency filtering to reduce the measurement bias observed at high locomotion speeds. Methods: The AG aggregation method and band-pass filter was identified and replicated by evaluating the output from a sinusoidal acceleration entered into Actilife. The replicated AG aggregation was applied to the Axivity AX3 monitor and validated using a mechanical setup and 24-hour free-living recordings from 9 subjects. Locomotion-optimized frequency filtering was developed and evaluated based on AG acceleration data generated in 63 subjects divided into three age groups (children, adolescents, adults) engaged in a standardized 4-speed walking and running protocol. Results: The mechanical validation demonstrated almost identical output across all rotational frequencies. The free-living data showed a quadratic weighted Cohen's Kappa of 0.945 with intensity classification and an absolute difference ranging from -0.5% to 4.7% with habitual activity. The measurement bias at high locomotion speed was confirmed for the original AG aggregation in all age-groups, whereas it was clearly reduced with the locomotion-optimized frequency filtering. Conclusion: The proposed aggregation method is valid for generating AG counts with alternative brands of activity monitors measuring raw acceleration. The addition of the new frequency filtering improves assessment of high-intensity physical activity. Albeit, reducing the measurement bias eliminates the presence of the original linear association between locomotion speed and counts output at locomotion speeds below 10Kmh-1.

1-55 Improved classification accuracy of resistance training exercises using wrist-worn activity monitor

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Using a wrist-worn activity monitor, previous research has found that resistance training exercises can be accurately classified with around 80% accuracy (Conger et al., 2016). More sophisticated modeling techniques may be able to improve on the accuracy of classifying this type of activity. PURPOSE: The purpose of this study was to examine the use of a wrist-worn, tri-axial accelerometer-based activity monitor (ActiGraph Link) for classifying upper- and lower-body dumbbell resistance training exercises using convolutional neural networks (CNN). METHODS: A total of 144 participants were asked to perform one set of ten repetitions using light weight dumbbells during 12 different dynamic dumbbell exercises. The exercises included: bench press, shoulder press, biceps curls, upright rows, lateral raises, triceps extensions, triceps kickbacks, bent-over row (standing), bent-over row (kneeling), goblet squats, walking lunges, and calf raises. Participants' data were divided into three groups: 68 in the training group, 18 in the validation group, and 58 in the testing group. Tri-axial accelerometer, gyroscope, and magnetometer data were utilized in development of prediction model. A confusion matrix was used to assess accuracy of the prediction model. RESULTS: Each participant completed all exercises. Data from the magnetometer did not significantly improve the model, thus was not used in the model development. Using the tri-axial data for the accelerometer and gyroscope for the CNN model, the confusion matrix indicated that the model was able to accurately predict the individual exercise 93.7% of the time. The accuracy for the individual exercises ranged from 77.6% to 100% with ten of the twelve exercises demonstrating accuracy of 93.1% or higher. CONCLUSION: This study demonstrated that accuracy for predicting resistance training exercises from a wrist-worn activity monitor is improved using CNN.

1-57 Optimal motion and mobility aid manipulation planning to enable personal activity monitoring and facilitate safer sit-to walk transitions

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One of the most prevalent contributing factors to falls observed in the hospital and long-term care facilities is the lack of mobility aid usage and transferring to and from a mobility aid for ambulation. Currently, available technology including bed alarms, visual observations and wearable devices is mostly for monitoring individuals. All of these technologies have only marginally addressed the urgent need to reduce patient falls because they only provide an alert and a limited amount of time to respond to an event. Hence, an intelligent mobile patient assistant robot is needed to bridge the gap that exists in modern fall monitoring technology. A mobile robot can dwell with a patient and respond like a nurse by providing physical assistance (i.e. deliver a mobility aid). The robot should be intelligent enough to decide how and when to deliver a mobility aid, and be able to efficiently maneuver within a semi-structured environment without collisions. One of the challenges with this important task is the ability to manipulate the walker while moving. A synergy-based algorithm was developed for optimal motion planning and manipulation planning using Model Predictive Control (MPC) and convex optimization. The algorithm is able to avoid static obstacles in the environment and dynamic obstacles, including moving objects and humans. A main contributions of the proposed algorithm is the ability to consider human constraints and limitations in both decision making and path planning. Optimization objectives can be time minimization, path length minimization, energy minimization, or a combination. Using a synergy of convex optimization and MPC has the advantage of finding the global optimum path with high computational speeds. Thus, the robot can act fast in most events, which is critical for this application. Simulation results show the reliability and desirable performance of the algorithm in different environmental and individual conditions.

1-59 Towards an improved step detection algorithm based on continuous wavelet transform (CWT)

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When detecting steps with wearables, one often faces the problem of algorithms not performing well enough for special cases like slow gait speeds or impaired gait. A promising approach presents itself with the wavelet transformation, which is a known tool for the detection of irregular structures, e.g. peaks in a time series, and has also already been widely used for the analysis of physical behavior. Yet, most of these approaches rely on the well-established mother wavelets, which do not always suit a given signal pattern. A step detection algorithm is presented, which applies concepts of the wavelet transformation to 3D accelerometry data measured by an actibelt using a generic standard step pattern, thus, taking the waveform of a step into account. The presented step detection algorithm is layered into three different phases. First, regions of interest are detected within a given accelerometer signal using an activity count. In a second step gait sequences are extracted within those regions of interest using several metrics, including frequency and signal power relations. Finally, steps within the gait sequences are detected by convolving the signal with the generic step pattern. A feasibility check with the implemented step detection algorithm is performed by comparing the algorithm to two different step detection approaches. For this purpose a historic gold standard data set containing actibelt data for about 15

subjects walking at 5 different speeds was reanalyzed. The improvement in sensitivity, especially for slow gait speeds, is shown. Further refinement and validation using real world data is warranted.

1-61 Measurement of daily energy expenditure in humans using a body-worn direct calorimetry device

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PURPOSE: Previous approaches using body-worn devices to measure free-living daily energy expenditure (EE) in humans using direct calorimetry have been limited by an inability to accurately measure evaporative heat loss. The Personal Calorie Meter (PCM) uses a heat flow gauge embedded in a permeable membrane to measure dry and evaporative heat loss. Total heat flux and estimated body surface area are then used to estimate minute by minute EE. In this ongoing study, we compared daily EE measured using the PCM with concurrent measurements using whole-room indirect calorimetry (WRC). METHODS: Subjects were studied during two different 24-hour periods under low and high physical activity levels (PAL, ~1.4 and 1.7 x resting metabolic rate, respectively) in the WRC. During the low PAL condition, subjects performed 20 minutes of housecleaning activities. During the high PAL condition, subjects performed 30 minutes of treadmill walking, 30 minutes of stationary cycling, and resistance exercises using dumbbells. Daytime EE was calculated as the total EE from the time the subject entered the WRC until bedtime. RESULTS: 21 subjects (15 F/6 M, 50 ±18 yrs., BMI=26±5 kg/m2, mean±SD) have completed at least one study visit in the room calorimeter. During the low PAL condition (N=19), average daytime EE measured by the PCM (1203±387 kcal, mean±SD) did not differ from WRC (1329±232 kcal), but the range of intra-individual differences was large (-899 to +740 kcal). During the high PAL condition (N=17), average daytime EE measured by the PCM (1724±615 kcal) did not differ from WRC (1739±333 kcal), but there was a wider range of intra-individual differences than during the low PAL condition (-1188 to +1076 kcal). CONCLUSION: These preliminary data demonstrate the feasibility of measuring EE in humans using portable direct calorimetry. Further refinements are needed to improve the accuracy of the PCM on an individual level.

1-63 The difference in activity outcomes between an ankle-mounted and thigh-mounted accelerometer in knee osteoarthritis patients under free-living conditions

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The beneficial effects of PA on knee osteoarthritis (KOA) are well known. Activity monitors seem to offer the best balance for PA assessment in daily life. Their validity under laboratory-controlled settings has been demonstrated, yet different devices might produce different outcomes under free-living conditions. The aim was to compare the activity outcomes measured by an ankle-mounted and thigh-mounted accelerometer in KOA patients under free-living conditions. Thirty-five clinically diagnosed KOA patients were monitored for 1 week using an ankle-mounted bi-axial accelerometer (SAM) and a thigh-mounted tri-axial accelerometer (AX3). Activity parameters were extracted using custom-developed algorithms. Descriptive statistics, differences and correlations between both devices were determined. The AX3 measured significantly fewer steps (-4886 steps, -37.8%). However, a strong correlation exists between the measured steps (r=0.80, p=0.00). Also, the AX3 classified less time as active (12.7 vs. 44.0%) and more time as inactive (87.2 vs. 56.0%), compared to the SAM. Differences in measured steps

correlated with the AX3-measured time spent cycling (ρ=0.73, p=0.00). Both devices appear valid in controlled environments, yet differences in outcomes arise once employing both devices simultaneously under free-living circumstances. A possible explanation is the wear position, as thigh-mounted accelerometers systematically measure less daily steps (25-30%) compared to ankle-worn accelerometers. Moreover, the AX3 classifies crank revolutions as cycling whereas the SAM considers them as steps. Hence, the significant correlation between the difference in measured steps and time spent cycling measured by the AX3. Finally, the SAM classifies a higher percentage of the wear-time as 'active'. As the SAM-data is presented in 1-minute intervals, minutes containing e.g. few steps will therefore be classified as active minutes, even though only a couple of seconds were spent active.

1-65 Measuring upper limb activity with accelerometry in stroke patients

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A stroke often results in motor impairments of the upper limb (UL), which results in less UL activity in daily life. Optimizing UL activity in daily life is a frequent target of rehabilitation, and therefore assessing it is important. Accerelometry is an objective method to measure UL activity. Most devices developed so far have limitations from the viewpoint of feasibility, costs, user-friendliness, and validity. We present a new device (Activ-UL) that offers a solution for these limitations. The configuration of the Activ-UL is based on the Activ8; a single-unit, 3-axis accelerometer which measures time spend in several body postures and movements (P&M) and the intensity (movement counts) of those P&M per epoch. The Activ8 is designed to wear in a trouser pocket or at the front of the upper leg and is valid in both healthy subjects and stroke patients. To measure UL activity we use a new configuration in which we add two additional Activ8's, one on each wrist, with a wristband. The output of these additional Activ8's is total movement counts per epoch. The Activ-UL provides well interpretable outcome measures, such as the amount of unilateral and bilateral UL activity and the ratio of impaired-non-impaired UL activity during sitting and standing. The advantages of the configuration with one accelerometer on the leg, is that upper limb movement during e.g. walking is does not affect the outcomes. The validity of the Activ-UL is topic of a current study, as well as its use to assess UL recovery after stroke. Some future perspectives are its use in treatment, with feedback in patient-therapist meetings, or continuous feedback via an app on a smartphone. The Activ-UL can be used to personalize treatment and to set individual targets for rehabilitation. Another future functionality can be stimulating UL activity via auditory signals or vibrations.

1-69 Review of Statistical Methods for Ecological Momentary Assessment Data and their Application in a Study of Rhythms of Emotion, Activity, and Sleep in Individuals with Mood Disorders

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Continuing advancements in wearable technology have done much to facilitate the continuous collection of patient data, in particular with regards to ecological momentary assessments (EMA). The resulting increase in accuracy and resolution over multiple concurrent measures results in a rich set of data capable of answering many complicated and unique questions regarding subject health and mental status in multiple domains. The complex structure of data necessitates the development of analysis methods which take into account multiple levels, multiple modalities, and can quantify the relationship

between these various modalities in successive time periods. The first section of this talk will be a review of currently established methods for analyzing EMA data, detailing strengths and limitations of these methods. Following this review, we show an application of many of these methods to a large family study of the rhythms of emotion, activity, and sleep as trait markers of people with the full range of mood disorders.

2-2 The effect of location on walking behaviours of individuals with Intermittent Claudication

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Purpose: To explore differences in walking behaviour in different locations between participants with Intermittent Claudication (IC) and controls. Methods: Pairs of participants with IC and matched controls [gender, age ±5 years, home within 5 miles] wore an activPAL monitor and carried an AMOD AGL3080 GPS device for 7 days. GPS data categorised activPAL walking events occurring: at home (<=50m from home co-ordinates) or away from home; and indoors (signal to noise ratio <=212db) or outdoors. In each location, outcome measures (number of walking events, walking duration, steps, cadence) were compared between groups using a paired t-test (parametric) or Wilcoxon signed ranks test (non-parametric). Locus of activity (distance from home) at which walking was conducted was compared between groups. Results: Participants (n=56) were mostly male (64%) with mean age 67 [54-89] years. Severity of IC was moderate (ankle-brachial pressure index 0.71 [0.54-1.12]). Participants with IC spent less time walking and took fewer steps than the controls at all locations (table). In most locations, this walking was also conducted in fewer events. However, away from home the number of walking events was similar in both groups. Median distance from home of walking was similar between groups (1.1(2.8) vs. 2.3(2.7)km; p=0.092), but maximum distance from home was significantly lower in the IC group than the controls (3.7(6.8) vs. 8.2(7.3)km; p=0.003). Discussion: Participants with IC consistently walked for less time and took fewer steps than matched controls, and this did not differ by location. However, walking away from home was undertaken in a similar number of walking events, indicating that fewer steps were taken in each event and reinforcing the perception that people with IC have to stop regularly due to pain. Although the maximum locus of activity was probably reached by motorised transport, the IC group did not walk as far from home, possibly contributing to social isolation.

2-4 An investigation into the effect of lower limb exercise programme on objectively measured physical activity in individuals with knee osteoarthritis.

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Osteoarthritis (OA) is one of the leading causes of pain and disability. Exercise has been recommended as a core treatment for OA. Previous studies have shown that adults with symptomatic knee OA take between 4000-6700 steps per day, which is less than the recommended 7000 steps a day for developing and maintaining function. Therefore, the purpose of this study was to investigate whether an exercise programme changed activity atttributes such as length of time walking, standing, stepping, sitting, energy expenditure, and transitions, in individuals diagnosed with knee OA. Individuals radiologically and clinically diagnosed (American College of Rheumatology (ARC)) with knee OA were recruited to the study. Participants completed an 8-session lower limb exercise programme over a 4-week period. Activity data were collected using an activPAL activity monitor for 7 days at baseline and again 6-weeks

after the programme. Measurements included sitting time, standing time, walking time, stepping, energy expenditure and transitions. Data were analysed using paired sample t-tests. Forty-three participants (24 female; 19 male) completed the programme with a mean age of 64.36 (SD 8.92) years (14 kellgren-lawrence (KL) grade 2; 14 KL grade 3; 10 KL grade 4 and 5 ARC criteria). Walking times significantly increased on average from 8.1 hours, (SD 2.6) to 8.7 hours (SD 3), (p=0.03). Stepping time significantly increased on average from 37457, (SD 14505) to 40834, (SD 16299), (p=0.03). Consequently, the average steps per day increased from 7491 to 8166. Energy expenditure significantly increased on average from 166.5 hours, (SD 8.6) to 169.5 hours, (SD 7.4), (p=0.03). Significant results were only seen during weekdays, not at weekends. Our clinically significant findings demonstrate that a lower limb exercise programme increases objectively measured physical activity attributes and mobility in OA patients, therefore having a greater impact on developing and maintaining function.

2-6 Inertial sensor based normative spatiotemporal gait and postural sway parameters in typically developing children and young adults

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BACKGROUND: The use of inertial sensors to analyze gait and balance is increasingly popular due to their portability, relatively low cost and ability to be used in the clinic or community. One widely-used system is MobilityLab (APDMTM). However, normative data using this system has not yet been established in children or young adults and is essential to compare with data obtained in clinical populations. METHODS: We collected gait, turning and balance data from an instrumented self- selected and fast paced 2 minute walk (i-WALK) and i-SWAY in typically developing children and healthy young adults between the ages of 5 and 30 years of age (n=95) . Data was stratified into the following age group 5-6 (n=14); 7-8 (n=16), 9-10 (n=7), 11-13 (n=13), 14-21 (n=9), and 22-30 (n=36) years. RESULTS: There were no differences between male and female metrics; therefore data was combined for analysis. Means, standard deviations and age based comparisons for spatiotemporal and turn measures are presented in Table 1. Cadence decreased significantly from 5 yrs. to those > 14 yrs., gait speed achieved adult values by 8 yrs. and gait variability decreased from age 5 to adulthood . Swing/stance/ double support times did not differ between groups. Absolute stride length increased with increasing age but when expressed as % height did not. Turn duration was longer in those 22-30 yrs. compared to 5-8 yrs. but the number of steps to turn did not vary between groups. Children aged 5-8 had increased postural sway measures on many i-SWAY conditions (eyes closed, on foam, tandem) compared to older age groups. CONCLUSIONS: Normative data from this study may be useful to clinicians and researchers using the MobilityLab system to analyze gait and balance in children and young adults. Further validation of this system with gold standard methods is needed in children.

2-7 Objective inertial sensor based gait outcome measures for efficacy of cyclodextrin treatment in Niemann-Pick Type C1 (NPC): Preliminary analysis

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OBJECTIVE: To longitudinally evaluate the efficacy of hydoxypropyl-ß-cyclodextrin (HP-ß-CD) treatment on ambulatory function in NPC1 METHODS: Three patients with NPC were treated biweekly with HP-ß-

CD intrathecally through an expanded access IND. Disease course for ambulation was tracked every 2 to 3 months for 30 to 36 months with an inertial sensor system (Mobility Lab APDM, OR). An instrumented two minute walk test (i-WALK) was used in 2 patients and a 7 meter Timed Up and Go (i-TUG) was performed 6 times in the third. Percent of scores improved by >10%, changed by <10% (unchanged/stable), and worsened by >10% from baseline to present was quantified for each gait and turn parameter. RESULTS: Subject 1 (age 17) presented with cerebellar gait ataxia. 6/13 variables improved (stride velocity 20%, cadence 16%, double support time 14%, gait variability for stride length 29%, velocity 20%, and frontal plane trunk ROM 36%), 5/13 stayed the same and 2/13 worsened (frontal trunk ROM 29%; number of steps to turn 15%) over time. Subject 2 (age 15) presented with normal gait except for slightly increased gait variability and double support time. 1/13 variables improved (double support 24%), 8/13 stayed the same, and 4/13 worsened (frontal trunk ROM 19%, gait variability for stride length 97%, velocity 57%, cadence 27%). Subject 3 (age 14) presented with a clumsy, slow gait, severe cognitive dysfunction and intractable seizures. 6/15 variables improved (frontal plane trunk ROM 37%, turn duration 15%, turn to sit velocity 26.5% and duration 38%), 5/15 remain unchanged and 4/15 worsened (stride lengths 21%, gait variability for stride length 22%, velocity 82%, and frontal trunk ROM 52%). CONCLUSIONS: The use of the Mobility Lab inertial sensor gait analysis system is feasible to determine efficacy of pharmaceutical interventions in neurological populations. HP-ß-CD treatment appears to have stabilized or improved the majority of gait outcomes in this NPC1 cohort.

2-10 Classification of occupations by accelerometer-derived variables for physical behaviour: Health Survey for England 2008

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Objective: Leisure time sedentary behaviour (SB) is known to be associated with a number of health-related outcomes (HRO); however, for those who are economically active, occupational activity (OA) contributes towards their daily physical activity (PA) and SB. It is known that office-based workers accumulate the majority of their sitting time at work. There is limited research into OA across other occupational categories; therefore, the aim of this study was to classify occupational categories into low, intermediate and high OA, based on accelerometer activity variables. Methods: Based on methodology from a study in the USA using the National Health and Nutrition Examination Survey (Steeves et al., 2015), accelerometer-derived variables were computed from the Health Survey for England 2008. For each of the 25 sub-major groups of the Standard Occupational Classification 2000, the following variables were derived: total activity counts/day, activity counts/min, proportion of wear-time in SB, light PA, lifestyle PA and moderate-to-vigorous PA. The sum of the ranks of these variables was used to create a summary score for each occupational category: this score was ranked to establish categories with low, intermediate and high OA. Results: Of the 2356 adults with accelerometer data, 839 were in full-time employment and provided ≥4-days of valid data (≥10 hours wear-time). 'Health professionals' were classified as having lowest OA; 'Skilled agricultural trades' were classified as having highest OA (Table 1). Employees in high OA categories were more likely to be older and male compared to those in low OA categories. Conclusions: Objectively measured OA allows for further exploration of OA with HRO.
Steeves, J. A., Tudor-Locke, C., Murphy, R. A., King, G. A., Fitzhugh, E. C., & Harris, T. B. (2015). Classification of occupational activity categories using accelerometry: NHANES 2003-2004. International Journal of Behavioral Nutrition and Physical Activity, 12(1), 89.

2-12 Stand up to loose fat? Standing versus sedentary behaviour increases fat oxidation and energy expenditure

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Aim. Some studies have shown an increase in energy expenditure in response to standing versus sitting, but data so far is still limited and inconclusive. This study aimed to measure the energetic cost and substrate oxidation of standing versus sedentary behaviour using a respiration chamber, thereby better mimicking a daily life situation where a sitting working desk would be replaced by a standing desk. Methods. Twelve subjects (1 male, 11 female) with a mean age of 20 ± 1 y and a BMI of 22.7 ± 3.2 kg/m² entered the respiration chamber in the morning after an overnight fast. First, basal metabolic rate (BMR) was measured for 35 minutes while the participants lay on the bed awake and motionless. Then subjects spent 30 minutes seated comfortably in a desk chair performing computer work and thereafter spent 30 minutes standing comfortably on both feed while performing computer work on a standing desk. Oxygen consumption and CO2-production were measured continuously over the entire interval. Prior to entering the chamber, three accelerometers were attached with adhesive tape, one to the sacrum and one to each leg (just above the knee). Differences between conditions were tested with repeated measures ANOVA. Results. EE significantly increased from laying to sitting (1.15 ± 0.12 vs. 1.31 ± 0.18; $p<0.01$) and from sitting to standing (1.43 ± 0.22; $p=0.018$) (Figure 1A). The RQ decreased from 0.85 ± 0.09 for laying to 0.79 ± 0.04 for sitting and 0.77 ± 0.06 for standing ($p=0.016$) (Figure 1B). Movement of mainly the right leg increased significantly during standing ($p<0.01$) (Figure 1C). Discussion. This preliminary analysis indicated that EE and fat oxidation increased as a consequence of standing which seems at least partly explained by increased leg movement. Applying a standing desk in the office may have positive effects on energy balance.

2-14 Actigraphy-based Assessment of Circadian Rhythm: Association with Subclinical CVD Measures among Police Officers

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OBJECTIVE: Associations between actigraphy based estimates of circadian rhythm and cardiovascular disease have not been investigated among police officers. Literature describing the methodology for estimating circadian rhythm parameters from wrist activity data are scarce. This study provides the method for estimating parameters of circadian rhythm from wrist movement data and examine the association of these parameters with subclinical CVD measures: carotid intima media thickness (IMT), brachial artery flow-mediated dilation (FMD), and ankle brachial index (ABI). METHODS: Participants were officers from the first follow-up examination of the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study. Wrist movement data were collected using an actigraph. A cosine curve with a 24-hour period was fit to estimate the three parameters of a circadian rhythm: Mesor, Amplitude, and Acrophase. The common carotid artery (CCA) intima media thickness (IMT), and FMD were assessed using ultrasound. Correlation analyses were used to assess associations between circadian rhythm parameters and the subclinical CVD measures. We utilized data from officers who wore the actigraph for at least 7 days and had non-missing values for CVD measures (n=210). RESULTS: Following adjustment for demographic and life style variables, mean IMT was negatively associated with both mesor ($r=-0.15$, $p=0.037$) and amplitude ($r=-0.15$, $p=0.047$). Similarly the maximum IMT was negatively associated with

both mesor (r=-0.19, p=0.009) and amplitude (r=-0.16, p=0.030). FMD was negatively associated with mesor (r=-0.18, p=0.012) while ABI was not significantly associated with either mesor or amplitude. CONCLUSION: Reduced levels of circadian rhythm parameters were associated with increased carotid arterial wall thickness and impaired brachial reactivity, early indicators of atherosclerosis progression. Future prospective studies that elucidate the underlying mechanisms of this relationship are warranted.

2-16 Development of a self-reported neighbourhood-specific physical activity questionnaire

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Purpose: To modify items from an established and widely-used self-report tool (International Physical Activity Questionnaire - IPAQ) to capture neighbourhood physical activity (PA). Methods: A convenience sample of n=68 Calgary (Canada) adults (age ≥20 years) completed a PA questionnaire on two occasions, 7-days apart. The questionnaire captured days/week and usual minutes/day of transport cycling (TC), transport walking (TW), leisure walking (LW), moderate physical activity (MPA), and vigorous physical activity (VPA) undertaken during the last 7 days. These IPAQ items were modified by adding 'inside your neighbourhood' within each question. To estimate test-retest reliability, days/week, duration/day, and duration/week between the two occasions, we conducted Wilcoxon signed-ranked tests and Spearman's rank correlations (r). Percent of overall agreement and Kappa statistics (κ) estimated the consistency in participation ('none' versus 'some' days/week). Results: The sample was mostly of women (63.2%) and those with university education (80.8%). The mean (±SD) age was 56.0±13.2 years. Reliability of reported participation in neighbourhood PA ranged from poor (MPA κ=0.23MPA) to moderate (VPA κ=0.59), while proportion of overall agreement ranged from moderate (MPA 64%) to excellent (TC 81%). Correlations between neighbourhood PA between the two occasions ranged from poor (MPA r=0.22) to moderate (VPA r=0.62) for days/week, poor (MPA r=0.22) to moderate (VPA r=0.58) for minutes/day, and poor (MPA r=0.19) to moderate (VPA r=0.60) for minutes/week. Excluding the non-participants from the analysis improved the reliability estimates for 8 of the 15 PA variables. Wilcoxon sign-ranked tests detected significant ($p<0.05$) differences in reported neighbourhood TC and TW for days/week, minutes/day, and minutes/week between testing occasions. Conclusions: Apart from MPA, our findings suggest that the modified IPAQ items can provide reliable estimates neighbourhood PA.

2-18 Older adults' step counts associated with both sitting less and standing more

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The slogan "stand up, sit less, move more" reflects a growing interest in multi-faceted physical activity interventions. When people sit less, they tend to increase light physical activity more than moderate-to-vigorous physical activity. It is less clear whether the pattern of sedentary behavior is associated with activity levels. This study tested the hypothesis that both the duration of sedentary behavior and the frequency of sit-to-stand transitions predict step counts. Community-dwelling older adults (n = 101) wore activPAL3 activity monitors for 15 consecutive days (exchanging the device after one week). Multilevel modeling was used to regress daily step counts on the frequency of sit-to-stand transitions and the duration of sedentary behavior (controlling for age, sex, and body mass index). Substantial within-person variation existed in daily sitting time (ICC = .50), the frequency of sit-to-stand transitions (ICC = .37) and step counts (ICC = .31). At the person level, older adults who sat less (b = -0.79, p < .01)

and stood up more frequently (b = 0.07, p < .01) took more steps on average. Sitting time was not associated with the frequency of sit-to-stand transitions on average (p > .05). At the within-person level, older adults took more steps on days when they sat less than usual (b = -0.51, p < .01) and stood up more frequently than usual (b = 0.05, p < .01). Men (b = 1.46, p=.01), younger participants (b = -0.09, p < .05), and those with lower body mass index (b = -0.11, p < .05) took more steps on average. Physical activity may be influenced by interrupting sedentary time more frequently as well as reducing total sedentary time. It may be easier to monitor the frequency of discrete behaviors, such as standing up, than it is to monitor the duration of continuous behaviors (e.g., walking, sitting). Experimental tests of interventions to break up sedentary time more frequently are needed to test this emergent hypothesis.

2-20 The volume and pattern of objectively-measured sedentary behavior among stroke survivors: Findings from REasons for Geographic and Racial Differences in Stroke (REGARDS) Study

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BACKGROUND: Accumulating evidence shows that sedentary behavior is associated with deleterious health outcomes; necessitating an urgent need to identify populations that spend excessive time sedentary. Few data exist examining sedentary behavior in stroke survivors relative to their peers. Using data from the REasons for Geographic and Racial Differences in Stroke (REGARDS) Study, the purpose of this secondary analysis was to examine differences between stroke survivors and control participants in their volume and pattern of objectively-measured sedentary behavior. METHODS: We studied participants with a self-reported history of stroke (n=285) and age, sex, and race matched controls (n=285) from REGARDS, a population-based study of black and white adults ≥45 years. Sedentary behavior was objectively measured among ambulating participants using a hip-mounted accelerometer worn for seven days. The volume of sedentary behavior (e.g. total sedentary time) was expressed as the percentage of wear time sedentary. The pattern of sedentary behavior (e.g. accumulation in prolonged, uninterrupted bouts) was defined as the percentage of total sedentary time accrued in uninterrupted bouts ≥30, ≥60, and ≥90 min. RESULTS: Stroke participants spent significantly more time sedentary compared to controls (Stroke: 82.8 ± 9.3% vs. Control: 77.6 ± 9.2%, p<0.001). Stroke survivors also accrued greater amounts of total sedentary time from prolonged, uninterrupted bouts ≥30 min (Stroke: 56.0 ± 18.2% vs. Control: 47.5 ± 15.0%, p<0.001), ≥60 min (Stroke: 33.8 ± 19.5% vs. Control: 25.5 ± 15.4%, p<0.001) and ≥90 min (Stroke: 20.2 ± 17.0% vs. Control: 13.9 ± 13.2%, p<0.001). CONCLUSION: Stroke survivors accrue higher volumes and exhibit more deleterious patterns (e.g. prolonged, interrupted bouts) of sedentary behavior than their peers. Research examining sedentary behavior as a therapeutic target for secondary prevention of stroke survivors may be warranted.

2-22 StepWatch Activity Monitor and Actigraph Use in Wheelchair Athletes

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The StepWatch Activity Monitor (SAM) and Actigraph GTX3 have both been shown to be 96-100%, accurate, when compared to steps observed during laboratory-based ambulatory activity. While they

are excellent tools to measure community walking, some patient populations function in the community using a combination of both walking and wheelchair activity, and a further subset of these patients use a wheelchair for transport, as well as sports. The purpose of this study was to assess the accuracy of the SAM and Actigraph during wheelchair activities at two exercise levels, both which should have a zero step count. Two independent cohorts were tested. Group 1 consisted of twelve healthy adults performing a six minute push test (SMPT). Group 2 were eight members of an adolescent wheelchair basketball team tested during a 2hr scrimmage/practice. Visual observation was used to confirm the number of ambulatory steps taken was zero. The hypotheses were that manual wheelchair propulsion at a steady state (SMPT) would result in no steps counted by the SAM/Actigraph, while both devices would erroneously count "steps" during the sporting activity. The average number of "steps" taken during a SMPT was 19±25 (range:0-85) with the Actigraph. No "steps" were detected using the SAM in Group 1. In Group 2, the average "step" count during basketball practice was 1421±750 (range:612-2798) using the Actigraph and 1363±1238 (range:84-3462) using the SAM, and correlated with playing time, despite the leg/ankle being strapped down. Caution should be heeded when utilizing the SAM in individuals who participate in wheelchair sports. Additional written activity logs should be used to exclude periods of time during which high acceleration sporting activity occurs, or patients should be fully educated in removing the SAM during non-ambulatory wheelchair sports.

2-24 Measurement of physical activity and sedentary behavior in breast cancer survivors: Congruency of four measurement tools

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To compare sedentary time (ST), light intensity activity (LPA) and moderate vigorous intensity physical activity (MVPA) estimates using multiple measurement tools in breast cancer survivors. Methods: Survivors (N=414, age=56.7±9.2y, BMI=26.2±5.4 kg/m2) wore an accelerometer (ACC) for 7 consecutive days and completed a modified Godin Leisure Time Exercise Questionnaire (GLTEQ; assessed LPA and MVPA), International Physical Activity Questionnaire (IPAQ; assessed ST, LPA and MVPA), and Sitting Time Questionnaire (STQ; assessed ST). Estimates of ST, LPA and MVPA from the measurement tools were compared using RMANOVA and Spearman's Rho. Results were stratified by participant characteristics. Results: For ST, estimates were lower ($p<.001$) for the IPAQ (Mdiff=-300.5; SE=8.5) but not the STQ (Mdiff=-1.3; SE=15.4) compared to the ACC. Correlations for both measures with the ACC were fair [rho=0.26 (STQ); rho=0.30 (IPAQ)]. LPA estimates were lower for the GLTEQ compared to the ACC (Mdiff=-224.5; SE=3.2; $p<0.001$). MVPA estimates were lower on the IPAQ than the ACC (Mdiff=-67.4; SE=6.2). No differences existed between ACC and GLTEQ MVPA estimates, and the correlation was moderate (Mdiff=-2.8; SE=1.0; rho=0.56). Differences between estimates on the GLTEQ and ACC were greater for older survivors (≥60 years) for LPA ($p=0.02$). For MVPA, differences between estimates were greater for older survivors and those with ≥1 chronic condition ($p<0.001$ and $p=0.01$, respectively; GLTEQ) and for individuals who were non-white and had more advanced disease ($p=0.02$ for both; IPAQ) compared to the ACC. Differences between the STQ and ACC were greater for survivors with more advanced disease ($p<0.001$). Conclusions: Congruency of measurement was dependent on measurement tool, activity intensity and participant characteristics. Prior to choosing an activity or ST measurement tool in breast cancer survivors, target outcome, implementation context, and participant characteristics should be considered.

2-26 A Just-In-Time-Adaptive-Intervention system for improving physical activity levels of individuals with spinal cord injury

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Introduction: Lack of regular physical activity (PA) in the general population is a top public health concern, and this problem is even more acute among individuals with spinal cord injury (SCI). Only 13-16% of persons with SCI report consistent PA, and the majority report virtually no regular PA. Accurate real-time assessment of PA in individuals with SCI could allow just-in-time adaptive interventions (JITAIs), potentially leading to improvements of PA levels in the community. Objective: To develop and evaluate a JITAI system for assessing and providing feedback about PA levels in individuals with SCI who use manual wheelchairs for mobility purposes. A secondary goal is to develop a system that can collect long-term PA levels (3 months) in the community. Methods: We have integrated three off-the-shelf devices to concurrently capture both the wheelchair and arm movements. The wheelchair and arm movements are captured by a bicycle odometer (Panobike speed sensor) and an Android smartwatch (LG Urbane), respectively. Both of these devices (Fig.1) wirelessly transmit data to an Android based smartphone via Bluetooth for real-time data collection. The smartphone will have the capability to provide: 1) feedback on PA level, 2) individualized PA interventions, and 3) context-sensitive ecological momentary assessments. Results: We have developed a JITAI system that can measure PA levels from individuals who use manual wheelchairs and provide real-time feedback. The accuracy of the wheel rotation monitor was 0.24±0.64% for various distance measurements. The arm movements captured by a wrist worn smartwatch had similar accelerometer pattern and magnitude as compared to a wrist worn ActiGraph. Conclusions: Use of off-the-shelf components will allow us to test the system in real-world settings. We plan to pilot test the JITAI system in 20 individuals with SCI in the community in the next two years. Research Support: Craig H Neilsen Foundation Pilot grant (#382252).

2-30 Is sedentary behaviour related to bone mineral density in high-risk fracture patients?

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BACKGROUND Bone is constantly remodeling in response to mechanical loads causing strains on bone. It is hypothesized that the mechanical loads during sedentary behaviour (SB) are not high enough to conserve bone Therefor, in addition to know risk factors, genetics and nutrition, SB might be a contributing factor for low bone mass in high-risk fracture patients. METHOD A cross-sectional study was executed at the fracture liaison service in 300 patients aged 50 years and over with a recent fracture. Physical activity (MVPA and SB) was measured by an activity monitor (MOXX, Maastricht Instruments) over a 1-week period. It was associated with bone mineral density (BMD), assessed via a DEXA scan, using linear regression models controlling for season, fracture type, age and BMI. RESULTS In both men and women no significant associations were found between SB and BMD. However in women total-hip BMD (TH-BMD) was associated with vigorous physical activity (VPA)(BVpa 0.134 p=0.033), BMI(BBMI 0.497 p=<0.001) and age(Bage -2.63 p <0.001), Femoral-neck BMD(FN-BMD) was associated with BMI(BBMI 0.422 p=<0.001) and age(Bage -0.253 p=<0.001) and Lumbar-spine BMD (LS-BMD) was associated with BMI(BBMI 0.35 p=<0.001). In men FN-BMD was associated with VPA (BVPA 0.256 p=0.021), BMI (BBMI 0.308 p=0.005) and age (Bage -0.235 p=0.031). TH-BMD was associated with BMI

(BBMI 0.38 p=0.001) and no associations were found with LS-BMD. CONCLUSION In patients of 50 years and over with a recent fracture no association was found between SB and BMD in both men and women. In contrast VPA was positively associated with FN-BMD in men and TH-BMD in women independent of SB. This indicates that even if adults spent a large amount of the time sedentary, regular VPA can be sufficient to conserve bone.

2-32 Estimation of muscular and cardiovascular load and fatigue using exposure variation analysis, multiscale permutation entropy and heart rate variability during a full working day among blue-collar workers with lifting tasks. Cross-sectional workplace study

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Aim: To investigate associations between perceived exertion and perceived fatigue and objectively assessed muscular and cardiovascular load during a full working day among workers with manual lifting tasks. Methods: 159 men and 41 women from 14 workplaces with manual lifting tasks participated. Participants reported perceived exertion and fatigue (BORG-CR10) at mid-day and after work. Muscular and cardiovascular load was measured throughout an entire working day using surface electromyography (EMG) of the thigh, lower back and neck muscles and electrocardiography (ECG), respectively. The workers performed standardized box lifts using 5, 10, 20 and 30 kg before and after the working day. Accordingly, corresponding EMG-values for 0 to 30 kg could be identified using linear regression. The data analysis is not fully completed at this point in time. But, we are planning to do the following analyses: Exposure variation analysis (EVA) will be identified in time intervals [0-0.5, 0.5-1, 1-2, 2-5, 5-10, >10] sec at amplitude levels corresponding to [0-1, 1-5, 5-10, 10-20, 20-30 and >30] kg. Moreover, multiscale permutation entropy (MPE) will be computed in 30 minute intervals throughout the working day. Lastly, heart rate variability (standard deviation and low and high frequency range and ratio) and average cardiovascular load will be calculated as the average percentage of the heart rate reserve capacity (maximum heart rate minus resting heart rate) during the day. Results and discussion: The results are on the way and the final version of the methods used for data analysis will be presented at ICAMPAM2017.

2-34 Sit-to-stand movement repetition during the acute stroke rehabilitation period

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Sit-to-stand movement repetition during the acute stroke rehabilitation period Andrew Kerr[1], Jesse Dawson[2], Terry Quinn[2] [1]University of Strathclyde, [2]University of Glasgow Background The sit-to-stand (STS) movement is an important, frequently performed, task commonly affected by stroke. Repetitive practice is likely to improve ability and is therefore recommended, however current levels of practice repetition are unknown. This observational study aimed to count STS movements during the acute rehabilitation period of stroke patients. Methods: Participants were medically stable patients referred for rehabilitation following a recent stroke. A physical activity monitor (ActivPAL) was worn on their unaffected or dominant thigh. Stroke severity (NIHSS) and STS ability (independent or required assistance) were recorded at baseline. After 14 days of continuous wear the ActivPAL was removed and the data downloaded for analysis. Results: A heterogeneous group (n=37) were recruited; aged 68.4±13.15 years, weight 77.12±22.73Kg, Height 1.67±0.1m within an average of 9±9 days of their stroke

and with a stroke severity score of 6.4±3.3 (i.e. moderate). The whole group performed a daily mean of 25.00±17.24 STS movements per day (24 hours) during the 14 day period. Individuals requiring assistance (n=17), however, only achieved 14.29±16.10 movements per day while the independent participants (n=20) achieved 34.10±12.44. The number of STS movements increased from 20.84±19.42 at baseline to 28.49±20.84 on the day before the ActivPAL was removed with greater improvement in the independent group (9.40±14.08) compared to the assistance group (5.59±14.09). Discussion: These very low levels of STS activity cast doubt on whether a training effect is being achieved. The average for the whole group is substantially below older adults living in the community (71±25) and the participants requiring assistance recorded levels below that associated with improvement in previous research. STS activity has been suggested as a proxy measure of general physical activity and these low levels agree with previous reports of generally sedentary behaviour during the post stroke rehabilitation period.

2-36 Pattern changes in activity and sedentary behaviour during a pedometer intervention: a physical activity bout analysis using accelerometry

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AIMS: The purpose of the present study was to assess whether a daily step count (SC) intervention leads to change in physical activity (PA) and sedentary behaviour (SB) patterns. METHODS: Thirty healthy young adult women were randomly assigned to an 8-week of intervention group that wore an accelerometer and were instructed to increase their SC by at least 21,000 steps per week from their baseline (corresponding to an extra 3,000 steps per day on average) (n=16) or a group that wore an accelerometer (with a blank display) and were instructed to maintain their usual lifestyle (n=14). The changes in time spent engaging in PA of light intensity (LPA), moderate-to-vigorous intensity PA (MVPA) and SB were measured by the Lifecorder accelerometer and self-reported. PA was analyzed according to the bout durations (lasting longer than 32 s, 1 min, 3 min, 5 min or 10min, plus 30 min, 1 hr, 2 hr, 3 hr and 5 hr for SB). A two-way repeated measures ANOVA (group × period) was applied. RESULTS: In the intervention group, after one and eight weeks, MVPA which was expressed as a percentage of the total time during which the accelerometer was worn, were significantly increased compared to the baseline values ($p<0.05$). The %SB was significantly decreased ($p<0.05$), whereas the %LPA was significantly increased only at one week of intervention ($p<0.05$). The duration and frequency (bouts/day) of MVPA in ≥32 s, ≥1 min, ≥3 min or ≥5 min was significantly greater than that of the baseline. In contrast, no significant changes in the group × period interactions were observed for LPA. The duration of ≥32 s − ≥2 hr of SB at one and eight weeks was significantly decreased. CONCLUSION: The present data indicated that the pedometer-based intervention program breaks up SB, accompanied by pattern changes in the bout duration/frequency of MVPA and SB in young adult women. The composition of SB changes was also highlighted.

2-38 Integrating Accelerometer and Continuous Glucose Monitor Data to Study Postprandial Glycemia

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Advances in wearable kinematic (e.g., accelerometers) and physiologic (e.g., heart rate) sensors allow multiple health parameters to be measured overtime. Integrating data from these heterogeneous

sources can provide a unified view of important health behaviors and their corresponding physiologic effects. Purpose: The purpose of this study was to create a data integration system to combine data from a wearable accelerometer and a continuous glucose monitor (CGM). Methods: Healthy, overweight/obese older adults (N=18, 69±4y, weight = 87.3±12.0 kg) completed three, 5-hour meal tolerance test while wearing an activPALTM accelerometer and a Medtronic iPro CGM. After consuming a standardized meal, participants performed 1) uninterrupted sitting (US): sedentary behavior (SB) was maintained for 5 hours, 2) intermittent walking (IW): SB was interrupted every 30m with 1.5 min of moderate intensity walking (36 min total) and 3) continuous walking (CW): treadmill walking (36 min) was performed 30 minutes post meal, followed by uninterrupted SB for the remainder of the condition. Results: A customized R (cran.r-project.org) program was developed to synchronize and visualize events-based accelerometer data with CGM data collected every 5 minutes. The activPALTM events files were adapted to second-by-second files and corresponding CGM data were aligned based on the time-stamps of each file. Conclusion: Integration of multiple streams of sensor data can provide deeper interpretation and understanding of complex health information. The data integration system developed in the current study will be used to study how physical behavior impacts postprandial glycemia. Visualizing physical activity data from an accelerometer, integrated with corresponding physiologic parameters could help expose habitual behavior patterns important in disease etiology.

2-40 Impact of Inertial Measurement Unit on Activity Recognition using ActiGraph GT9X

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BACKGROUND: Automated recognition of physical activity behaviors is commonly attempted using accelerometers, but use of additional movement sensors may help. The inertial measurement unit (IMU) of the ActiGraph GT9X (AG) includes a triaxial gyroscope and magnetometer; however, there is currently no convention for using these data. PURPOSE: This study trained and compared artificial neural networks (ANNs) that predicted activity type from the AG accelerometer with and without IMU-derived features. METHODS: Thirty participants (age 23.0 ± 2.3 years; BMI 25.2 ± 3.9) completed 10 activities for 7-min each while wearing an AG on the hip, both wrists, and both ankles. Raw samples from accelerometer data (80 Hz) and IMU data (100 Hz) were averaged over each second for each axis. Magnetometer data were transformed to indicate cardinal direction. The data were then summarized over each minute using the features chosen by Staudenmayer et al. (1) for continuous variables (acceler. and gyro.) and the number of direction changes (magnetometer). For each attachment site, three ANNs were trained and cross-validated (30% holdout) based on the following feature sets: 1) raw acceleration only (FS1); 2) FS1 plus gyroscope data (FS2); 3) FS2 plus magnetometer data (FS3). Accuracy was summarized using percent accuracy and kappa statistics. RESULTS: Each site yielded a model that was at least 68.7% accurate ($\kappa = 0.65$). Within attachment sites, the feature sets performed similarly, with a maximum accuracy difference (Left Ankle, FS2 vs. FS3) of 3.6% ($\kappa = 0.04$). See table 1. CONCLUSION: Combining IMU data with acceleration improved activity recognition accuracy, with a greater contribution from gyroscope data than magnetometer data. 1. Staudenmayer J, Pober D, Crouter S, Bassett D, & Freedson P (2009). An artificial neural network to estimate physical activity energy expenditure and identify physical activity type from an accelerometer. Journal of Applied Physiology, 107(4), 1300-1307.

2-45 The effect of walking speed on quality of gait in older adults

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Introduction: Gait quality characteristics estimated from daily-life trunk accelerometry can contribute to the identification of individuals at high risk of falls (van Schooten et al, 2016). Since older adults with high fall risk tend to walk slower than older adults with a lower fall risk, walking speed may underlie differences in gait quality. Therefore, the aim of this study was to investigated the effect of walking speed on gait quality characteristics among older adults. Methods: Trunk accelerations of 11 healthy older adults (aged 70 ± 4 yrs) were recorded during 5 minutes of treadmill walking at four different speeds, i.e., 0.5, 0.8, 1.1 and 1.4 m/s. From these trunk accelerations we determined step frequency, root mean square, harmonic ratio, index of harmonicity, sample entropy and logarithmic divergence rate per stride. Results: All gait characteristics were significantly affected by walking speed, except sample entropy in antero-posterior (AP) direction. An increase in walking speed resulted in a higher step frequency, root mean square, harmonic ratio and logarithmic divergence rate per stride. For index of harmonicity and sample entropy, we observed direction dependent effects. With increasing walking speed, index of harmonicity in vertical (VT) direction increased, while in medio-lateral (ML) and AP directions it decreased. Sample entropy was weakly affected negatively in VT and positively in ML direction, and had small effect sizes and few significant post-hoc comparisons. Conclusion: An increase in walking speed resulted in higher gait intensity, more symmetry and stability, reflecting qualitatively better gait. Increased walking speed further led to higher gait smoothness and regularity in VT, lower smoothness in ML and lower smoothness and regularity in AP direction. These results suggest that differences in walking speed between people at high and low risk for falls might partially explain differences in gait quality between these groups.

2-46 Sources of Error for Wearable Step Counters

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Purpose: To determine the validity of step counters during activities of daily living and treadmill and over-ground ambulation, compared to hand-counted (HC) steps. Methods: Participants (N = 21, age 25.6±9.0 yr) performed 15 activities for 2 min each while wearing step counting devices on the non-dominant wrist (Garmin Vivofit 2, Fitbit Charge, Polar A360, Withings Pulse Ox, and ActiGraph GT3X), hip (Digi-walker SW-200, Fitbit Zip, Omron HJ-322U, and GT3X), and ankle (three StepWatch devices with default and modified settings). For the GT3X, three step algorithms were used: with and without the low frequency extension (LFE), and a moving average vector magnitude (MAVM) for raw acceleration. The criterion measure was HC. The activities were split into three categories: six activities of daily living, five treadmill walking and running activities, and four over-ground walking activities with arms in different positions (e.g. holding umbrella, pushing a stroller). Device validity was assessed for each activity category using equivalence testing, mean absolute percent error (MAPE), and root mean square error (RMSE). Results: For activities of daily living, none of the methods were equivalent to HC (equivalence zone, 20.8-25.4 steps). For treadmill activities, only the StepWatch with modified settings (90% CI, 220.4-239.4) and hip GT3X with LFE (90% CI, 201.5-225.7) were equivalent to HC steps (equivalence zone, 201.2-245.9 steps). For over-ground ambulation, the StepWatch with default (90% CI, 199.2-208.7) and modified settings (90% CI, 207.4-218.2), Fitbit Zip (90% CI, 202.4-211.1), Digi-walker SW-200 (90%

CI, 199.3-210.7), and hip GT3X with LFE (90% CI, 193.6-204.4) were equivalent to HC (equivalence zone, 186.9-228.4 steps); no other monitors were equivalent. MAPE and RMSE values appear in the table. Conclusion: The StepWatch and hip GT3X with LFE were the most valid methods across all activities; however, no method worked well for activities of daily living.

2-48 Regularity of cyclic movements assessed by wearable systems: method and applications' survey

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The regularity of a cyclic human movement characterized by a pseudo-periodic pattern of biomechanical variables is relevant for identifying motor disturbances and can be assessed by an autocorrelation analysis. The study of movement regularity is somehow specular to the study of movement variability and is supported by the same strong indications in the assessment of pathology-related motor disturbances (Hausdorff, 2007). Published papers have assessed regularity of trunk movement during gait analysing signals from accelerometric sensors aligned with an anatomic reference axes (Moe-Nilssen, 2004; Tura, 2010). This study presents a generalization of those methods by adopting a triaxial inertial sensor (WaveTrack, Cometa Systems, Italy) and an autocorrelation analysis applied to the acceleration module. This aspect is crucial when considering cyclic multiplanar movements which include rotations. The methods was set up to analyze acceleration module. It computes, in a time window, the cycle duration and the corresponding autocorrelation coefficient aCC. In short-time measurements (a unique time window including few movement cycles) the autocorrelation coefficient quantifies regularity (the more regular the movement, the closer to one the index). In prolonged measurements, the analysis is performed on a moving window and the time profile of the two computed variables let to study endurance-related aspects of regularity as well as alternation of regular and not regular movements in unrestricted activity monitoring (figure). The method has been tested, to demonstrate its applicability, in several contexts including locomotor acts, swimming, horse riding, performing arts and in monitoring of daily activities. Those applications let us to discuss the location of the sensors on different body parts and criteria to fix analysis parameters. In conclusion the method proved to be reliable and able to provide relevant information concerning regularity of human movements.

2-50 Detecting the activities of daily living of manual wheelchair users in the real world using inertial sensors

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Shoulder pain in adults who use manual wheelchairs (MWCs) is often caused by rotator cuff tears and tendinopathies resulting from shoulder impingement. To better understand the link between MWC use and shoulder impingement, it is important to quantify the type and frequency of activities of daily living (ADLs) performed in the everyday life of MWC users. The purpose of this IRB approved study was to develop an algorithm to accurately identify ADLs of MWC users during day-long collections in their natural environment. For initial algorithm development, preliminary data was collected on one female participant (19 yrs). Upper limb and trunk kinematics were measured in the laboratory using APDM inertial measurement units (IMUs), each containing a tri-axial accelerometer, angular rate gyro, and

magnetometer, as a series of MWC-related ADLs (level and overhead reaching, crossbody lifting, body transfers, level and ramp propulsion) were performed. One IMU each was secured to the trunk and left/right upper arms using elastic straps. Data were collected at 128 Hz. Dynamic activity was detected from the upper arm tri-axial acceleration data using an algorithm previously validated for able-bodied adults. A pattern recognition algorithm including an artificial neural network was developed which could discriminate level and ramp propulsion from the non-propulsion activities using upper arm and chest acceleration parameters with 98.3% accuracy. The algorithm is being further developed and validated to discriminate between the other investigated activities based on their distinct acceleration patterns and as seen in the Abstract Supplement in combination with IMU-derived shoulder kinematics. Future work will determine the frequency with which MWC users perform the specific ADLs in their free-living environments and combine this exposure data with the relative impingement risk of ADLs to determine a measure of cumulative impingement risk of MWC-associated ADLs.

2-52 Advanced signal processing approach to walking detection in the lab and in the wild using raw accelerometry data

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In recent years wearable devices became very popular in physical activity measurement research. Typically, raw data collected from such devices is summarized as 'activity counts', which combine information of human activity with an influence of a surrounding environment. In the proposed approach, we show advantages of using raw 'unsummarized' acceleration measurements for recognition and quantification of walking. We focus on salient walking features, such as periodicity, duration, speed and intensity. Specifically, we present an algorithm based on the Continuous Wavelet Transform (CWT) capturing the globally non-stationary, but locally quasi-periodic characteristics of walking. The CWT is sensitive to subtle changes, breakdown points or signal discontinuities. This is essential in walking recognition, where both subtle and sudden changes in walking frequency are the norm. We discuss the algorithm developed to recognize and estimate walking periods and fundamental walking frequency. We validate our method on the data collected, both in the laboratory experiment and in the free living environment, from 48 participants of the Development Epidemiologic Cohort Study (DECOS), a part of the National Institute on Aging, Aging Research Evaluation Accelerometry (AREA) project. For data collected in the laboratory experiment, i.e. for labelled data, the median true positive rate (sensitivity) was equal to 0.98 and median true negative rate (specificity) was equal to 0.96. Next, we present validation on the data in free living environment. The efficiency of the method is compared with indications of activPAL monitors worn by participants during this study.

2-54 Differentiating Walking from Stair Climbing based on the Raw Accelerometry Data

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Wearable accelerometers offer a noninvasive and objective measure of subjects' physical activity (PA) and are now widely used in observational and clinical studies. Accelerometers record high frequency data and produce an unlabeled three-dimensional time series at the sub-second level. An important activity to identify from such data is walking, since it is often the only form of exercise for elder and impaired populations. While much work has been undertaken to advance the use of accelerometers in public health research, methodology is needed to quantify the physical characteristics of different types of PA from the raw signal. Our work addresses the classification of the walking into level walking, descending stairs and ascending stairs. We collected data on 32 middle-aged subjects in order to extract useful and interpretable features based on the Fourier and wavelet transforms. We build subject-specific and group-level classification models utilizing a tree-based classifier. We evaluate the effects of sensor location and tuning parameters on the classification accuracy of these models. In the group-level classification setting, we proposed a robust feature normalization approach and evaluated its results by comparing to other models. The classification accuracy on the subject-specific level was on average 87.6%, with the ankle-worn accelerometers showing the best performance with the average accuracy 90.5%. Figure 1 displays the classification accuracy for the devices worn on a wrist, hip and both ankles. At the group-level, the average classification accuracy using the normalized features was 80.2% compared to 72.3% for the unnormalized features. In summary, our work provides a framework for better extraction and use of the raw accelerometry data to differentiate among different walking modalities. We show that both at a subject-specific level and at a group level, overall classification accuracy is above 80% indicating excellent performance of our method.

2-56 Identifying Physical Activity Intensities and Types using Wrist Accelerometer Data

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INTRODCUTION: Researchers have relied on accelerometer-based measurements to assess physical activity (PA) in community-dwelling settings. Although hip-worn accelerometer data is validated in the current literature, PA assessment using wrist-worn accelerometer still lacks data. PURPOSE: To investigate the capability of a wrist-worn accelerometer to identify levels of activity intensities, sedentary behavior, and locomotion. METHODS: This study evaluated 25 young adults (14 females; 33.8±10.7 yrs; 26.4±5.1 kg/m2) who performed 34 simulated tasks of sedentary (e.g., computer work), activity (e.g., gardening), and locomotion (e.g., self-paced walk). Accelerometer data were collected at 100 Hz using a tri-axial wrist-worn accelerometer and compared to energy expenditure measured using a portable indirect calorimetry system. We constructed variables covering time and frequency domains; such as vector magnitude (VM) and its angle with the vertical axis, dominant frequency (DF) and its fraction of power, and the fraction of power covered by human movement frequencies (0.6 - 2.5 Hz). We used regression methods to estimate metabolic equivalent score (METs) and applied classifiers to identify activity intensities, sedentary behavior, and locomotion. RESULTS: The constructed variables estimated METs with low error (rMSE = 1.2 METs) and classifying activity intensities, sedentary behavior, and locomotion tasks with high accuracy (accuracy: 97%, 80%, and 96%, respectively). Of constructed variables, lack of variation in VM (< 0.06 m/s2) and its angle with the vertical axis (< 7 degrees) distinguished sedentary tasks with 92% accuracy. The DF (1.7±0.6 Hz) paired with a noticeable power (0.06±0.03) were indicators of locomotion with 90% accuracy. CONCLUSION: Wrist accelerometer data can identify type and intensity of PA with high accuracy. Future work will require comparisons during free-living conditions to confirm validity.

2-58 Mean Skin Temperature as Covariate to Predict Energy Expenditure.

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Introduction: Accelerometry (ACC) and heart rate (HR) are the main proxies for wearable measurement of physical activity and energy expenditure (EE). High accelerations are indicative of intense activity with a corresponding high-energy expenditure. With increased EE tissue oxygen demand increases and HR may increase to balance tissue oxygen supply. However, HR may also change for other regulatory reasons than oxygen balance; maintenance of body temperature by skin blood flow (SBF) regulation being one of them. Skin vasodilation increases skin temperature (Tsk) and supports thermoregulation. Increased SBF may require increased cardiac output and consequently result in increased HR, in absence of increased EE due to physical activity. This study tested the hypothesis that mean Tsk is a significant covariate in the estimation of EE in addition to HR and ACC. Methods: 20 healthy participants were studied in couples (1M,1F) for 1 shared labday. EE (indirect calorimetry, Maastricht Instruments [W]), mean skin temperature (14pt ISO, iButtons [°C]), HR (Equivital [BPM]) and activity (accelerometry, Actiwatch [counts]) were measured during supine and sedentary position, 1km/h walking and preferred walking speed for 2 clothing conditions (0.4&0.8clo). EE and ACC data were normalized to the supine condition. Multiple regression analysis was applied to test the hypothesis: (EE = a0 + a1HR + a2ACC + a3Tsk_mean). Results: Tsk_mean was a significant covariate in the prediction of energy expenditure in addition to heart rate and accelerometry ($r^2 = 0.97$, $p<0.001$; Mean ± 95% CI: a1 = 0.0116±0.0089, a2 = 0.1646±0.0405, a3 = -0.2834±0.2407). Conclusion: Changes in HR for thermoregulatory reasons significantly influence the prediction of EE. Increased HR that is normally associated with increased energy expenditure may instead be caused by SBF regulation. Inclusion of Tsk_mean as a proxy for SBF unmasks this covariate effect and may improve prediction of EE with wearables.

2-60 Modeling subject response to interventions aimed at increasing physical activity: a control systems approach

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In order to design effective personalized adaptive interventions that promote physical activity, it is necessary to i) determine how the subject responds to treatment and ii) use this knowledge to determine the sequence of treatments that increase the level of physical activity while, at the same time minimizing the burden of the treatment. Given the fact that physical activity is a dynamical behavior, one needs modeling techniques that exploit the fact that intensive longitudinal data has high correlation in the sense that present measurements are highly correlated with the ones collected in recent past. The authors aim at exploiting approaches from the area of control engineering to address this problem. More precisely, in the work presented in this poster, we show how dynamical systems can be used to model behavioral responses to an intensive text message-based intervention which can potentially be used to develop optimal personalized adaptive interventions. To establish proof-of-concept for this approach, 10 adults wore activity monitors for 16 weeks and received five text messages daily at random times. Message content was randomly selected from three types of messages designed to target (1) social-cognitive processes associated with increasing physical activity, (2) social-cognitive processes associated with reducing sedentary behavior, or (3) general facts unrelated to either physical activity of sedentary behavior. Dynamical model was estimated for each participant to examine the

timing of responses to each type of text message. Study of the models using concepts from dynamical system analysis revealed heterogeneous responses to different message types that varied between people and between weekdays and weekends. These results demonstrate the potential of control systems engineering models for optimizing physical activity interventions.

2-62 A new wearable device for free-living measurement of respiration rate

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Current devices for estimating energy expenditure (EE) under free-living conditions typically utilise a small body-worn accelerometer and exploit the relationship between acceleration and EE. However, it may be possible to improve estimates of EE from additional physiological data, such as heart rate and/or respiration rate. Although there are a number of ambulatory devices which can accurately measure heart rate, existing devices for measuring respiration rate are not suitable for data collection in free-living conditions. Smartlifeinc Limited (Manchester, UK) have developed a system capable of accurately measuring respiration rate using a smart garment. The garment makes use of integrated textile sensors and impedance pneumography to measure the wearer's respiration. The garment is also able to collect heart rate and acceleration data and therefore provides an ideal platform for accurate quantification of EE in free-living. The study assessed the validity of the Smartlife system to measure respiration rate, comparing the measures to a laboratory spirometer. Five participants completed three minutes of four activities (standing, walking, running, cycling) with the final minute used to compare the smart garment and the spirometer measurements. For each activity, the Smartlife system was able to generate a signal (Figure 1) which was visually similar to that obtained by the spirometer. Furthermore, for 60% of the tests, it was possible to use an automated algorithm to estimate respiration rate to within 1.5 breaths per minute of the true value. This study demonstrates the potential of the Smartlife system for the measurement of respiration rate under free-living conditions. Although further algorithm development is required to automatically calculate respiration rate for all participants, these data indicate the potential of the Smartlife system for accurate estimation of EE using accelerometry, heart rate and respiration rate.

2-64 Estimation of respiratory volume from thoracoabdominal breathing distances: comparison of two models of machine learning

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Introduction. Gastinger et al. (2010) have validated a new device based on respiratory magnetic plethysmography (RMP) to evaluate temporal variation on respiratory volume (V) in sitting, standing and walking conditions. To validate their device the authors applied a multilinear regression (MLR) model. However, both, calibration and data processing could be improved using artificial neural network (ANN) model (Raoufy et al., 2013). Based on Gastinger et al., (2010) and Raoufy et al., (2013) studies, we aimed to develop the V estimation technique by using MLR and ANN models. The purposes of our study were both to improve the accuracy of V estimation and to facilitate the use of RMP technique. Our hypothesis was that the ANN model is more efficient than the MLR model. Methods. Fourteen healthy adults were

recruited. Subjects completed three sessions of activities, (i) Ventilation tests, (ii) Resting activities (natural and metronome breathing) : sitting, standing and lying lateral recumbent and (iii) Physical activities (PA) : computer work, walking at 4 and 6 km/h, running at 9 and 12 km/h and cycling at 90 and 110 W. Subjects were equipped with the iWorx spirometer and the Nomics RMP devices. The sensors were placed in the anterior and posterior positions over rib cage and abdomen. We developed and tested a MLR and a nonlinear ANN models. To assess these models the root-mean-square-error (RMSE) was computed. Results. For each activity, the RMSE obtained with ANN was significantly lower ($p < 0.001$) than the RMSE obtained with MLR (Figure 1). For all activities, the biais between the RMP volume and the spirometer volume was significantly higher ($p < 0.01$) for MLR model than ANN model. Discussion/Conclusion. This data processing of RMP technique seems a valid tool for V estimation in resting and PA. Futur works address the study of ecological activities with wireless transmission to estimate V in real-time conditions and then, the energy expenditure.

2-66 Validation of a Research-Grade Accelerometer in Estimating Free-Living Physical Activity: Effect of Sensor Location

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Research-grade accelerometers (RGA) are commonly used to monitor physical activity behaviors such as moderate-to-vigorous physical activity (MVPA min) and steps in surveillance, determinants and intervention studies. Despite the broad appeal of such devices for researchers, there is limited evidence validating RGA for estimating measures of physical activity in free-living settings. PURPOSE: To examine and compare the accuracy and precision of RGAs in estimating MVPA and steps from an RGA worn on the hip and wrist. METHODS: Seven participants were directly observed on three separate days for 2-hours each day in free-living settings. Participants simultaneously wore a StepWatch (SW), and hip- and wrist-worn ActiGraph GT3X-BT (AG). MVPA was assessed using a previously validated direct observation (DO) method. Linear mixed models were used to compare the accuracy and precision of the steps and MVPA estimates from the hip and wrist worn RGAs. Confidence intervals were computed to evaluate model prediction. RESULTS: The AG and SW estimates of steps and MVPA are significantly different than reference measures. For step estimates, the wrist AG significantly underestimated steps. For MVPA estimates, the hip AG significantly underestimated min and the wrist AG significantly overestimated min. CONCLUSIONS: These results are the first of its kind examining how monitor location affects commonly used measures of physical activity derived from an RGA tested in free-living settings. These results indicate that monitor location has a differential effect on accuracy and precision of the monitor measures. Funded by: NIH: 1F31HL129802-01

2-68 Effectiveness of interventions using wearable monitors to promote physical activity: a meta-analysis

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Objective: Wearable monitors are becoming popular in interventions promoting physical activity (PA). The added value of feedback by wearable monitors has not been studied systematically. The aim of this meta-analysis is to determine the effect of feedback on objective PA in interventions. Also, potential mediating factors in interventions will be examined. Methods: PubMed, Embase and Cochrane library

were searched for eligible full-text articles up to December 2015. RCTs in English were included if the difference between the intervention and control group was feedback on objectively measured PA. Other inclusion criteria were: objective PA was an outcome measure, intervention aimed at improving PA and counseling or behavioral change techniques (BCT) in interventions were only related to PA. Methodological quality was assessed by the PEDRO score. Effects were estimated by a random-effects model using the standard mean difference (SMD). Results: Fifteen studies (2593 participants) met the inclusion criteria. Two studies were excluded in meta-analysis due unusable PA data. The summary effect was in favor of the intervention groups (SMD = 0.31, 95% CI 0.07 - 0.55, z = 2.51, p = 0.01, I2 = 86%). Subgroup analysis showed the largest effect when objective feedback was combined with BCT, goal-setting and verbal feedback (SMD = 0.68, 95% CI 0.29 - 1.07). Daily feedback was the most effective compared to lower feedback frequencies (SMD = 0.67, 95% CI 0.13 - 1.21). No significant difference was found in comparison of subgroups based on type of feedback parameter (p = 0.97). Conclusion: Overall, adding feedback on objectively measured PA in interventions was effective. Combination of BCT, goal-setting and verbal feedback with objectively measured PA feedback was the most promising strategy in improving PA, whereby daily feedback is preferred. Feedback parameter does not seem to be relevant.

2-70 Wearable physical activity trackers: accuracy in measuring activity in people with Parkinson's disease

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Background: Despite known benefits of physical activity, people with Parkinson's disease (PD) may need motivation and tools to assist in increasing activity levels. Gait characteristics may affect the accuracy of wearable activity trackers in this population. The aim of this study was to determine the accuracy of the Fitbit Charge HR and Garmin Vívosmart® HR in measuring steps and reflecting intensity of activity in people with PD. Methods: Thirty-three people with mild-moderate PD performed six, two-minute indoor walks at their self-selected walking pace, and at target cadences of 60, 80, 100, 120 and 140 beats/minute. A 500m outdoor walk with terrain challenges was also performed. Step count was recorded by the two wrist-worn activity trackers (Fitbit and Garmin) and compared to an accelerometer (ActivPAL3). Intensity was recorded by a portable breath-by-breath gas analyser (VO2), heart rate and Borg scale. Results: Both activity trackers had low error (1-7%) and moderate to high consistency at self-selected pace both indoors (ICC 0.51-0.77; p<0.05) and outdoors (ICC 0.78-1.0; p<0.05) compared to the ActivPAL3. The Garmin recorded low error (<5%) and high agreement (ICCs >0.70; p<0.001) for all cadences >80 steps/minute. The Fitbit had high error (>10%) and low consistency for all cadences except 100-120steps/minute. Both recorded high error at 60steps/min. Cadence measured by the Fitbit and Garmin only weakly reflected incremental increases in heart rate from 60 to 140 steps/minute (ICCs 0.27-0.28; p<0.05), and did not reflect VO2 and Borg (ICCs 0.08-0.15, p<0.05). Conclusion: The Fitbit Charge HR and Garmin vívosmart® HR are accurate in recording steps at self-selected walking speeds indoors or outdoors in people with mild-moderate PD. The Garmin vívosmart® HR is more accurate at a variety of cadences above 60 beats/minute. Both commercial wearables did not reflect activity intensity across a range of cadences in people with PD.

2-71 Behavioural impact of a waist-worn tracker that targets sitting time

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Background: Wearable activity trackers are a rapidly advancing measurement and intervention tool, though few measure and target sitting time. A previously evaluated cluster-randomised trial provided one arm (n=66, 9 clusters) with a waist-worn tracker that, through a mobile application, provides real-time feedback and prompts on sitting, standing, stepping and posture (the LUMOback). This study evaluates the relationship of the trackers usage with activity changes. Methods: Of the 66 participants (47% men, mean+-SD age=37.6+-7.8 years), 37 provided data on tracker usage and three-month changes in time spent: sitting, sitting in prolonged (>=30 min) bouts, standing, and stepping as measured by the activPAL3 worn 24h/day for 7 days. These were assessed per 10-hour day at work and per 16 hours awake overall. Associations with activity changes of tracker usage (i.e., days used, time to usage cessation, usage during the activity assessment) were assessed, correcting for cluster, adjusting for age and sex using mixed models. Results: Over three months, the LUMOback was used for a median (25th, 75th percentile) of 5 (2, 14) days, with 6 of 37 participants (16%) never using it. Associations of usage with activity change were not statistically significant ($p<0.05$), with two exceptions: days of usage and time to last usage were associated with overall prolonged sitting. The direction of results indicated more usage was associated with greater reductions in prolonged sitting of approximately 30-45 minutes, with much smaller impacts on other activities. Confidence intervals frequently included potentially large differences. Conclusions: LUMOback usage was low overall. While the study was underpowered there was tendency for those who used the LUMOback more to have greater reductions in prolonged sitting than those with the lowest usage. A tracker with better uptake than the LUMOback but with similar features might help participants break up their sitting.

2-72 Self-Reported and Objectively Measured Physical Activity and Sitting Time in Relation to Self-Rated Health at the Age of 46

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AIMS Moderate to vigorous physical activity (MVPA) enhances health and decreases mortality risk. Excessive sitting time (ST) is an independent risk for mortality. PA and sedentary behavior have been often assessed subjectively in population based studies. The aim here was to determine the level of objectively measured PA, self-reported PA, and ST and their relationship to self-rated health (SRH) in midlife. METHODS NFBC1966 cohort included in 1966 born children in Northern Finland (n=12058). Data collection including questionnaires (response rate 67%, n=6851) was conducted at the age of 46 years. Leisure time physical activity (LTPA) was assessed with questions how often and for how long one participated in light and brisk PA. Weekly averages of MET-minutes (metabolic equivalent) of PA were calculated by multiplying PA frequency*duration*intensity (light 3, brisk 5 METs). SRH and ST were assessed with separate questions. PA was measured as MET-values every half minutes with wrist-worn Polar Active (Polar Electro, Finland) for 14 days. Daily average (min/day) spent in MVPA (≥3.5 MET) was calculated. Eligible data (n=5481, 98%) included ≥4 days and ≥600 min/day weartime. MVPA MET-minutes were calculated by multiplying duration with 5 METs. RESULTS The mean MVPA duration was 483 min/week (2415 MET-min/week), which was significantly higher than self-reported LTPA (median 188 min/week, 713 MET-min/week) ($p<0.001$). Self-reported ST was 450 (300-600) min/day. Men reported 60 min more ST than women ($p<0.001$). Those with at least good SRH had 59 min/week more MVPA and 112 min/week more LTPA compared to others ($p<0.001$). No significant difference was observed in ST between SRH groups ($p=0.251$). DISCUSSION Measured MVPA and self-reported LTPA durations were greater among those who rated their health at least good. No difference in ST was

observed between SRH groups. The results of this cross-sectional study suggest that higher amount of PA contributes to better SRH.

3-1 The influence of all aspects of physical activity on cardiometabolic health in an Irish adult population

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Introduction:Increased participation in moderate-to-vigorous physical activity (MVPA) and decreased sedentary behaviour (time spent in and frequency of sedentary activities) have positive influences on cardiometabolic health (CMH) (Wilmot et al., 2012). More recently, light intensity physical activity (LIPA) has become of interest (Kim et al., 2013). This study examined the impact of sedentary time (ST), sedentary bouts (SBs), standing time (StT), LIPA and MVPA on CMH in a cohort of Irish adults (65±5.5 years). Methods:Following ethical approval, participants (n=176, 51% female) provided fasted blood samples, which were analysed for triglycerides, glucose, total cholesterol, HDL-C and LDL-C. Seven-day activity data (ST, SBs, StT, LIPA and MVPA) were collected using an activPAL3 Micro. Partial correlation coefficients, controlling for age, were used to measure the strength of the associations between activity variables, BMI, cardiometabolic risk score (CMRS) and CMH markers. Multiple linear regression models were fitted, adjusting for age and sex. Results:Table 1 contains descriptive information of the health markers and activity data. ST, LIPA and MVPA were significant predictors of BMI, with LIPA having the strongest correlation (r=-0.27). ST, StT, LIPA and MVPA were significant predictors of triglycerides, with ST having the strongest correlation (r=0.29). ST, StT and LIPA were significant predictors of HDL-C, with ST having the strongest correlation (r=-0.39). ST, StT, LIPA and MVPA were significant predictors of CMRS, with ST having the strongest correlation (r=0.25). Discussion:ST was shown to be the strongest predictor of triglycerides, HDL-C and CMRS, with LIPA being the strongest predictor of BMI. Even though MVPA was shown to significantly predict BMI, triglycerides and CMRS, it did not explain as much of the variance in these outcomes as other activity variables. Targeting reductions in ST by increasing LIPA may be a plausible strategy for improving CMH.

3-3 Motor neglect after brain damage: evidences from differential actigraphy

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Motor Neglect (MN) is a neuropsychological syndrome characterized by an underutilization of controlesional limbs that improve with direct verbal suggestion, in the absence of strength, reflexes or sensibility deficits (Laplane and Degos, 1983). Since it is a disorder of the spontaneous movement, it is difficult to evaluate in a test setting and the diagnosis is carried out with clinical observations. The lack of a systematic evaluation has contributed to misunderstanding MN. The present study adopt a differential actigraphy approach (Rabuffetti et al, 2016) to objectively quantify upper limbs asymmetric motor behavior in daily activities. This method allows for the long-term assessment of spontaneous movements. We sought to understand whether the differential actigraphy could support MN detection.

We recruited 37 patients a unilateral hemisphere stroke and 20 matched healthy subjects. All patients underwent high resolution MRI brain scan. The patient group included 6 individuals with MN, according to Migliaccio's clinical scale (2014), 23 with motor deficits (H+) and 8 without motor disturbances (H-). We predicted that differential actigraphy would evidence, asymmetry in H+ and MN, no asymmetry in H- group. The protocol included a cognitive and motor examination. Two indexes for upper limbs are considered: an index derived from bilateral Motricity Index Score to quantify motor capacity asymmetry at medical examination and a 24h differential actigraphy index, related to motor performance asymmetry in daily spontaneous activities. The results (see figure) reveal that the three patient groups can be discerned in the plot according expectations. Moreover 3 H+ cases with mild asymmetry at the medical examination evidenced a much larger asymmetry in daily activities, thus being candidate for a MN diagnosis. Based on results, we suggest that actigraphy may reveal the lack of spontaneous movement which is essential to identify MN.

3-5 FXTAS, PD, and ET subjects demonstrate distinct gait, balance and tremor deficits under normal, environmentally challenging, and dual-task conditions using an inertial sensor system

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Background and Aim: Fragile X-associated tremor/ataxia syndrome (FXTAS) affects carriers of a 55-200 CGG expansion in the FMR1 gene and may be misdiagnosed as PD or ET due to overlapping motor symptoms. It is critical to characterize distinct phenotypes in FXTAS compared to PD and ET to improve diagnostic accuracy. Therefore, we compared FXTAS, PD, ET and controls using quantitative measures of gait, balance, and tremor. Methods: Subjects with FXTAS (n = 10; 69.7±6.8 yrs), PD (n = 15; 70.9±8 yrs) and ET (n = 9; 69.6 ± 7.4 yrs) and controls (n = 12; 64.4±7.1 yrs) underwent gait/balance testing with an inertial sensor system (APDM; Oregon). Instrumented Timed Up and Go (i-TUG) and 2-minute walk (i-WALK) were used to test gait, and i-SWAY to test balance. DT conditions included a verbal fluency task. Subjects also underwent tremorography using the ETSenseTM system (Great Lakes NeuroTechnologies Inc.). Results: On the i-TUG, FXTAS subjects had increased sit-to-stand peak velocity compared to PD (p=0.04). On self-selected speed and DT i-WALKs, they had increased stride length (p=0.03 and 0.04, respectively), and during self-selected and fast i-WALKS they had reduced cadence (p=0.03 and 0.04, respectively) compared to PD. On the i-SWAY, both FXTAS and ET subjects had increased jerk (m2/s5; smoothness of path sway) compared to PD during the foam, feet apart, eyes closed condition (p=0.01 and 0.04, respectively). On tremorography, FXTAS subjects showed reduced rapid alternating movement amplitude compared to PD (p = 0.0045), and PD subjects showed reduced rapid alternating movement amplitude and speed compared to ET (p=0.0002 and 0.0115, respectively). Conclusions: This pilot data demonstrates that FXTAS, PD, and ET subjects exhibit distinct deficits in gait, balance and tremor under normal, environmentally challenging and DT conditions. This suggests that these quantitative measures may be sensitive to distinguish FXTAS from PD and ET.

3-7 Measurement of Physical Activity Levels and Self-Efficacy during Early Recovery after Acute Myocardial Infarction

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Background: Self-efficacy and regular physical activity are particularly important for cardiac patients as these favorably influence multiple coronary risk factors. Few studies have measured both cardiac self-efficacy and patterns and levels of physical activity after acute myocardial infarction during the early recovery phase. The aim of this study was to assess the relationship between, and changes in, self-reported self-efficacy and physical activity levels at baseline, two weeks (T1) and six weeks (T2) after hospital discharge, following acute myocardial infarction. Methods: This study was a cohort study with a repeated measures design. A purposive sample of 100 Jordanian patients was recruited. Participants did not have access to cardiac rehabilitation. The cardiac self-efficacy questionnaire was administered at baseline, T1 and T2. A body-worn activity monitor (activPAL3) was worn for 7 consecutive days, at T1 and T2. Results: Average self-efficacy scores at baseline were 22.14± 8.3, 35.09± 9.1 at T1; and 48.09± 8.5 T2. Self-reported cardiac self-efficacy scores improved significantly between T1 and T2 across all subscales; (maintain function, control symptoms and healthy lifestyle (P<.05) and global cardiac self-efficacy (P<.05)). Average step count per day at T1 and T2 was 6,981 ± 2,800 and 7,149 ± 2,575. Average upright time (stepping and standing time) at T1 and T2 was 18.45 ± 2.06 and 18.53 ± 1.74 hours/day. There was no significant statistically significant changes between T1 and T2 in any of these measures of levels of activity or in the patterns of activity. Discussion: Self-efficacy levels and changes were consistent with previous literature. Physical activity levels did not change, which was not consistent with other studies. Increase in self-efficacy did not influence physical activity levels. Research is needed to understand how to improve physical activity in the early recovery phase after acute myocardial infarction.

3-9 The association of sedentary behaviour and mental wellbeing in the workplace

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Background: Sedentary behaviour (SB) is highly prevalent in workplaces and this behaviour can be detrimental to health; however, little is known about SB and its association with mental wellbeing (MW). Therefore, the main aim of this pilot study was to examine the impact of SB on MW using the work environment as a case study. Methods: A convenience sample of staff, (females (52.4%); median age 33.0 (IQR 28.5-44.0)) and postgraduate students (n=21) from the University of Salford were grouped into those with sit-stand desks (n=9) and those without sit-stand desks (n=12). Data were collected for a 7-day period using the activPAL, a daily activity diary, and a questionnaire that included the validated Warwick Edinburgh Mental Wellbeing Scale. Statistical analysis was carried out to test for differences in sitting times between both groups and correlation tests were used to examine associations between sitting at work and MW. Results: Baseline characteristics showed no difference in gender, BMI, or education level; however, there was a significant difference in median age for those who had desks (45.0) and those without (30.5) (p=0.015). Median daily waking sedentary time was 9.55 hours (8.72-10.71) for those with sit-stand desks and 9.56 (8.90-10.51) for those without sit-stand desks; however, this was not statistically significant (p=0.808). The group without sit-stand desks spent more time sitting at work than the group with sit-stand desks (73.6% vs. 64.1%); however, this was not statistically significant (p=0.219). There was an inverse association between time spent sitting and MW scores, but this was not significant (p=0.825). Conclusions: There were no differences in sitting times between the groups despite the use of sit-stand desks in one of the groups. Prolonged SB in the workplace may be inversely associated with MW; however, more research is needed in a larger cohort that would enable adjustment for confounders to be made.

3-11 Associations of objectively assessed sedentary time and physical activity with mortality in a Swedish population based cohort - a 15 year follow-up

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Longitudinal data on associations of sedentary time or physical activity and mortality using objective measures such as accelerometry are rare. This study aimed to investigate the associations of objectively assessed sedentary time, light intensity physical activity (LPA), Moderate to vigorous intensity physical activity (MVPA), and total physical activity with all-cause mortality and mortality from cardiovascular disease (CVD) or cancer in a population based cohort after 15 years follow-up time. We analyzed data from 851 adults in the Sweden Attitude Behavior and Change study (ABC) 2001-2002, with 14.2 years mean follow-up time and 12,117 person-years at risk. Cox proportional hazards models estimated hazard ratios (HR) of mortality with 95% confidence intervals (CI). Primary exposure variables were tertiles of time (in minutes) spent sedentary, in LPA, and in MVPA and total accelerometer counts. Compared with the least sedentary participants, those in the most sedentary tertile had an increased risk of all-cause mortality, HR: 2.6 (1.4, 4.9), which was slightly enhanced when adjusted for 150 min/week of MVPA. They had significant higher risks in a multi-adjusted models for CVD and cancer mortality. For all-cause mortality, those in the highest LPA tertile had a HR:0.34 (0.17, 0.67) compared with the lowest tertile. A similar pattern was found for CVD and cancer mortality. More time spent in MVPA was associated with lower mortality. The largest risk reduction was found for CVD mortality, with an almost 90% lower risk in the tertile with the most time in MVPA. In conclusion, this study confirms a strong relationship between MVPA and mortality and adds new insight into the risk of too much sedentary time, as well as the health benefits from LPA.

3-13 Ability of thigh and hip-worn Actigraph accelerometers to classify postures and activity behaviors in children

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Background: Postural classification using a thigh-worn activPAL inclinometer is the 'gold standard' for identifying sitting and standing and postural transitions. However, the activPAL inclinometer does not measure physical activity intensity and is costly for large scale studies. The hip-worn Actigraph accelerometer has been found to be a valid and reliable instrument to assess physical activity in children and, when mounted on the thigh, is comparable to the activPAL inclinometer for postural classification. In free living and laboratory conditions, the Actigraph is more sensitive to motion than the ActivPal. Therefore, the thigh-worn Actigraph accelerometer may be an alternative device to the activPAL in large projects to provide rich data on posture and activity behavior classification in children. The aim of this study was to measure the agreement in postural classification using the inclinometer function between thigh and hip-worn Actigraph accelerometers in 9-10 year-old boys, during school hours. The study also examined the relationship between inclinometer determined posture classification to accelerometer determined sedentary time and physical activity. Methods: Fifty Year 4 boys from a private school in Perth, Australia wore two Actigraph accelerometers (worn on thigh and hip) during school hours for one week as part of a larger study examining the health and educational outcomes of introducing standing desks into the classroom. Between monitor postural agreement was calculated from hip and thigh inclinometer data (proportion of time spent sitting, standing and stepping). Results: Data collection and

analysis is ongoing and will be completed in March 2017 Conclusions: Results of this study will assist in developing accurate methods of postural and activity behavior classification in children.

3-17 Tracking Recovery from Orthopedic Surgery in Youth with CP

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Aim: This is a case series of three children with cerebral palsy (CP) who were evaluated in the Gait Lab to assist with surgical plan and tracked during recovery using an activity monitor. Included are BC, a 14 y.o. boy with mixed spasticity and dystonia, JA, an 8 y.o. boy with diplegia, and AM, a 4 y.o. girl with hemiplegia. Clinical Data: Patients were independent in walking ability pre-operatively. Each underwent surgery as recommended by gait analysis. Surgeries included: for BC a right subtalar joint fusion and midfoot osteotomy, for JA bilateral femoral derotation osteotomies, tibial derotation osteotomies, hamstring lengthenings and gastrocnemius recessions, and for AM right gastrocnemius recession. As part of the pre-op gait analysis, free living walking activity was measured with the Step Watch. Bjornson's report of average daily stride total for youth age 10-13 years old was used for comparison (typically developing=6,739 / CP=5,603).1 Outcome: Patients returned at 3 and 6 months post surgery for repeat monitoring. Clinical report at 3 months included: for BC, foot pain and hypersensitivity, for JA, problems with transportation to PT, and for AM, complaint of foot turning out. These cases demonstrate wide variation in the recovery of walking shortly after surgery (figure 1). BC had an expected small decrease in strides at 3-months, and at 6-months he averaged 1,000 strides per day below his pre-op average. JA had a dramatic decrease in average daily stride count at 3-months, an expected decline given his extensive surgery. AM more than doubled her stride values at 3-months and maintained these gains at 6-months. Summary: Monitoring the free-living walking activity of youth with CP provides supplemental information to lab-based gait measures. Tracking surgical recovery with a new clinical protocol will allow us to objectively measure progress in surgical recovery, modify rehabilitation programs, and quantify functional outcomes after gait surgery.

3-19 Barriers to older medical patients walking in hospital

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Introduction: We aimed to identify patient- and time-specific barriers to walking among older medical inpatients. Methods: 154 medical inpatients aged ≥65 years, premorbidly mobile, with an anticipated length of stay ≥3 days, were recruited. Step-count (Stepwatch Activity Monitor) and potential barriers to walking were recorded daily until discharge or for a maximum of five weekday. These included medical status, walking ability, presence of catheters and intravenous lines, agitation or confusion, reported fatigue, pain, fear of falling, and instructed bedrest. Linear mixed effects models were used to measure the associations between log-transformed daily step-count and potential barriers, adjusted for each other, and key patient characteristics on admission: age, sex, height, weight, physical performance (SPPB), number of medications, and illness severity (CIRS-G). Due to missing data, the analytical sample included 147 patients. Results: In the fully adjusted mixed effects model, step-count increased linearly by an average of 12% (95% CI 2% to 23%) for each day of observation. However, the mixed effects model with patient-level random intercept and slope factors fit the data better than the random intercept model ($p < 0.001$), or the model with no random effects ($p < 0.001$), suggesting there was

considerable patient-level variability in step-count trajectories. Among time-varying predictors, the ability to walk independently was associated with a 46% increase in daily step-count (95% CI 12% to 91%); while a decrease in daily step-count was linked to fear of falling (-27%; 95% CI -46% to -1%), being tethered to the bed (-21%; 95% CI -39% to +3%), and instructed bedrest (-68%; 95% CI -78% to -47%). Conclusion: Daily step-count trajectories were variable, even when adjusted for patient characteristics on admission. The results suggest that patients tethered to the bed, unable to walk independently, and fear falling may require more support to walk in hospital.

3-21 Patterns of objectively measured sedentary time in adults with intellectual disabilities.

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Introduction: Adults with intellectual disabilities (ID) experience multiple social disadvantage and significant health inequalities. Due to rates of obesity around 50% and an increased prevalence of diabetes, there has been a growing interest in whether supporting adults with ID to make positive changes in lifestyle behaviours can lead to health improvement and a reduction in health inequalities. A recent systematic review of sedentary behaviours in adults with ID identified sedentary behaviour as an important area for research, with adults with ID spending 552-643 minutes per day sedentary. However, the relevance of sedentary behaviour to the health of adults with ID is limited by previous research focusing on total sedentary time, with a lack of data on recommended measures of patterns of sedentary behaviour. The aim of this study is to address these issues by following best practice recommendations and reporting the patterns of objectively measured sedentary time in adults with ID. Methods: A secondary data analysis will be conducted of baseline 7-day accelerometer data from two randomised controlled trials of lifestyle behaviour change programmes which measured sedentary time in adults with ID using the ActiGraph GT3X+. Sedentary time will be defined as <100 cpm and examined using multiple measures, in accordance with best practice recommendations: total time (hour/day), weighted median bout length (minutes), number of bouts >30 minutes, maximum bout length (minutes), and number of postural transitions (derived from inclinometer data). All analysis will be conducted using SPSS. Results: Descriptive statistics will be presented for all participants (n=151). Patterns of objectively measured sedentary time will be reported for each measure. Discussion & Conclusion: Results will be discussed in relation to previous research and future implications.

3-23 Measurement of Physical Activity by Accelerometry in Infants and Toddlers

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Research on the physical activity levels of infants (<12 months old) and toddlers (12-24 months old) is limited. The purpose of this study was to describe physical activity levels of infants and toddlers using accelerometers worn at the wrist, hip, and ankle. Twelve participants (5 months to 22 months) wore 3 ActiGraph accelerometers (GT1M, GT3X, GT3X+) on the right wrist, hip, and ankle during activities in the child care setting. Six (2 female, 4 males) of the children were non-walkers and 6 (4 female, 2 male) were walkers. Each participant wore the 3 accelerometers for 30-minute periods on 1-5 occasions and data were collected/ downloaded in 15-second epochs. Mean counts per 15-seconds for each wear placement and by ambulatory group were calculated. The percent of time spent in 3 intensity categories (sedentary, light, MVPA; Trost et al., 2012) was calculated and differences between walkers and non-

walkers were examined. Data were collected for 1200 minutes of wear, with a range of 36 to 152 minutes per child. Mean counts/15s were 123.1 for hip, 476.0 for wrist, and 365.6 for ankle for non-walkers. Similarly, the counts/15s for walkers were 128.6 for hip, 501.8 for wrist, and 374.1 for ankle. Table 1 shows the percent of time spent in each intensity category by wear placement and ambulatory group. While there were no significant differences between the groups, there were differences in the percent of time in each intensity level based on the placement. In this preliminary study, we demonstrate the feasibility of using accelerometers in infants and toddlers and present data on the average counts from 3 wear placements. Cutpoints for toddlers were used to describe physical activity levels for this sample, indicating clear differences in activity time based on placement. Continued research is necessary to understand accelerometer data processing in children in this age group.

3-25 Machine learning algorithms for activity recognition in ambulant children and adolescents with Cerebral Palsy

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Machine learning (ML) approaches have emerged as a more accurate alternative to processing accelerometer data than traditional cut-point methods in typically developing youth. However, to date, no studies have examined the accuracy of ML approaches in children and adolescents with Cerebral Palsy (CP). Purpose: To develop, test, and compare activity recognition algorithms trained on hip and wrist accelerometer data in ambulant children and adolescents with CP. Methods: 18 children and adolescents (mean age: 12.6 + 3.1 y) with CP classified at GMFCS Levels I to III completed 6 activity trials while wearing an ActiGraph GT3X+ accelerometer on the hip and wrist. Trials were categorised as sedentary (SED), standing utilitarian movements (SUM), comfortable walking (CW), and brisk walking (BW). Random forest (RF), support vector machine (SVM), and decision tree (DT) activity recognition models were trained from the raw acceleration tri-axial signal using time and frequency domain features extracted from 10 s non-overlapping windows. Performance was evaluated using leave-one-out-cross validation. Results: Cross-validation accuracy for the hip RF, SVM, and DT models was 0.87 (95% CI: 0.86 - 0.88), 0.86 (95% CI: 0.84 - 0.87), and 0.79 (95% CI: 0.78 - 0.80), respectively. Accuracy for the wrist RF, SVM, and DT models was 0.81 (95% CI: 0.80 - 0.82), 0.81 (95% CI: 0.80 - 0.82), and 0.78 (95% CI: 0.77 - 0.80), respectively. Recognition accuracy was consistently excellent for SED (93 - 97%), and very good to excellent for SUM (86 - 91%). For the Hip RF and SVM, recognition accuracy was modest for CW (65 - 69%) and very good for BW (86 - 88%). Conclusions: Supervised ML algorithms such as RF, SVM, and DT are useful for predicting PA type from accelerometer data collected in ambulant children and adolescents with CP. While all classifiers provided acceptable recognition accuracy, classifiers trained on hip data yielded significantly better performance.

3-27 Reliability and validity of the activPAL for measuring stepping and reclining in unilateral lower limb amputees

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Introduction: Valid, reliable measurement of physical behaviours in adults with limb absence is essential to accurately describe physical behaviour patterns and intervention effects. Purpose: To assess parallel forms reliability and criterion-related validity of the activPAL for measuring steps and reclining time in simulated lifestyle activities in adults with unilateral lower limb absence. Methods: 15 adults completed three circuits of simulated kitchen work, sitting, lying and purposeful walking on level ground and stairs. Three trained raters independently analysed video recorded trials for incidental stepping, purposeful stepping and reclining. Simultaneous data were obtained from two activPAL monitors placed on the sound and prosthetic side. Data were analysed using oneway intraclass correlation coefficients (ICC; parallel forms reliability), and with Pearson correlations, oneway repeated ANOVAs, and Cohen's d (criterion-related validity). Results: Parallel forms reliability (prosthetic side vs. sound side) was poor for incidental steps (ICC = .05, d = 0.41) but acceptable for all other measures (ICC = .69-.98; d = 0.02-0.17). Correlations between direct observation and activPAL ranged from r = .65-.98 (activPAL on sound side) and from r = .30-.99 (activPAL on prosthetic side). Mean differences between observed measures and activPAL measures were generally large for all stepping variables (d = 0.56-4.22); observed mean scores were systematically higher than from the activPAL. Correlations were higher for reclining time (r = .98-.99), and differences were smaller (d = 0.25-0.28), although the pattern was similar (observed scores were higher). Conclusions: activPAL data from the sound side and prosthetic side are similar for adults with unilateral lower limb absence. Validity of the activPAL in this population seems poor in simulated lifestyle activities. These results may be at least partly due to the brief sampling period or the simulated activity protocol.

3-29 Ambulatory Activity Profile Following Treatment for Clubfoot at age 10yrs

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Clubfoot is a common orthopaedic condition treated during infancy with nonoperative means (Ponseti casting, physical therapy), and when correction is incomplete, surgical treatment. Following orthopaedic correction, it is unclear if patients with clubfoot have lasting functional deficits. Objective measures of community ambulation may provide clinicians valuable insight on the efficacy of treatment. To compare the ambulatory activity levels of children 10 years following treatment for clubfoot to a group of typically developing peers. As part of a prospective IRB approved study, 117 children with a history of clubfoot (56 surgical [SX], 61 nonoperative [NO]; age 9.8 years) wore a StepWatch Activity Monitor for a minimum of 1 week. Raw stride data were processed to identify the intensity/duration/volume of ambulatory activity bouts along with the total steps and total ambulatory time. 42 age-matched controls (age 9.8 years) were used for comparison of ambulatory activity. Mann-Whitney tests (α=0.05), were used to evaluate differences between children with clubfoot and controls. Clubfoot patients reported similar involvement in sports, PE and a typical week of activity as controls. During the weekday, children with clubfoot took significantly fewer steps ($p=0.02$) and had fewer total ambulatory minutes ($p<0.01$) than controls. There were no clinically significant differences in ambulatory bout intensity/duration. There were no significant differences in the weekend ambulatory outputs of children with clubfoot compared to controls. Hourly analysis showed no significant difference in steps taken between the hours of 09:00-15:00 in those children treated SX compared to those treated NO. Clubfoot patients at age 10 years take fewer steps and spend significantly less time in community ambulatory activity when compared to their peers. Ambulatory activity intensity-duration is not reduced and there was a minimal difference in patients treated surgically vs. nonoperatively.

3-31 Three Days Monitoring of Activities of Daily Living among Healthy and Parkinsons Disease Patients

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INTRODUCTION Parkinson's disease (PD) is a neurodegenerative disorder and two of its cardinal symptoms are tremors and postural instability [1]. More than 50% of PD patients fall a year which negatively impacts activity levels and overall quality of life. To evaluate fall risk in everyday environments, an activities of daily living (ADL) assessment is essential. Inertial Measurement Units (IMU) allows for different metrics of the dynamic and static measurements to be determined for PD and healthy subjects. METHODS Total of four subjects, two PD patients and two healthy subjects, were recruited. Subjects wore a DynaPort MM++ at the sacrum for 3 days data collection, removing the device was permitted only for bathing. Subjects maintained a log of activities to keep track of their ADL. Resultant acceleration was filtered using Butterworth filters with cut off frequency of 0.001Hz and 5Hz to determine static and dynamic activities. Using this method, the quantity and duration of dynamic and static activities were compared between healthy and PD groups. RESULTS Data indicated dynamic activity rate of the healthy subject group was 4.4% and 2.2% for PD group. As hypothesized, the healthy group had approximately twice the amount of dynamic activities compare to PD subjects. Figure 1 shows the average percentage difference of dynamic and static performance among the healthy subjects and PD patients. DISCUSSION A limitation of our pilot study was a small sample size, making it difficult to specify if our result was significant. CONCLUSION The objective of this research was to evaluate three consecutive days of regular activity of PD patients and healthy subjects and compare the differences in dynamic and static measurements. Our pilot results indicate the capability of using IMUs for detecting ADL and that healthy subjects participate in more dynamic activities than PD patients.

3-33 Do Sources of Psychological Stress Differentially Impact Exercise? Results of a 1-Year Observational Study among Healthy Adults

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BACKGROUND: It is known that Psychological stress influences healthful behaviors and habits throughout the lifespan. It's unknown whether the various sources of psychological stress (e.g. work-related stress, argument-related stress), influence exercise habits. Using mobile technology to gather data for a year, this study was conducted to investigate whether exercise participation varies by source of daily stress in healthy adults. METHODS: Data were collected from an observational study of healthy adults (N=79; 43% male, mean age: 32±9 years) for 365 days. Exercise was measured using a wrist-based Fitbit Flex and was defined as at least 24 min of moderate or vigorous physical activity (MVPA) within any consecutive 30-min period. Each day was categorized as an exercise or non-exercise day. Exercise over the study period was expressed as the percentage of valid wear days (≥10 hours) wherein exercise was objectively measured. Electronic journals, that used the participant's own smartphone, was used to ask daily sources of stress by text messages ("Just before the prompt, did you experience stress from any of these: work, argument, traffic, deadline trouble, paying bills, running late, or other, with the participant checking all that apply). RESULTS: The percentage of days exercised for each stress reported

on a given day are as follows: work: 30.0% (SD: 19.7), argument: 34.6% (SD: 27.8), traffic: 32.2% (SD: 25.2), deadline trouble: 30.9% (SD: 26.5), paying bills: 30.5% (SD: 29.7), running late: 32.7% (SD: 26.5), and other: 40.6% (SD: 23.5%). In a linear mixed model, the percentage of days exercised was greater on days when 'other' variable was reported compared to the alternative variables that were reported (p-values <0.05). CONCLUSION: Exercise participation largely didn't vary by source of stress except on days when the 'other' response was selected. Future studies elucidating these other sources of stress that influence exercise participation may be warranted.

3-35 Synergistic association of objectively measured physical activity and diet quality in older Japanese adults: the Nakanojo Study

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INTRODUCTION Our aim was to determine associations between physical activity, dietary quality and serum albumin. METHODS Subjects were Japanese aged 65-84 years (104 men, 106 women). 24-h pedometer/accelerometer data were collected continuously for 365 days, with baseline evaluation of serum albumin, and questionnaire determination by trained interviewers of weekly intake of 29 food groups and 10 kinds. A serum albumin of 2.7 through 4.2 g/dL was classified as a high risk for malnutrition. Repeated measures analyses of variance assessed the association of yearlong physical activity with intake of 10 food groups. Multi-adjusted logistic regression analyses assessed independent relationships between baseline physical activity and the risk of malnutrition, after controlling for age, sex, smoking and alcohol consumption. RESULTS The intake of beans, fruit, green vegetables and fish was higher in those with greater daily step counts and greater activity >3 METs. However, the flavor and MSG consumption were lower in those with greater daily activity. A multivariate-adjusted odds ratio predicted that the cardiovascular risk was 2.0-3.3 and 3.0-4.9 times greater in the two least active quartiles of participants (taking <6,900 steps/day and spending <14 min/day at >3 METs, respectively) relative to the most active quartiles (taking >8,093 steps/day and spending >19 min/day at >3 METs, respectively). DISCUSSION AND CONCLUSIONS Our cross-sectional data suggest that in older adults, objectively-measured yearlong physical activity is associated with a greater intake of some foods (beans, fruit, green vegetables and fish). After adjusting for potential confounders, cardiovascular risks are associated with both daily step count and daily duration of habitual activity >3 METs. Physical activity appears related to healthy eating, and elderly people should be encouraged to take at least 7,000-8,000 steps/day and/or spend at least 15-20 min/day at >3 METs.

3-37 On the measurement of running style in extreme conditions: recording and analysis of 3D acceleration data during a mountain ultra-marathon in the alps

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Background In order to improve usability of wearables such as the actibelt in clinical trials we use experience from other fields with extreme requirements. Ultramarathons in mountains are an underresearched (https://peerj.com/articles/2591/) and particularly interesting field, as athletes and devices are brought to their limits. Methods We equipped two experienced mountain runners with an actibelt (recording box with 100 Hz, 3D). In addition they wore GPS watches and had RFID chips leaving

time stamps at fixed checkpoints. The recording boxes were returned after the race and an interview about user and running experience was conducted with one of the athletes. Standardized analysis packages in R and exploratory algorithms were used for data analysis and visualization. Results Both runners wore the belt without interruption during the race (110km, 6.500 m, 16/17 June 2016) in the Großglockner area in Austria. No complain about usability, apart from a minor temporary discomfort. Data from the race from both runners could be downloaded from the recording boxes and 100% of the data was available for analysis. One of the GPS watches stopped working before the end of the race. Both runners were relatively close to each other (less than 10 minutes apart) such that one had an approximate GPS location also for the runner with the broken GPS watch. Total time in the race was a little less than 25 hours. Number of steps, speed, activity temperature were plausible. Different phases of the race could be identified and quantified with feature extraction (e.g. "Kleist plots", functional data analysis). Discussion/Conclusion The technology platform actibelt is capable to capture high quality and meaningful data in extreme conditions. Empirical data can be collected to inform runners and coaches about new and important aspects of running style and performance.

3-39 Impact of the EGNOS feature and environmental conditions on GPS accuracy during outdoor walking

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Although Global Positioning System (GPS) offers interesting opportunities when studying physical activity, the level of obstruction due to environmental conditions impairs its accuracy. Satellite-based augmentation systems, such as EGNOS (Geostationary Navigation Overlay Service), are expected to significantly improve the GPS positional accuracy. We aimed to assess the impact of the EGNOS feature, and the interaction with the level of obstruction, on GPS accuracy in the estimation of outdoor walking distances. Eleven subjects (F/M=3/8;22±1years;177±6cm;70±9kg) took part in this study. Prescribed walking protocols (PWPs) were performed in 3 locations, corresponding to 3 distinct environmental conditions with low (outdoor athletic track), medium (public park) and high (urban canyon) levels of obstruction, respectively. Each PWP was repeated twice on two different days, and consisted of a series of randomized walking bouts (50 to 400 m), performed at a ''usual'' and then at a ''slow'' pace (n bouts=288/location). Subjects were equipped with two GPS receivers (DG100 GlobalSat®) recording at 0.5-Hz. From a PWP to another one, the EGNOS function was disabled on one GPS receiver, whereas it was enabled on the other one. The coefficient of variation was computed to estimate the error in GPS distances estimation. GPS accuracy decreased with the increase of the obstruction level, regardless of whether or not the EGNOS function was enabled (Table 1). As the level of obstruction increased, the error in GPS distances estimation tended to be lower when the EGNOS function was disabled. In restricted locations with a high level of obstruction, it is likely that the differential corrections send by the geostationary satellite add extra error to the measurement performed by the GPS receiver. However, this additional error seems fall within the test-retest variability of this GPS receiver, when estimating outdoor walking distances.

3-41 Reliability of stair climbing parameters measured with an inertial measurement unit fixed to the lower back

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Introduction: The Dutch government aims to enable older people to live independently as long as possible, implying that fewer older adults will be admitted to residential care homes. It is not so much diseases as such, but rather their ensuing limitations that cause the main obstacles to independent living. To live independently, many older adults need stair climbing ability. It was shown that older adults perform activities of daily life near their maximal capabilities (Hortobágy et al. 2003). Due to its high demand of muscle strength, stair climbing ability is an important activity to quantify. The aim of this study was to investigate the reliability of stair walking parameters measured with an inertial measurement unit (IMU). Method: 11 women (66.0 ± 7.5 yrs) were instructed to ascend and descend a 3 step staircase 4 times and a 12 step staircase 2 times at a fast but comfortable speed. Participants wore an IMU on their lower back. From the trunk data, we determined the duration of the different phases (stance, rise/decline), step frequency, mean and peak power, trunk angle and movement intensity. Results: The test-retest reliability for all parameters was acceptable for both the 3 and 12 steps staircase (ICCs ranging from 0.60 to 0.92), except for the mean stance duration during ascent, trunk angle during ascent and descent, step frequency during descent for the 3 step staircase and intensity during the ascent rise phase for the 3 step staircase. Conclusion: The results indicate that it is feasible to measure qualitative parameters for stair walking with only one IMU placed on the lower back. Further, the test-retest reliability was acceptable for almost all parameters. The feasibility to use this method under free-living conditions will be explored in future research.

3-43 Precision and patient acceptance of a belt-worn wearable (actibelt) in patients with osteoporosis and/or after trauma surgery

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Mobility plays an important role, in particular for patients with osteoporosis and after trauma surgery, both as an outcome and as treatment. Mobility is closely linked to the patient's quality of life and exercise is a powerful additional treatment option. In order to be able to generate an evidence base to evaluate various surgical and non-surgical treatment options, objective measurements of patients mobility and exercise over a certain timeperiod are needed. Wearables are a promising candidate, with obvious advantages compared to questionnaires and/or PROs. However, when extracting parameters with wearables, one often faces the problem of algorithms not performing well enough for special cases like slow gait speeds or impaired gait, as they typically appear in this patient group. We plan to further extend the applicability of the actibelt system (3D, 100Hz), in particular to improve the measurement precision of real life walking speed in slow and impaired walking. We are using a special measurement wheel including a rotating 3D accelerometer that allows to capture high quality real life walking speed and distance measurements, and a mobile high resolution camera system. In a first block 14 patients with osteoporosis were included in the study and equipped with an actibelt. Patients were asked to walk as "normal" as possible, while wearing their usual apparel, in the building and outside the building. They climbed stairs and had to deal with all unexpected "stop and go" events that appear in real world walking. Various gait parameters will be extracted from the recorded data and compared to the gold standard. We will then tune the existing algorithms as well as new algorithms (e.g. CWT) to explore

potential improvements of both step detection and speed estimation algorithms. Further refinement and validation using real world data is warranted.

3-45 Physical activity recognition using wrist-worn accelerometers: comparison of dominant and non-dominant arm

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The purpose of this study was to determine whether there is a difference in physical activity assessment between a wrist-worn accelerometer at the dominant or non-dominant arm. The secondary purpose was to assess the concurrent validity of measures of physical activity from the wrist-worn accelerometer and the waistworn accelerometer. Forty adults wore three accelerometers simultaneously, one on the waist and one each on the non-dominant wrist and dominant wrist, respectively, for 24 consecutive hours of free-living conditions. Data were uploaded from the monitor to a computer following a 1-day test period. There were no significant differences in physical activity when comparing the dominant versus the non-dominant wrist, regardless of axis (P>0_05). Mean daily accelerometer output data from both wrists were strongly correlated with average counts per minute from the ActiGraph worn around the waist (r = 0_88, P<0_001). Findings suggest that the choice to wear the accelerometer on the nondominant or dominant wrist has no impact on results. Data from this study contribute to the knowledge of how to best assess physical activity habits.

3-47 Joint Angle Measurement in Yoga using IMUs

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There are many human activities in which success depends on the correct coordination and control of body movement. Exercises such as yoga can benefit from real-time feedback on the motion of the body segments. This preliminary study shows that inertial measurement units (IMUs) can be used as a tool for providing real-time or end of session feedback about specific activities. Such information may help to improve the learning speed and quality of a yoga training session. A motion capture system consisting of 17 IMUs distributed over different body segments was used to capture the body kinematics. The IMUs fit in a suit which fits comfortably on the subjects and minimally interferes with the study exercises. A template for the acceptable form of six different yoga poses was created using the pose recommendations from an instructional manual. Subjects were given general instructions on how to make the poses and their performance on certain metrics was compared to that of an instructor. In the figure, the performance of a group of 10 subjects (7M, 3F) doing a half-wheel yoga pose was compared to that of an instructor (F). It shows that for the first metric -"Do not bend elbow", the group mean was 20 deg. higher than that of the instructor even though the instructor also deviated from the ideal (0 deg.) by about 11 deg. It also shows that the instructor was steadier in the pose than the average group performance as the standard deviation of her lateral bend angle metric is about 0.5 deg. lower than the group mean. In conclusion, we show that the IMU system can distinguish between the performance of an instructor and novices. The system, along with its graphical avatar, can be used to improve the quality of the exercise.

3-49 Concurrent measurement of GPS and event-based physical activity data: a methodological framework for integration.

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Purpose: To develop a framework for the integration of event-based physical activity data (characterised as a variable duration starting at non-regular times) with GPS data (characterised as regularly sampled data). Methods: Framework development was conducted on concurrent GPS and activPAL data from 56 individuals. Data integration was based on the principle of using GPS derived outputs to create additional outcomes associated with each (activPAL) walking event. Scoping of the range of GPS outcomes and permutations of integration of sampled data with event-based data was used to create a framework indicating how each category of GPS outcome data should be processed to derive an outcome for each walking event. Results: Five types of GPS outcome were identified: categorical (e.g. outdoors) and scale (e.g. distance from home) outcomes relating to a single GPS point; and categorical (e.g. uphill), scale (e.g. distance) and rate (e.g. speed) data relating to successive pairs of GPS points. Walking events interacted with GPS data in three ways: (1) a walking event could occur between GPS points (containing no GPS data points) or (2) one or more GPS data points could occur during the event. In each case a rule-based assessment was required as to whether a nearby GPS point should be included when deriving the outcomes. Finally, there was a sub-set of interactions (3) where (after judgment on including nearby points) only one GPS point occurred during the walking event. The framework for processing data for each type of GPS outcome and interaction with event-based data is shown in the table. Discussion: Combining data from different sources can add richness and context to the measurement of physical behaviour. However integration can be complicated when data output is in very different formats. The framework presented here provides a consistent method of integrating event-based and sampled data, which could be applied to integration of datasets across varied contexts.

3-51 The effect on human activity recognition classifier accuracy with changing windowing overlap.

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Accurate Human Activity Recognition (HAR), using body-worn inertial sensor technology, can promote safer independent living and physical health assessment in the older adult population. A suite of HAR algorithms have been developed for tri-axial accelerometer data recorded from the L5 location using 42.3hours of a high-resolution data-set [1]. The effect of windowing overlap percentage on the classification accuracy of HAR algorithms, developed using three different supervised machine learning classifier types, are examined. Nine different HAR algorithms were developed using 27 different spatial, temporal, trigonometric and kinematic features of biomechanical movement. The activities detected include: sitting, standing, lying, walking, shuffling, stairs (ascending and descending) and transition. A 33% hold-out validation was used to assess classifier accuracy. A sliding window width of 1 second and overlap percentages of 25%, 50%, 75% and 99% were used. The weighted KNN with a 99% overlap produced the highest accuracy of 94.69%. Overall KNN algorithms performed better than both neural network and decision tree algorithms, Figure 1. Figure 1. It is interesting to observe that the KNN classifiers benefit significantly from increased window overlap, whereas both the decision tree and neural network classifiers do not. We have examined the effect of a sliding window overlap on HAR

algorithm accuracy, generated using three different machine learning approaches. A weighted KNN algorithm with a 99% overlap produced the highest detection accuracy. Reference: [1] A. K. Bourke, E. A. F. Ihlen, R. Bergquist, P. B. Wik, and J. L. Helbostad, "Validation of Existing Systems and Development of New Algorithms for Body-Worn Activity Classification Systems for Independent Living Older Adults--Description of the Study Protocol and a Reference Dataset," Sensors (Basel).

3-53 Calibration of triaxial accelerometers in swimming

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The main purpose of the present investigation was to create an equation to estimate physical activity intensity in Metabolic Equivalents (METs), though triaxial accelemetry in swimming, and to discover the optimal placement of accelerometers in water activities. The study was performed in 11 adults (18 to 27 years old) without any physical limitation for swimming. All participants had height and weight assessed and underwent a swimming protocol of 800m in front crawl, divided in 4 stages of 200m with increasing speed. Physical activity was assessed with triaxial accelerometry (Actigraph wGT3X; GT9x Actigraph Link+, USA) and oxygen consumption (VO2) by spirometry (Cosmed K4b2, Italy). The accelerometers were placed in the wrist and in the waist. Physical Activity values were recorded in counts per 5 seconds (counts/5s) and later converted in counts per minute (counts/min). VO2 was converted into METs. Results showed a moderate positive correlation between counts/min and METs ($r=0,588$; $p<0,05$). The variation of percentage of METs per counts/min was 31,2%. The best regression model to predict METs from counts/min was: [METs = -1,417 + (0,00096 * (countsaxis2wrist/min)) + (0,00023 * (countsaxis3waist/min)) - (0,00034 * (countsaxis1waist/min))]. Results showed that the wrist accelerometer was the best location justifying 28,5% of the variation of METs whilst the waist only justified 16,1%. This study concludes that the ideal placement to predict physical activity intensity in METS with an accelerometer, during swimming, is the wrist, because the 2,7% loss in precision by removing the waist accelerometer doesn´t justify the added complexity to the equation and the protocol. Grants: Research Center supported by: UID/DTP/00617/2013

3-55 Validity and Relevance of Distinguishing Cycling in Physical Activity Logs

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Cycling can be a major contributor to meeting physical activity recommendations however most activity monitors are not able to classify cycling. At best, cycling is classified as stepping. For people who cycle frequently, this would result in a significant underestimation of energy expenditure. A new software feature for the activPAL3 activity monitor has been developed that classifies cycling activity. This study aimed to assess validity of this classification, and to estimate the relevance of quantifying cycling in terms of the contribution of cycling to meeting physical activity guidelines. Ten participants (21-53yr) wore an activPAL3 continuously for 7 days. In addition, they kept an activity diary in which they explicitly recorded all cycling periods. Participants were asked not to change their normal, weekly activity pattern. ActivPAL3 data were analyzed with the new algorithm, which also classified sitting/lying, standing and stepping events. Cycling classification was compared to the diary records. Energy expenditure of cycling events was estimated based on classified duration of the cycling events and estimated energy cost of cycling derived from the literature (walking 3MET; cycling 6MET). Over the one-week period all

participants registered a total of 144 cycling events in their diaries. ActivPAL3 algorithm recognized 143 of these cycling events. The median duration per day was 25.9 [IQR:10.3-35.3] minutes, the median number of events per day 2.1 [1.1-3.0]. The median cycling time as a ratio of the total cycling and stepping time (the time assigned to stepping only by previous software version) was 32.8 [17.9-34.5]%. The estimated energy expenditure increased comparably. The median ratio of energy spent cycling over total energy expenditure was 49.4 [30.4-51.3]%. It is concluded that activPAL3 is able to accurately classify cycling events and that, in these subjects, cycling had a major contribution to total active time and energy expenditure.

3-57 Activity counts/minute from two non-proprietary algorithms compared to those obtained from ActiLife

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Background: ActiLife software is the most commonly used tool to convert raw acceleration data to activity counts; however, the proprietary nature of its data processing system is limiting. Purpose: To compare two non-proprietary algorithms (Alg1, originally developed; Alg2, Qmedic Health Inc.) relative to the ActiLife process for producing activity counts from raw acceleration data collected among a sample of 6-20 year-old participants. Methods: 116 children and adolescents (52% female, age=12.7±4.3 yrs) completed up to 16 simulated free-living (seated rest, movie watching, coloring, stair-stepping, basketball dribbling, and jumping jacks) and treadmill-based (0.81-8.10 km/h in 0.81 km/h increments) activities each lasting 5 min. ActiGraph GT3X+ accelerometers (80 Hz initialization) were worn at the waist (right-hip) and on the non-dominant wrist. Mean vector magnitude activity counts/minute (cpm; normal filter) were calculated using Alg1, Alg2, and ActiLife for each participant. Mean cpm from Alg1 and Alg2 were compared to ActiLife using equivalence testing (equivalence margin [EM]: ±5% ActiLife cpm). Correlations and median absolute percent error (MdAPE; (|(ActiLife-test method)|/ActiLife)*100) for Alg1 and Alg2 with ActiLife cpm were also calculated. Results: Alg1 (CI: waist=0.8-1.4%, wrist=2.6-3.3%) and Alg2 (CI: waist=1.7-2.4%, wrist=1.9-2.5%) waist and wrist cpm were equivalent to ActiLife. All correlations for Alg1 and Alg2 with ActiLife cpm were ≥0.999. MdAPE values for Alg1 (waist=1.0%, wrist=2.8%) and Alg2 (waist=2.1%, wrist=2.1%) were small and similar in magnitude. Conclusion: Both non-proprietary algorithms produced activity count estimates comparable to those obtained from ActiLife. Additional analysis is needed to evaluate the performance of these algorithms for producing congruent activity counts relative to ActiLife's low-frequency extension filter.

3-59 Validation in free-living conditions of physical activity energy expenditure prediction from hip-worn triaxial accelerometry processed with an automatic posture and activity recognition algorithm

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Accelerometry (ACC) is increasingly used to quantify physical activity (PA) and related energy expenditure (PAEE) in free-living conditions. Yet, single linear regression equations used to convert ACC to PAEE have shown their limits, mostly because the relationship linking ACC to PAEE depends on PA type and intensity. To overcome this problematic, here we developed a PAEE predictive model based on

an activity recognition algorithm (relying on time and frequency domains ACC features; Bastian 2015). The model was validated in free-living conditions. A general weighted multi-linear model (WMLM) built on an activity classification was estimated from PAEE measured by indirect calorimetry (SERVOPRO-4100, Servomex, UK) in 61 subjects wearing an ActigraphGT3X TM (ActiGraph Ltd, USA) while performing, in laboratory, 20 standardized 5-min activities, clustered in 6 groups (lying, slouching, sitting, standing, small-utilitarian-movement/walking/running, cycling). Model performances in estimating PAEE and total energy expenditure (TEE) were computed on 1) the initial learning set, using a leave-one-out cross-validation (LOOCV), 2) two groups with ACC acquired in free-living conditions (with prior activity clustering by the recognition algorithm): during a 3h controlled in-city circuit including 29 specific activities (n=20; reference PAEE for each activity from ActiheartTM, Camtech, UK) and a 14-day period (n=56; reference daily PAEE and TEE by doubly labeled water [DLW]). As illustrated in Table 1 the WMLM outperformed a simple linear model (estimated on the same initial learning set) and the Freedson combined 2011 equation implemented in Actilife (v. 6.13) for the prediction of both PAEE and TEE. Prior activity identification associated with an activity-based multilinear model significantly improves PAEE prediction from ACC both for continuous and mean daily measures. Funding: ANR Diabeloop AP

3-61 Comparability of raw and count-based data from the ActiGraph GT9X Link and GT3X+ accelerometers

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As new accelerometer models are produced, it is important to confirm that data collected by new and older models are comparable. PURPOSE: Compare raw and count-based data between the ActiGraph GT9X Link and GT3X+ accelerometers. METHODS: Adults (n=26) wore Link and GT3X+ monitors on the right hip for an 80-minute semi-structured protocol, performing 12-21 sedentary, household/chore, and ambulatory/exercise tasks for 2-15 minutes each. For each monitor, mean and variance of the raw (60 Hz) data for each axis and vector magnitude (VM) were extracted in 30-second epochs. A machine learning model was used to predict energy expenditure in METs from the raw data. Raw data were also processed into activity counts in 30-second epochs for the x, y, and z axes and VM, with the Freedson 2011 count-based regression model used to predict METs. Time spent in sedentary, light, moderate, and vigorous intensities (≤1.5, 1.6-2.9, 3.0-5.9, and ≥6.0 METs, respectively) were derived from raw and count data METs predictions. Squared correlations (R^2) were calculated to compare raw and count data, and percent (%) agreement was used to compare epoch-by-epoch activity intensity between devices. RESULTS: For raw data, R^2 values between devices for mean acceleration were 0.93, 0.82, 0.60, and 0.71 and for variance were 0.96, 0.97, 0.83, and 1.00 in the x, y, and z axes and VM, respectively. For count data, corresponding R^2 values between devices were 0.99, 0.97, 0.92, and 0.99, respectively. The count-based model had significantly higher %agreement (95.5±4.0%) than the raw data model (61.5±27.6%; $p<0.001$). DISCUSSION: Raw and count data were highly correlated between monitors. Count-based activity intensity had high %agreement between monitors, but %agreement for raw data activity intensity estimates was lower. Data filtering and/or more robust raw data models may be needed to improve comparability of activity intensity estimates between the ActiGraph Link and GT3X+ accelerometers.

3-63 A Review of Step-counting Devices' Mean Absolute Percent Errors (MAPE): Informing Validation Standards

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A tally of steps taken is the most common output produced by modern wearable technologies. Furthermore, it has broad research and clinical applications in surveillance, intervention, and program evaluation. The growing number of step-counting devices has created an increased need to develop validation standards, including setting acceptable tolerances for error. A previous opinion-based "practically relevant" error level of 5% is of limited utility. PURPOSE: To review treadmill-based device validation studies and tabulate step-count mean absolute percent error (MAPE) values by speed. These values were used to derive an empirically-based tolerance for error for evaluating validity of step-counting device. METHODS: PubMed was searched for treadmill-based validation studies that 1) compared device-detected and observed step-counts, and 2) reported MAPE or values needed to calculate MAPE. Reference sections of identified studies were reviewed for other studies meeting these criteria. In total, 109 full-text articles were identified and 21 were included to produce 371 treadmill walking bouts at different speeds, grouped to the nearest 0.5mph increment. Median and quartile values were calculated for each grouped speed. RESULTS: Step-count accuracy was highest (evident by low MAPE values) from 2.5-4.0mph. Median MAPEs from 2.0-5.0mph were consistently below 5%. Median MAPEs from 2.5-4.0mph were consistently below 3%. MAPE values for very slow walking speeds (≤1.5mph) had more variation and the highest median MAPE (19.5%). CONCLUSION: For slow to very fast walking speeds (2.0-5.0mph), the tolerance for error of step-counting devices should be an MAPE <5%. For normal walking speeds (2.5-4.0mph), this tolerance for error should be an MAPE <3%. Devices should be developed and validated to meet these standards. Future research and product development should look to increase accuracy at very slow walking speeds while maintaining accuracy at faster walking speeds.

3-67 Valid detection of wheelchair driving in addition to regular posture and motion detection

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Background: The Activ8 is a commercially available and valid activity monitor, which in its usual set-up (one sensor attached to the leg or in a trouser pocket) is used to quantify regular body postures and movements (sitting, standing, walking, bicycling and running). To quantify physical behavior in patients who also use a wheelchair (eg. incomplete spinal cord injury), we developed a new method to measure wheelchair activities (wheelchair driving and handcycling) in addition to regular body postures and movements. Objectives: To assess whether wheelchair driving can be validly detected in addition to regular body postures and motions by a set of two Activ8's, one attached to the leg and one to the wheelchair. Methods: Nine healthy participants performed a series of representative daily activities according to a protocol including different types of self-propelled wheelchair driving (wheelchair driving with arms and/or legs and handcycling) and other activities while seated in the wheelchair. One Activ8 was attached to the leg, the other to the spokes of the wheelchair-wheel. Data from the two Activ8's was combined in MatLab with a custom-made algorithm (fig 1). Video recordings were used for reference. The main outcome was overall agreement. Results: Overall agreement for the detection of wheelchair driving was 99.5% (inter-subject range: 98.6 - 99.8%). Sensitivity was 100% and specificity

was 94.3% (inter-subject range: 83.5% - 97.2%). During the protocol-activities "maneuvering with wheelchair" and “writing, seated in wheelchair” small time differences were found (5.4% and 0.9% respectively). Conclusion: Different types of self-propelled wheelchair driving can be validly detected by a set of two Activ8’s and a custom-made algorithm. This measurement method enables quantification of the whole array of main body postures and movements in daily life in people who are partly wheelchair-dependent.

3-69 Accuracy of wristable heart rate monitors during treadmill walking/running in healthy young adults

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AIM. The purpose of the present investigation was to examine the accuracy of the wristable heart rate (HR) monitors during the treadmill walking and running in the healthy younger adults. METHODS. Twenty-two younger adults (14 men and 8 women) participated in the present investigation (21.1±1.6 years of age, 167.6±7.9 cm of height, 58.3±8.4 kg of body mass). All subjects walked at the speed 60 and 100 m/min, and ran at the speed of 180 m/min on the motor driven treadmill. The duration of each stage was 5 minute, and the 1 minute of the resting period was set between the stages. All subjects wore 2 wristable HR monitors (A360, POLAR; vivo-smart-HRJ, GARMIN) on their wrist, and these 2 wristable HR monitors determined HR based on the blood flow sensing photo plesthysmography techniques. Furthermore, as the criterion measurements, subjects wore HR chest strap (M400, Polar). RESULTS. In regard to the resting period and the end of the stage (final 30 seconds of 600 seconds), the HR assessed by wristable monitors did not differ significantly compared with the criterion measures, excluding the HR by vivo-smart-HRJ at 60 m/min ($p<0.05$). In contrast, the HR at the beginning of the stages (final 30 seconds of 600 seconds) differ significantly compared with the criterion measures, regardless of the treadmill speed and the type of the wristable HR monitors ($p<0.01$). DISCUSSION. The results of the present investigation suggest that the accuracy of the wristble HR monitors might be limited when the HR maintained at steady state during walking and running. In regard to the intermittent activity in short period including the habitual physical activity, the validity of wristable HR monitors remain unclear.

3-71 Does it matter which wrist you wear your FitBit to count steps?

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Purpose: To evaluate the accuracy of step counts detected by the Fitbit Blaze (FB) when worn on the dominant vs. non-dominant wrists in healthy adults. Methods: Fifteen participants (age=28.2 ± 6.2 years; BMI=23.6 ± 3.6 kg/m2) wore the FB on the distal part of the dominant (D) and non-dominant (ND) wrists during a simulated free-living protocol. Activities included: standing and stacking books (SSB), cleaning a counter top (CCT), vacuuming (V), level treadmill walking at 3 mph, (WTM), and running at 5.5 mph, 5% grade (RTM) for 3 min each. Step counts displayed on the two monitors were manually recorded immediately before and after each activity. Video recording of the activities were reviewed to obtain criterion steps, where a step was defined as an instance when the heel was lifted completely and placed back on the ground. Mean step differences between the criterion and each device were compared using Independent t-tests. Results: Mean step differences between the D and ND-worn FB for

SSB (62.9 ± 69.7 vs. 48.6 ± 62.7), V (113.7 ± 50.2 vs. 117.0 ± 47.6), WTM (60.2 ± 56.3 vs. 62.4 ± 74.6), RTM (57.0 ± 63.6 vs. 51.1 ± 59.6) were non-significant (P > 0.05). Differences during the CCT were significantly different (0.75 ± 73.8 vs. 43.6 ± 50.6), p = 0.017). Conclusion: Wearing FB on the D vs. ND did not have a statistically significant effect on step counts during most activities. However, a significant difference during CCT suggests that activities performed predominantly by the dominant hand may further inflate steps. Additionally, within subject variability in wearing the FB during free-living interventions may compromise the comparability of step estimates.

3-72 Usability of consumer devices for self-monitoring sedentary behaviour/inactivity: Experiences from a sample of office workers

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Purpose: To summarise office workers' experiences of trialling several consumer devices for self-monitoring sedentary behaviour/inactivity (Darma cushion, Jawbone UP24, LumoBack, Polar Loop). Methods: 31 office workers wore between one and three devices (each device trialled by 10 people) that could monitor and provide feedback on sitting/inactivity for up to 1 week. For each device, participants completed a questionnaire asking about the following: battery life, charging, synching data, presentation, navigation and understanding of feedback, ease of use, obtrusiveness and usefulness for monitoring sitting behaviour and encouraging reductions in sitting. Each question was scored on a scale of 1 to 5, 1 being the least positive and 5 being most positive answer. Focus groups were conducted to obtain more detailed feedback. Results: Participants were 72.4% female, age categories (20-29yrs=6%; 30-39yrs=32%; 40-49yrs=36%; 50-59yrs=26%). When scores were averaged for all questions the Darma scored the highest (mean 4.1/5), closely followed by the Jawbone (4.0/5), then the Polar Loop (3/7/5) and LumoBack (3.6/5). Scores for each individual question are presented in Table 1. Participants reported that the Lumoback was comfortable, except during hot weather, the app was easy to understand but all had problems with calibration. Participants found the Darma to be accurate, easy to set up, easy to view and understand feedback and liked being able to change the intensity and frequency of vibration reminders. Mixed views were reported for the aesthetics of the Polar Loop, the accuracy was questioned but the feedback on the app was easy to understand. Participants found the Jawbone easy to wear, found the vibration function helpful but mixed views were reported for the app. Discussion and conclusion: This sample of offices workers preferred the Darma cushion for self-monitoring sedentary behaviour. This data can be used to inform interventions using self-monitoring devices.

3-73 The Relationship Between User Height and Steps Measured by a Consumer Activity Tracker

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INTRODUCTION: By 2018, it is estimated that 82 million Americans will use an activity tracker, however it remains unclear if these devices can accurately estimate physical activity (PA) metrics they purport to measure. At a set locomotion speed, a person's stature is inversely associated with the number of steps taken. This natural relationship offers an opportunity to investigate how a person's height modify's the accuracy and precision of consumer activity tracker step estimate. PURPOSE: To examine how the height

of a user affects estimates of steps taken, measured by the Misfit ShineTM (a consumer activity tracker; MS), using a hip-worn ActiGraph GT3X accelerometer (AG) as a measure of concurrent validity for steps. METHODS: Sixteen participants wore a MS on the right and left wrists, and both an MS and AG on the right hip during three one-hour simulated free-living sessions: a sedentary session (SS), a sedentary plus walking (SW), and a sedentary plus jogging session (SJ). During the SW and SJ sessions, participants sat for 30 minutes, then walked (SW) or jogged (SJ) for 30 minutes at 5.15 or 8.0 kph, respectively. Linear slopes and R2 values were used to assesses the relationship between participant height and estimated steps. RESULTS: In all 3 sessions, as hypothesized, the AG showed a negative slope, ranging from -13.8 to -0.89. A similar negative slope was observed for the MS during the SJ session, For all wear locations; slopes ranged from -13.8 to -9.8 and R2 values ranged from 0.26 to 0.32. During SS and SW, MS steps showed little relation to height; slopes ranged from -4.84 to 0.66 and R2 values ranged from <0.01 to 0.16. CONCLUSION: Although MS step counts showed an inverse association with height during jogging, this relation was not observed during walking.

4-2 The level of disagreement between self-perceived and accelerometer-measured daily steps in women - the mPED trial.

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Objectives A daily step goal (i.e. 10,000 steps/day) has been widely used to promote daily physical activity. Implicit to this goal is the belief that individuals are able to estimate their daily steps. The aims of this study were to quantify the agreement between women' perceived and objectively measured daily steps, and to explore whether previous pedometer use is associated with a more accurate perception of daily steps. Methods In this cross-sectional analysis, we included 210 women (mean age 52.4 years old (SD ±11); 56.7% white). Participants were asked to estimate their daily steps using a study run-in mobile phone application at the end of each day. No feedback was provided to participants for their daily steps. Objective daily steps were measured by a triaxial accelerometer. We evaluated the agreement between perceived steps and objective daily steps using a Bland-Altman plot. Additionally, we used general linear models to explore whether previous pedometer use was associated with a more accurate perception of daily steps. Results The mean run-in period was 20.92 days (SD±3.9). The mean number of daily perceived steps was 2751 (SD±2191) and objectively-measured steps was 5442 (SD±2946). These two measures were correlated, r = 0.38 (p<.0001). However, the agreement between the two measures was poor. A Bland-Altman plot (Figure 1) indicated that perceived steps were significantly lower than objectively measured steps. Past pedometer use was not associated with the more accurate perception of daily steps when controlled for sociodemographic variables (p=.08). Discussion Our study indicates that women had difficulty estimating their daily steps independent of their past experience with pedometer use. If physical activity campaigns continue their focus on 10,000 steps per day, it is important to understand how we can help individuals to more accurately determine their daily steps, e.g. in terms of minutes of walking or pedometer use.

4-4 The relation between physical activity, sedentary behaviour and physical function in knee osteoarthritis patients

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Knee osteoarthritis (KOA) patients often show an inactive and show sedentary behaviour, which detrimentally affects their physical function. On the contrary, regular physical activity (PA) during daily life, besides exercise, has been suggested to improve their physical functioning. Therefore, the aim is to determine how physical activity and sedentary parameters are related to physical function in KOA patients. Thirty-five clinically diagnosed KOA patients were monitored for 7 consecutive days using tri-axial accelerometers. Activity parameters were extracted using custom-developed algorithms. Furthermore, participants performed three functional tests: 40m fast-paced Walk Test (WT), Timed Up and Go Test (TUGT) and 15-Stair Climb Test (SCT). Spearman's correlations between activity parameters and functional tests were determined (α=0.05). The participants (BMI: 27.5±4.6 kg/m2, age: 60±10 yrs.) were predominantly female (55%). The amount of activity bouts and steps during level walking were unrelated to the physical tests; however, the bouts and steps while climbing stairs were significantly related (ρ=-0. 52 - -0.70, p = 0.00). The number of sit-to-stand (STS) transfers and short sedentary bouts (lasting 0-10 or 10-60 seconds) were also significantly related to physical functioning (ρ=-0. 51 - -0.58, p = 0.00). The amount of steps taken per day by knee osteoarthritis patients seems to be unrelated to physical function. This measure should therefore be used cautiously when describing patients' functioning during daily life. The number of stair-climbing bouts and steps, STS-transfers and short-sedentary bouts might be a better indicator, as they are all moderately related to lab-based physical functioning. A possible explanation could be that stair climbing and sit-to-stand transfers are more challenging activities for KOA patients, since they load the knee joint more heavily compared to level walking, thereby introducing higher levels of pain.

4-6 Inertial sensor based fall risk variables are indicators of frailty among cardiovascular disease patients prone to adverse post-operative outcomes

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Introduction As the number of falls in elderly population continues to rise and an analogous increase in healthcare utilization, the assessment, and prevention of falls in frail elderly cardiovascular disease (CVD) patients remains a high priority for the health care professionals. Patients with intrinsic cardiac cause for falling have been found to be frail and submissive to morbidity and mortality as the post-operative outcome. In this study, authors have examined the effects of movement variability and fall risk characteristics in identifying patients likely to have an adverse post-operative outcome. Methods Sixteen elderly CVD patients (Age 76.1±3.6 years) who were scheduled for cardiac surgery the next day were recruited for this study. Based on STS recommendation guideline, eight of the CVD patients were classified as frail (prone to adverse outcomes with gait speed ≤0.833 m/s) and other eight patients as non-frail (gait speed > 0.833 m/s). Results Smartphone derived walking velocity was found to be significantly lower in frail patients than that in non-frail patients ($p<0.01$). Mean COP radius ($p<0.01$), COP Area ($p<0.01$), COP path length ($p<0.05$) and mean COP velocity ($p<0.05$) were found to be significantly higher in frail patients than that in the non-frail patient group. Nonlinear variability measures such as sample entropy were significantly lower in frail participants in anterior-posterior ($p<0.01$) and resultant sway direction ($p<0.01$) than in the non-frail group. Conclusion This study identified numerous postural and movement variability parameters that offer insights into associated fall risk and post-operative adverse outcomes among CVD patients. In future, smartphone-based clinical measurement systems could serve as clinical decision support system for assessing patients quickly in the perioperative period.

4-8 How many weekdays of StepWatch Activity data are necessary? A preliminary analysis of various patient populations

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Researchers have shown that the minimum number of days necessary to describe habitual ambulatory activity from accelerometry data varies based on the patient population. As the use of objective ambulatory activity monitors becomes more popular in a wide range of patient populations, knowing the minimum number of days in these populations helps to ensure measurement reliability. The purpose of this study was to apply the Generalizability (G) theory to determine the minimum number of days of ambulatory activity monitoring necessary in various patient populations. A retrospective analysis of StepWatch Activity Monitor data collected between 2009-2015 was performed on 5 subject cohorts: children with clubfoot (Clubfoot; range 9-11 yrs.), Children without disability (Children; range 9-11 yrs.), patients with a hip deformity (Hip; range 15-25 yrs.), adults without disability (Adults; range 22-45 yrs.) and patients with a neurologic condition including cerebral palsy and hereditary spastic paraplegia (Neuro; range 7-35 yrs.). All data were collected using a 10sec interval on the SAM and subjects were only included in the analysis if they completed 10 weekdays. G theory was used to analyze the step data (stride x 2) for each day of the week for each participant across patient cohorts. A total of 112 subjects and 1,110 days were included in this analysis. Variance in step counts attributed to the participants ranged from 34-65% with the lowest being the Children and the highest being the Neuro. To reach a G coefficient of ≥0.80, the minimum number of weekdays were as follows: Clubfoot - 7, Children- 8, Hip - 6, Adults - 4, Neuro - 3 days respectively. The findings of this study suggest that there are different requirements for the minimum number of days that are necessary to reliably measure habitual ambulatory activity in various patient populations and should be incorporated into study design.

4-10 Objectively measured physical activity across different occupations among aging workers

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Physical activity during working hours contributes to total daily physical activity, but the levels of physical activity may vary between different occupational groups. The aim of this study was to examine objectively measured physical activity across different occupations. We used daily mean counts/min derived from wrist-worn ActiGraph wActiSleep-BT accelerometers to examine physical activity in self-reported work days and non-working days among aging workers in the Finnish Retirement and Aging Study. Of the 317 participants (mean age 62), 292 (92%) wore the accelerometer minimum of 2 work days and 2 non-working days. As classified by International Standard Classification of Occupations, 126 participants had a high (e.g. teachers, doctors), 147 intermediate (nurses, secretaries) and 19 low occupational class (hospital aids, janitors). Mean (95% CI) total physical activity within high, intermediate and low occupational class was 2270 (2170-2370), 2500 (2410-2590) and 2650 (2400-2900) counts/min, respectively (gender-adjusted p=0.0006). The difference was driven by different physical activity levels during work days: high 2250 (2150-2350), intermediate 2560 (2470-2650) and low class 2960 (2700-3220), p<0.0001. We did not find statistically significant differences in activity levels on non-working days: high 2440 (2320-2560), intermediate 2500 (2390-2610) and low class 2300 (2020-2620), p=0.50. In conclusion, aging workers in low occupational class had higher physical activity on work days

than workers in high occupational class, whereas no differences in physical activity level were observed on non-working days.

4-12 Can continuous monitoring of physical behaviour of older adults in care homes provide useful information to improve care?

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Background: With a growing population of older adults, the number of individuals entering care homes is increasing. Abnormal changes to day-to-day physical behaviour such as very long daytime sedentary periods and frequent occasions of getting up at night are detrimental to health and may also highlight an underlying health issue. These changes often go unnoticed by care home staff until cumulative changes result in observable adverse health issues. The aim was to determine the feasibility of continuously monitoring physical behaviour using a body-worn activity monitor in a care home setting and extract measures on the changes to normal physical behaviour that would provide useful information to care staff. Methods: We collected activity data using a thigh mounted activity monitor (activPAL3) on 21 individuals for continuous periods ranging from 5-98 days (total 516 days). To quantify sedentary behaviour during day and activity at night, we derived two measures i) Frequency of getting up at night ii) Number of continuous sedentary bouts greater than 1, 2, 3 and 4 hours during the day. Results and Discussions: The total daytime sedentary time ranged between 10.34-15.99 hrs and total activity time at night range between 0-3.5 hrs. The figure summarises the number of continuous sedentary bouts and the frequency of night time activity. There were 74 days (out of 516 days) of continuous sedentary bouts over four hours and 155 nights (out of 516 nights) where there were more than four upright periods. Using real-time monitoring, this information can be used to prompt the carer to provide an appropriate intervention for the care home resident. Conclusions: It is feasible to continuously monitor physical behaviours of older adults living in care homes for long periods of time. The extracted measures of continuous sedentary behaviour during day and activity at night could provide useful information for the care staff and may lead to improved care.

4-14 Wearable activity data to identify the cardiometabolic phenotype of employees achieving physical activity guidelines

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Background: Little is known about the clinical utility of tracking activity with wearable devices. Purpose: To evaluate the relationship between cardiometabolic risk and attaining physical activity guidelines in a workplace setting. Methods: Healthy volunteers with desk-based jobs consented to wear activity tracker for minute-to-minute recording and display of physical activity (PA). Health surveys and cardiometabolic risk factors were assessed at baseline and 6 months. We considered guidelines recommending ¡Ý7000 steps per day and/or ¡Ý150 minutes moderate intensity physical activity (MIPA) per week. Participants achieving guideline recommendations were compared to those who met neither guideline. Average steps per day and average minutes of MIPA per week for each participant determined whether they met the guidelines. Multiple linear regression analyses adjusting for age and gender were used to identify significant differences between groups. Results: Of 431 volunteers, 346 had sufficient activity data for analysis. Volunteers were predominantly male (n=206, 59.54%), white (64.5%), ages 35-50 (50.57%), and

overweight (females > males, BMI, mean ¡À SD, 28.58 ¡À7.00 vs. 27.31¡À5.21). Their average steps/day was 7,231.36¡À2,485.1, with 204.45 ¡À49.20 minutes of light, and 26.37 ¡À17.80 minutes of MIPA. Participants meeting both guidelines (n=122) had a significantly lower BMI (p<0.001) and were more likely to be male (p<0.001) compared with those meeting neither (n=137). Achieving 150 minutes of MIPA per week either alone or in combination with 7000 steps/day was significantly associated with lower BMI, weight, waist-hip ratio, HgbA1c, and HDL cholesterol. Achieving 7000 steps/day alone was not associated with these benefits. Conclusion: Participants achieving 150 minutes of MIPA per week either alone or in combination with 7000 steps/day had a more favorable cardiometabolic risk profile than those who did not. The clinical implications over time are unknown.

4-16 Environmental factors moderate the effect of a physical activity intervention

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Purpose: Identify whether natural environmental factors such as season, weather conditions, and day length moderate the effect of a physical activity intervention. Methods: Participants (N=204, 77% female, age=33±11y, BMI=28.2±7.1 kg/m2) in the Make Better Choices (MBC) Study were randomized to one of two activity-related intervention arms: 1) increase physical activity arm or 2) decrease sedentary behavior arm. Participants wore an activity monitor for five weeks: a two-week baseline assessment phase and a three-week intervention follow-up phase. Activity monitor data were used to estimate min/day spent in MVPA. Average temperature and day length for Chicago were obtained from the National Climatic Data Center and combined with MBC accelerometer data. Linear mixed-effects models determined whether these environmental factors moderated the effect of the MBC intervention on MVPA. Moderation was assessed by estimating a three-way time by treatment arm by environmental factor interaction. Separate models were fit for season, daily average temperature, and day length. Results: There was a significant moderating effect of season on MVPA, the difference between treatment arms at follow-up was 10.4 minutes greater in summer than in winter (95% CI: 1.1, 19.6; p=0.029). When environmental factors were examined, there was a significant moderating effect of temperature, every 10° increase in temperature resulted in a 1.6 min/day difference (95% CI: 0.3, 2.8; p-value=0.015) in MVPA between treatment arms at follow-up. There was a significant moderating effect of day length; every additional hour of daylight was associated with a 2-minute difference (95% CI: 0.8, 3.5; p-value=0.002) in MVPA between treatment arms at follow-up. Conclusion: Results reveal day length and temperature moderate change in MVPA during a physical activity intervention. This suggests when designing physical activity interventions, strategies to overcome environmental barriers should be considered.

4-18 Does cardiac rehabilitation reinforced with a behavioral intervention improve physical behaviour? The OPTICARE randomized controlled trial.

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Introduction: Current cardiac rehabilitation (CR) is insufficient to achieve relevant improvements in physical behavior. Our objective was to determine whether CR reinforced with a lifestyle behavioral program leads to larger improvements in physical activity and sedentary behavior. Methods: A total of 491 patients with acute coronary syndromes (57 years; 80% men) were randomized into: 1) 3 months

standard CR; or 2) CR+: CR with a lifestyle behavioral group program using pedometer feedback consisting of 3 sessions during rehabilitation and 3 sessions during a 9 month follow-up period. Physical behavior was measured with ActiGraph GT3X+ and expressed as steps/day, moderate-to-vigorous physical activity (MVPA) and sedentary behavior (SB). Measurements were performed at baseline (T0), post-CR (T1), 9 months post-CR (end follow-up program, T2), and 15 months post-CR (T3). Longitudinal between-group differences were analyzed with GEE models. Results: Results on physical behavior outcomes are shown in Figure 1. Compared to standard CR, the CR+ group resulted in 522 steps/day extra post-CR (p=0.02) and 383 steps/day extra (p=0.150) at 15 months follow-up. Although a trend was found for the CR+ group for larger improvements in MVPA at T1 (see Figure) this was not significant (p=0.240) and follow-up between-group differences were small p=0.834 at T3). SB did not show any between-group differences. Conclusion: Compared to standard CR, reinforcement with a lifestyle behavioural group program resulted in higher daily step activity in patients with acute coronary symptoms, while improvements in MVPA were minimal. These results suggest that objective feedback, in our study provided by pedometers, is important during counselling to reach physical behaviour changes. Although the intervention needs optimization for sedentary behavior and long term benefits, we recommend to implement a lifestyle behavioral program using pedometer-feedback as part of CR.

4-20 Can the custom algorithm for one fitness wearable be used for another device?

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The use of fitness wearables to objectively quantify daily physical activities (PA) is increasingly popular as the sensing technology continues to improve and becomes more affordable. While most of the off-the-shelf wearables showed fair validity in tracking PA in ambulatory population, they were found to be invalid for recognizing and quantifying wheelchair related activities, and thus cannot be used directly by wheelchair users. Numerous custom algorithms have been developed for wheelchair users in the past decades based on some popular devices, e.g., Sensewear (SW) and ActiGraph (AG). However, with more fitness wearables being introduced to the market nowadays, creating custom algorithms for every device becomes unrealistic. We have previously developed and validated custom algorithms for estimating energy expenditure (EE) of wheelchair users based on SW and AG worn at the upper arm, respectively. In this paper, we evaluate how the custom algorithm for each device perform when data collected from the other device are used as inputs. We have collected data from a total of 48 wheelchair users who completed about 3 hours of various PA including wheelchair propulsion at different self-selected speeds over different terrains, adaptive sports, and household chores. Results showed that the custom SW algorithm and custom AG algorithm had relative errors of -0.42±16.16% and -9.79±13.94%, respectively, when their own data were used as inputs. When the AG data applied on the custom SW algorithm, the error was -4.03±13.60%; and when the SW data applied on the custom AG algorithm, the error was -15.02±16.76%. In any cases, the custom algorithms outperformed the default outputs of SW and AG which errors of -58.34±32.41% and 19.63±28.16%, respectively. It seems feasible to adapt the custom algorithm for one fitness wearable to other devices worn at the same location on the body.

4-22 Comparing Preschoolers' Physical Activity and Sedentary Time During Childcare Hours Using 20 and 60 Minutes Non-Wear Time Thresholds

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Background: Accelerometers are widely used to measure preschoolers' physical activity levels in childcare. The decision rules adopted when analyzing accelerometer data can influence the activity behaivours observed. Specifically, the application of consecutive zeros (i.e., non-wear time), may be particularly poignant for young children, given their sporadic movement patterns and the required nap time enforced in childcare centers. This study explored differences in physical activity and sedentary time among preschoolers enrolled in childcare when applying two non-wear time criteria. Methods: Preschoolers enrolled in the Supporting Physical Activity in the Childcare Environment (SPACE) randomized controlled trial were recruited from 22 childcare facilities in London, Ontario. Preschoolers wore an Actical accelerometer, using a 15-sec epoch, for 5 consecutive days during childcare hours. Using population specific cut points, baseline data were analyzed to compare preschoolers' accumulated sedentary time and physical activity (i.e., light, moderate-vigorous, and total) for both 20- and 60-mins of consecutive zeros via paired sample t-tests. Only participants with a minimum of 2 valid days (5 hrs of wear-time) were included. Results: Preschoolers' (n = 239) hourly rate of light (M = 21.58 vs. 18.64), moderate-vigorous (M = 5.70 vs. 4.95), and total (M = 27.27 vs. 23.63) physical activity were all significantly higher when a 20-mins of consecutive zeros threshold was applied compared to 60-mins ($p < .05$). In contrast, preschoolers rate of sedentary time was higher using 60-mins (M = 36.37) rather than 20-mins (M = 32.74) of consecutive zeros, and this difference was significant $t(238) = 27.11$, $p < .05$. Conclusion: Findings suggest that the non-wear time criteria employed when analyzing preschoolers' accelerometry data has a significant impact on the observed activity levels; adopting a shorter threshold (20-mins) may be more appropriate for this unique population.

4-26 Increased Standing Time Is Associated with Lower Diastolic Blood Pressure in Adolescents.

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Increased participation in moderate-to-vigorous intensity physical activity (MVPA) positively impacts biomarkers of health in adolescence (1). However, MVPA accounts for only a minimal proportion of total daily activity behaviours. The relative contribution of objectively determined activity behaviour at the lower end of the activity intensity continuum, such as sitting/lying time(SLT), standing time(ST) and light intensity physical activity (LIPA) to biomarkers of health is understudied. This study examined the relative contribution of activPAL 3TM micro (AP3M) determined activity behaviours with biomarkers of health among Irish adolescents.Following ethical approval, a random sample of Irish adolescents (n=239,mean-age(SD)=16.4(0.9)yrs)) had their height and weight (for Body Mass Index (BMI)), waist and hip circumference (for waist-to-hip ratio), blood pressure (BP) and 4-site sum of skinfolds measured after wearing the AP3M for 9 consecutive days. The amount of time spent in SLT, ST, LIPA, and MVPA was quantified (2). Linear mixed-effects models examined the relationship between SLT, ST, LIPA and health biomarkers while controlling for age, sex and school effects. Table 1 illustrates the anthropometric, health and activity variables for all participants. Regression analysis identified diastolic BP to have a significant negative relationship with ST(¦Â=2.55,SE=1.28,p¡Ü0.001) and LIPA (¦Â=4.24,SE=1.28,p¡Ü0.001) and a significant positive relationship with SLT (¦Â=1.19,SE=0.43,p¡Ü0.006).

No relationship was observed between activity behaviours and body composition measures. These findings suggest that, although causality cannot be determined, diastolic BP is negatively associated with ST & LIPA and positively associated with SLT, highlighting the potential benefits of increased ST & LIPA and reduced SLT for health in adolescents. Further experimental research is needed to determine whether causal relationships exist between SLT,ST, LIPA and biomarkers for health.

4-28 Quantifying Daily Activity and Energy Expenditure in Spinal and Bulbar Muscular Atrophy

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STUDY AIM: To quantify activity patterns during free-living conditions in a sample of men with spinal and bulbar muscular atrophy (SBMA) using an accelerometer (AM). METHODS: Subjects with genetically-confirmed SBMA were asked to wear an omnidirectional AM (Actical, Philips Respironics) for 10 consecutive days. AM were worn at subjects' hips during waking hours except for activities involving submersion in water. Data were collected at 30 second epochs and analyzed using the manufacturer's single regression model. The manufacturer's cutpoint between light and moderate energy expenditure was 0.031 kcal/min/kg, and the cutpoint between moderate and vigorous activity was 0.083 kcal/min/kg. RESULTS: Of the 54 men enrolled in the study, 23 men (age: 56±7.4 years, BMI: 28±5.2 kg/m2, disease duration: 15±8.8 years, CAG repeat: 47±2.3 codons; timed up and go test [TUG]: 11.0±5.6 sec; Adult Myopathy Assessment Tool [AMAT] total score: 29±6.1; average ± standard deviation) wore the AM for 10 consecutive days. Subjects averaged 3655±2314 steps per day. Analysis of calculated energy expenditure revealed that subjects spent on average 19.9±1.5 hrs/day (83.5%) engaged in sedentary activities, 3.0±0.9 hrs/day (12.4%) in light-intensity activities, 1.0±0.8 hrs/day (4.1%) in moderate-intensity activities, and no time participating in vigorous-intensity activities. SUMMARY/CONCLUSIONS: Subjects who wore the AM for 10 consecutive days had a slower averaged TUG time for their ages and had an average functional decline from predicted of 35% based on their total AMAT score. They accumulated approximately one-third the amount of daily steps recommended for adults and despite spending a considerable amount of time in sedentary and light-intensity activities, appear on average to meet current physical activity recommendations of 1 hour of moderate-intensity activity daily. Future studies are needed to explore the validity of the Actical AM for use in the SBMA population.

4-30 24-hour population-level activity patterns: application of relative versus standard reference frame

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Background: Population-level analysis of physical activity levels reveals a 24-hour pattern determined by the alignment of each individual's activity with a common reference point, i.e., the 24-hour standard timeframe. In this way, each person's day begins at midnight. At the population level, we see a gradual increase in activity during the morning. However, the reference for this is relatively arbitrary. We hypothesised that a different pattern of 24-hour activity would emerge if, instead of using the standard

timeframe, we used a timeframe defined for each individual, relative to the time the individual got out of bed. Methods: Using activity data from 30 university employees, recorded over 7 days using an activPAL3, we synchronised the start of each 24-hour period to the point at which each individual got out of bed. Time upright (standing and stepping) per 30 minute epoch was plotted. Results: The population-level profile of upright time based on the standard timeframe appears as a bell curve of activity (Figure 1A). Activity was low during the night, followed by a gradual increase in activity from 5 a.m. Activity peaked at ~10 a.m. with a second peak at ~5.30 p.m. Using the relative timeframe, there was a clear peak in activity within the first 30 min of getting out of bed (Figure 1B). Activity levels remained broadly stable for ~11 hours, with a gradual decline thereafter. Discussion: Using a timeframe relative to the time an individual wakes up has important implications for understanding population-level behaviours: most individuals show a clearly defined pattern that is different from the activity pattern derived from the 24-hour standard timeframe. These data might provide a better description of activity patterns within populations.

4-32 Objectively measured physical activity in a community sample of adolescents and young adults in Germany: Results of the BeMIND study

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This contribution provides an overview of the objective measurement of physical activity (PA) in the BeMIND study, a large scale epidemiologic prospective longitudinal study in Dresden, Germany ("BeMIND" - Behavior and Mind Health Study) that examines mental health and illness conditions as well as psychological, developmental, cognitive-affective and biological risk factors among adolescents and young adults (age 14-21 years). An integral part of the baseline examination of the BeMIND study is the everyday documentation conducted with help of Ecological Momentary Assessment methodology. On four days (two consecutive week-days and the weekend) participants were prompted eight times a day via smartphone to complete EMA items on their everyday experience and behavior. During the entire EMA assessment period heart rate variability (HRV) and accelerometry data (3-axis acceleration sensor motion data, sampling frequency of 12.5 Hz) were recorded continuously over the 4-day period (device: Firstbeat Bodyguard 2). Study participants were asked to wear the HRV sensor over the entire EMA period (including the night), which was attached with electrodes to the skin on the upper body. We collected objective HR and PA data from N=1,117 study participants. Approximately 5.5 million minutes were recorded (on average 3.6 days per study participant). For this analysis PA measures (MET per minute, MVPA estimates) were derived from HRV data. Statistical analyses were performed with Stata 14.0. Preprocessing of the HRV data was performed with Firstbeat analysis software. Initial analyzes indicate that the study participants were on average 167 minutes physical active (MVPA minutes) during the day (103 MVPA/minutes in 10 minute bouts). Overall there was no significant difference between male and female subjects, but a significant decline with age (212 MVPA minutes at 14 years vs. 132 MVPA minutes at the age of 21 years). Further results will be presented at the conference.

4-34 Contribution of work to overall sedentary behavior in Chilean workers

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Introduction: In the last decades, occupations have tended to reduce physical demands, facilitating inactive and sedentary behaviors (SB) across different regions. Chile is the fifth country with the most working hours in the Organization for Economic Co-operation and Development. However, Chile is lacking in objective measurement of SB in work settings to better understand the overall contribution of these contexts to total SB. The aim was to describe time spent in SB in working and non-working hours in Chilean employees from different work settings. Methods: 101 workers were recruited from different sectors (schools, offices, hospital, taxis, etc.) and asked to wear an ActivPAL accelerometer during 7 consecutive days. Time spent in SB during work and non-work time were compared using ANOVA by sex, age, body mass index, occupation and educational level. Multiple linear regression was used for adjusted analysis. Results: 96 employees completed the protocol (49.0% women; 39.0±12.39 years, BMI= 27.36±4.35 kg·m-2). Total time spent in SB was 9.2±2.15 h/day, in which men were more sedentary tan women (9.7±2.26 vs 8.6 ± 1.91 h/day; p=0.01). Mean relative time spent in SB at work was 50.4±17.39 per cent, that represented 49.9% of total time spent in SB in the whole day. Administrative and driving occupations were more sedentary than others with 54.3% and 72.1% of their time spent sitting, respectively. Adjusted differences in relative contribution of work to SB across sociodemographic characteristics were significant for sex only (p=0.024). Conclusion: Although Chilean workers spent large hours at work, the absolute and relative contributions of sitting time to overall SB in these settings is comparable with those observed in non-working hours. These findings suggest that.

4-36 Wearable sensor-based 48-hour activity and gait monitoring in the acute care setting

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troduction: Free-living physical activity profile of patients in the acute care setting could provide hospitals useful evidence determine appropriate point-of-care for patients. A recent review suggests the use of functional measures in inpatient setting has unexplored. Objective: The focus of this study is to develop a wearable activity and gait measurement in an inpatient setting for patients. Methods: Ten randomly selected patients in the acute care setting were participated. They conducted Timed Up and Go (TUG) test at the beginning of their treatment. The patients wore a single tri-axial accelerometer (Shimmer3, Ireland) on their chest using a pouch for 48 hours. The sensor system used to classify types of physical activity including lying, resting, sitting, standing, and walking. The amount of active and inactive activity profile was monitored according to the activity classification results. The gait characteristics evaluated according to gait intensity, symmetry, and variability. Clinical relevance of the multidimensional gait metric is evaluated through correlation with TUG as a standard protocol. Complete data was available for 6 of 10 patients due to compliance issues. Results: The results of the preliminary study showed inactive daily physical activity profiles. First, patients maintained very inactive physical activity patterns. Patients stayed more than 83% of their time on the bed with lying or resting activity. Further, correlation of gait intensity with TUG score shows a strong positive correlation ($r = 0.92$, $P < 0.002$). However, there was a less significant association of gait symmetry and TUG score. Conclusion: The wearable measurement utilized in the study is easy and cost-effective to implement, and the preliminary study results suggest that physical activity profile and ambulatory functioning characteristics in an inclusive way could help hospitals determine appropriate point-of-care including duration of stay for patients.

4-38 Fragmentation of Physical Activity is Associated with Poor Function in Older Adults

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It is well established that physical activity declines with aging, and that low levels of moderate to vigorous physical activity (MVPA) are linked to poor health and functional performance in older adults. However, the health implications of the daily patterns/temporal accumulation of physical activity remain unknown. We created an activity fragmentation index (AFI) to account for the number and duration of daily active bouts using 7-day accelerometry data from the Baltimore Longitudinal Study of Aging (n = 734, mean age 67.8 ± 13.2 years, 50% female). Minute-epoch activity counts were dichotomized into active or sedentary states, and summarized according to the distribution of active bout durations. AFI was calculated as the reciprocal of the average duration of the active bouts. Total daily volume of physical activity was summarized using total log-transformed activity counts (TLAC). Using multiple linear regression models adjusted for age, sex, height, weight, TLAC, and disease conditions, AFI was negatively associated with gait speed (β = -0.06 m/s, $p < 0.004$), and positively associated with laboratory assessments of high fatigability ($p < 0.001$). TLAC was a significant predictor of gait speed and fatigability until AFI was added to the model, suggesting that the duration and number of active bouts throughout the day mediates the associations among TLAC, gait speed, and fatigability. Together, these results imply that accounting for fragmented daily physical activity may be more important than total volume of physical activity when assessing functional performance in older adults. Further research is needed to validate this measure and determine the longitudinal value of activity fragmentation in predicting adverse outcomes in older adults.

4-40 Modeling Energy Balance while Correcting for Measurement Error via Free Knot Splines

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Self-reported measures of energy intake (EI) are known to be plagued by measurement error. Doubly-labeled water can measure EI with negligible error, but is expensive and cumbersome. An alternative approach that is gaining popularity is to use the energy balance principle, by measuring energy expenditure (EE) and change in energy stores (ES) and then back-calculate EI. Gold standard methods for EE and ES exist and are known to give accurate measurements, albeit at a high cost. We propose a joint statistical model to assess the measurement error in cheaper, non-intrusive measures of EE (mainly research and consumer wearables) and ES. We let the unknown true EE and ES for individuals be latent variables, and model them using a bivariate distribution. We try both a bivariate Normal as well as a Dirichlet Process Mixture Model, and compare the results via simulation. Our approach, to the best of our knowledge, is the first to account for the dependencies that exist in individuals' daily EE and ES. We employ semi-parametric regression with free knot splines for measurements with error, and linear components for error free covariates (eg. demographics). We adopt a Bayesian approach to estimation and inference and use Reversible Jump MCMC to generate draws from the posterior distribution. Based on the semi-parameteric regression, we develop a calibration equation that adjusts a cheaper, less reliable estimate, closer to the true value. Along with this calibrated value, our method also gives credible intervals to assess uncertainty. Preliminary results show our calibration helps produce a more accurate estimate. We conduct simulation studies to compare results for different modeling and data assumptions. Our approach compares favorably in terms of prediction to other commonly used models.

4-42 Reproducibility of Body Posture and Activity Intensity Measures in Adults

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INTRODUCTION: Epidemiologic studies of physical activity (PA) using accelerometers have typically relied on single 7-day assessment to estimate habitual activity but the stability of these measures over time is still not well understood. The present study estimated the stability of device-based measures over 6-months in adults. METHODS: We used data from 1,082 adults aged 50-74 yrs enrolled in the Interactive Diet and Activity Tracking in AARP (IDATA) study. Participants wore an ActivPAL 3 (AP) and an Actigraph GT3X (AG) twice for 7 days, 6 months apart. Both AP and AG parallel outcomes were generated for awake time using device-specific algorithms and were adjusted for differences between devices in nonwear time. AP measures included: time spent sitting or lying, standing, and stepping; while AG measures included: time spent in sedentary, light, and moderate-to-vigorous PA (MVPA), generated from Sojourn 3x. The reliability of two 7-day aggregates was determined by computing Intraclass Correlation Coefficients (ICCs) and respective 95% confidence intervals (95% CI). RESULTS: There were 450 males and 464 females (n=914 participants, 63.2±5.9 yrs, 23.8±4.2 kg/m2) with at least one-week estimate of PA and that on average, had 15.8 hrs/day of AP/AG data. The ICCs for measures obtained from AP and AG were similar and overall, reached 0.60. The ICCs for AP estimates of sitting, standing, and stepping were, 0.62 (95% CI: 0.57, 0.67), 0.64 (95% CI: 0.60, 0.69), and 0.60 (95% CI: 0.55, 0.64). ICCs associated with AG for sedentary, light, and MVPA were 0.60 (95% CI: 0.55, 0.65), 0.59 (95% CI: 0.54, 0.64), and 0.59 (95% CI: 0.54, 0.64), respectively. DISCUSSION AND CONCLUSION: The results provide evidence that both AP and AG classifications of activity are moderately stable over time. However, there is considerable within-subject variability that needs to be considered when estimating habitual activity in future studies.

4-44 Validation of APDM Opal Inertial Sensors for Gait Analysis in the Pediatric Population

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INTRODUCTION: Currently the electronic walkway system GAITRiteTM is regarded as a gold standard for measuring spatiotemporal gait parameters in a clinical setting. However, GAITRiteTM confines walking to a restricted area and limits the number of gait cycles collected. An alternative solution to such limitations may be wearable inertial sensors. The APDM® Opal sensors have been validated for young children (Lanovaza, 2017) (3-8 years old) and adults (Schmitz-Hübsch, 2016), but not for older children. The objective of this study is to test the validity of APDM® Opals against GAITRiteTM in a group of older children. METHODS: Six healthy participants (3 males) between 6-17 years of age completed 2-minute walk tests at regular and fast pace on a 25 meter long hallway, while wearing the Opals and passing multiple times on GAITRite. Passes on GAITRite were synchronized with Opal data collection. The variables of interest were gait speed, stride length, gait cycle duration, cadence and double support time. A Bland-Altman analysis was completed for each subject to determine agreement between systems for the selected gait parameters. RESULTS: Better limits of agreement was observed for the first 4 gait variables in Table 1. Our analysis also revealed small mean differences for all subjects on all parameters analyzed, except for double support time, where the size of the difference varied across the range of observed double support times. While no bias was detected for most variables, double support values by Opals underestimated those by GAITRite in our cohort. CONCLUSION: Results of this pilot

study support the validity of the APDM® Opal sensors in measuring gait speed, stride length, gait cycle time and cadence in children during a 2-minute walking test. Future studies are warranted with a larger sample size and broader age range to thoroughly represent the pediatric population.

4-46 Association of Resampled Accelerometer Data With Estimated Vo2max and Perceived Health Status in Population Based Sample

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Background The epoch length of the analysis of accelerometer data affects the estimation of moderate to vigorous physical activity (MVPA) time and bouts under free-living conditions. This study evaluated the influence of different epoch lengths on the association of MVPA time and bouts with VO2max and perceived health. Methods Participants (n=1237) were adult men and women with sufficient (>4days, >10h/day) accelerometer data (Hookie AM20, Traxmeet Ltd, Espoo, Finland). Their VO2max was estimated with 6 minute walk test and perceived health was categorized into five classes with questionnaire. Intensity of physical activity was estimated using mean amplitude deviation (MAD) of acceleration analysed in 6 s epochs. The MAD value of each epoch was converted to metabolic equivalent (MET) value. The data was resampled by exponential moving average (EMA) of the MET values using 1 min, 5 min and 10 min time constants. Total daily MVPA time and accumulated time of MVPA bouts (<10min, >=10 min) were calculated using both 6s initial data and 1 min, 5 min and 10 min EMA data. Spearman's rank correlation coefficients between MVPA times and both VO2max and perceived health score were calculated. Results The MVPA times and correlations are shown in the table 1. All correlations were statistically significant ($p<0.001$). All MVPA times were higher with higher VO2max or better perceived health. Discussion and conclusions Total daily MVPA time decreased and MVPA time accumulated from >=10 min bouts increased with increasing time constant. Thus the epoch lengths need to be considered when comparing results from different studies. The VO2max had the strongest association with the 1 min EMA data and the perceived health with 10 min EMA data. It is likely that there is no optimal time constant, but it has to be selected according the topic of interest.

4-48 A fast and robust algorithm for detection of sitting and standing from wrist-worn accelerometry data

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Developments in wearable technology enable researchers to continuously monitor many aspects of the physical activity in the real-life context. We propose a fast and robust algorithm to detect a body position (sitting vs. standing) from data collected by a wrist-worn accelerometer. The key idea leverages the observation that hands are pointed down during standing and pointed mostly horizontally while sitting. The proposed algorithm defines the dominant axis that reflects the spatial position of a wrist-worn device and results in the acceleration equal to 1g and 0g for vertical and horizontal position of a

hand, respectively. We calculate the median and the median standard deviation for the dominant axis in the sliding time windows. Our algorithm first discriminates between the idle and active states using the median standard deviation and then classifies the active state into sitting or standing by applying a linear decision boundary in the two-feature space: median and median standard deviation. Data were obtained from N=51 elder participants in the Developmental Epidemiologic Cohort Study (DECOS), a part of the National Institute on Aging, Aging Research Evaluation Accelerometry (AREA) project. All subjects were wearing ActiGraph GT3X on both wrists and an activPAL monitor on the thigh for 7days in a free-living environment. Gold standard for the sitting and standing status was obtained from activPAL. For the sensor placed on the right wrist the median true positive rate (sensitivity) of classification between sitting and standing was estimated to be 0.848, while the median true negative rate (specificity) was estimated to be 0.845; respective values for the left wrist were 0.824 and 0.821. We proposed a robust algorithm using the moving window medians and median standard deviations to differentiate between the sitting and standing positions. Our computationally efficient approach provides high classification accuracy using a small number of predictors.

4-50 Classification of Physical Activities and Sedentary Behaviour Using Raw Data of 3D Accelerometer

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INTRODUCTION Objective methods to measure physical activity (PA) and sedentary behaviour (SED) are needed to improve understanding of their health effects. The aim of this study was to develop and validate an algorithm for classifying different activities and SED from raw acceleration data. METHODS Twenty-two volunteers (age 32±11 years) completed a pre-defined set of controlled and supervised activities for 4 minutes each, with a 0.5-4 minute resting period between activities depending on the intensity of the previous activity. The activities included 8 daily physical activities (sitting on a computer, standing/poster viewing, wiping and setting up kitchen table, floor cleaning, slow walking, fast walking, occasionally running while passing football, and jogging). In addition, 6 of the participants performed lying on a sofa. Acceleration data were collected at 100Hz in range ±16g with a waist-worn 3D accelerometer (Hookie AM20). The data were used for training and testing a prediction model in MATLAB environment. The acceleration signals were filtered and resampled to 10Hz. The prediction model was built using bagged trees classifier and the most suitable extracted features (mean, max, min, zero crossing rate, and mean amplitude deviation [Vähä-Ypyä 2015]) were selected using a sequential forward selection method. Leave-one-out cross validation was used for validation. RESULTS Activities were classified as lying, sitting, light PA (standing, table wiping, floor cleaning, slow walking), moderate PA (fast walking) and vigorous PA (football and jogging) [Ainsworth 2000]. Total accuracy of the prediction model was 96.5%. Specificity and sensitivity for each activity class are shown in Table 1. DISCUSSION Based on the results PA types can be classified from raw data of the waist-worn 3D accelerometer using supervised machine learning techniques with a high sensitivity and specificity. The developed algorithm has a potential for objective evaluations of PA and SED.

4-52 Development of an algorithm to temporally align two common measures of sleep data in the Raine Study

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Sleep loss and sleep disorders are associated with a multitude of health problems, serious accidents and substantial economic burden. Currently, the most reliable method to monitor sleep and its disorders is polysomnography, however, this procedure is intrusive and costly. Measurement of human rest and activity cycles using small and lightweight accelerometers is increasingly becoming considered a viable alternative in sleep detection. Current actigraphic sleep/wake detection algorithms have predominantly been validated against polysomnography, although the accuracy of such validations is dependent on the degree to which the timestamps of these two methods are synchronised. We created and validated an algorithm to temporally align actigraphy and polysomnography data using a sample of 100 healthy young adults, recruited from a pool of participants in the Western Australian Pregnancy Cohort (Raine) Study. These participants underwent one night of polysomnography and simultaneous wrist actigraphy (Actigraph GT3X+). Our proposed alignment algorithm incorporates the raw acceleration data and considers the best alignment when the sum of the product of acceleration and polysomnography values are maximised. Segments of the night of various lengths and locations were considered as input values for the algorithm in addition to several values for the maximum allowable discrepancy. The optimal input values were determined by comparing accuracies, wakefulness detection rates and sleep detection rates calculated from two commonly used sleep/wake classification algorithms with the optimal alignment algorithm validated using a simulation study. Correct alignment of polysomnography and actigraphy timestamps allows for more accurate and detailed actigraphic sleep/wake detection algorithms to be created, thus potentially strengthening the use of actigraphy as an appropriate alternative in sleep detection.

4-54 A novel two-step algorithm for estimating energy expenditure from wrist accelerometer data in youth

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Purpose: Develop and evaluate a 2-stage energy expenditure (EE) estimation algorithm in which children's activity type is initially identified using a Random Forest (RF) classifier and EE is estimated using activity specific prediction equations (ASPE's). Performance is compared to ML regression models (RF, MLP) and published EE prediction models based on ENMO (Hildebrand) and activity counts (Crouter). Methods: 14 children (mean age 14.8 ± 2.6 y) completed 12 activity trials categorised as sedentary (SED: lying down, writing, computer game), light-intensity household activities or games (LHHG: sweeping, laundry, throw and catch), walking (W), running (R), or moderate-to-vigorous-intensity games (MVG: aerobics, basketball). During each trial, participants wore an ActiGraph GT3X+ tri-axial accelerometer on the wrist, and EE (kcal/min) was measured using the Oxycon Mobile portable calorimetry system. The RF classifier was trained using 25 features in the signal VM extracted from 15-sec non-overlapping windows. For ASPE's, features were averaged and aligned to EE. Predictors for the ASPE's included selected accelerometer features and BMR predicted from age, height and weight. All classification and regression models were cross-validated using leave-one out cross-validation. The 'caret" package within R was used to train models and evaluate performance. Results: Accuracy for the RF classifier was 93.6% (SED=99.5%, LHHG=92.6%, W=93.2%, R=91.5%, MVG=88.0%). RMSE's for the SED, LHHG, W, R, and MVG ASPE's were 0.17 ± 0.09, 0.34 ± 0.20 , 0.69 ±0.29, 1.47 ± 1.0, 1.32 ± 0.93 kcal/min, respectively. RMSE over all activity types was 0.78 ± 0.33 kcal/min which was significantly lower than that observed for RF (1.22 ± 0.58), MLP (1.33 ± 0.48), Hildebrand ENMO (1.81 ± 0.69), and

Crouter wrist VM (2.2 ± 0.54). Conclusion: A "divide-and-conquer" approach comprising activity recognition and ASPE's significantly improves EE prediction from wrist-worn accelerometry in youth.

4-56 Accelerometer-determined steps/min versus activity counts/min for discriminating moderate-intensity ambulation

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BACKGROUND: Various accelerometer cut points related to moderate-intensity have been proposed, thereby complicating physical activity assessment. In contrast, there is remarkable consistency supporting a cadence-based heuristic cut point of 100 steps/min for classifying moderate-intensity ambulation (3 metabolic equivalents [METs]). PURPOSE: To compare steps/min and counts/min cut points for discriminating 3 METs. METHODS: 77 participants (51% men, mean age=30.4±5.7 years; BMI=24.9±3.4 kg/m2) wore an ActiGraph GT9X Link on the right hip and completed a series of 5-min treadmill bouts from 0.5-6 mph. Testing was terminated upon completion of the bout during which the participant began to run, achieved >75% of maximum heart rate, or reported a Borg rating of perceived exertion >13. Intensity (METs) was measured using indirect calorimetry. A total of 620 person-bouts were included in these analyses (incomplete bouts excluded). Receiver Operating Characteristic (ROC) analysis was performed to determine the classification accuracy of 100 steps/min versus 1952 (Freedson) and 2020 (Troiano) counts/min for discriminating 3 METs. Optimal cadence and counts/min cut points for 3 METs were also identified using Youden's Index. RESULTS: Classification accuracies (Table 1) were similar for 100 steps/min, 1952 and 2020 counts/min, and for optimal cut points (96 steps/min and 1866 counts/min). CONCLUSION: 100 steps/min had a similar classification accuracy for discriminating moderate-intensity ambulation when compared to popular counts/min cut points. Further, 100 steps/min had similar classification accuracy when compared to the analytically optimal cadence cut point. Since activity counts lack a direct criterion standard and are inconsistently scaled between accelerometers, the use of cadence cut points provides an important opportunity to standardize and translate measurement of ambulatory behaviors in the laboratory, clinic, and free-living settings.

4-58 Evaluation of change point detection in the classification of activity transitions

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Background: Classification of activities from raw data using wrist worn accelerometers and event-based analysis of activities are recognised as important topics. However, little is known about the identification of transitions between activities. The ability to accurately segment accelerometer data into dissimilar activities will allow for more detailed study of the pattern of activity throughout the data gathering period. This work investigates change point detection on accelerometry data, demonstrating its effectiveness and computational overhead. Methods: Using data from accelerometers worn on the non-dominant wrist during a range of sedentary and light household activities (walking, talking, watching TV and washing "pots", etc.) multiple features were extracted from the raw data. Bayesian change point detection was used on all of these features and the highest performing feature was identified. Results: Bayesian change point detection was an effective method at identifying activity transitions when using

the average y acceleration as the input metric. However change point detection is poor at identifying the precise location on the change point. Conclusion: Change point detection represents an interesting and new approach to identifying activity transitions from raw accelerometry data, although further work would be required for both validation purposes and to progress from identifying the location of the activity transition to actually classifying the activities that are being transitioned to and from.

4-60 Functional modeling of individual walking strides in accelerometry data

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Quantifying gait parameters and ambulatory monitoring of changes in these parameters has become increasingly important for epidemiological, clinical and rehabilitation studies. Accelerometers can collect detailed information on dynamics of human movement in free-living, unconstrained conditions. Due to complexity and volume of accelerometry data collected in modern health studies, automatic and unsupervised methods for extraction of gait features are needed. We introduce a model designed to capture the stochastic nature of individual strides in accelerometry data collected during walking. The key element in modeling individual strides is a proper segmentation (estimation of beginnings and ends of individual strides). This is a challenging task because of the high between- and within-subject variability of stride signatures. We address these problems by introducing a two-step segmentation procedure that combines pattern-recognition with maxima-detection approach. We introduce the stride motif - a population-specific stride-pattern derived from the data, which is used for segmentation and modeling. Based on the stride motif we introduce a statistical model for individual strides that combines the population- and subject-level information. The parameters of the model are the subject-specific cadence and acceleration level. Additionally, the model captures the stride-specific deviation from the population-specific stride motif and the stride-to-stride variability of the walking acceleration. The proposed model is validated using accelerometry data collected during 1500 feet outdoor walking study. The experiment focused on 32 healthy adults equipped with accelerometers located on wrist, hip and both ankles. We analyze the performance of the segmentation method and present the variability of model parameters across subjects and sensor locations.

4-62 Tracking the real world - methods to evaluate and improve user acceptance of wearables in clinical trials

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Clinical treatments which directly focus or indirectly affect the mobility of patients are difficult to evaluate. Conventional clinical standard tests to determine patient's mobility are known to depend on the motivation of the subject itself and a training effect can bias the outcome. Therefore, measuring the mobility in the real world has the potential to provide valuable and more objective insights into the patient's well-being and quality of life. With respect to the patient's mobility, parameters such as real world walking speed and distance, falls and sleep quality are of particular importance and can be assessed using wearable sensor technology. Measurements are typically performed with special validated algorithms used to extract these parameters from the collected data. Obviously, a fundamental requirement for high quality measurements is a sufficiently long daily wearing time, which is often not the case. Therefore, factors influencing the patient's compliance are most interesting, but

complex, as they typically vary from one patient to another and high quality data about wearing time patterns are rarely available. Targeting "high wearing time" as a high-level requirement for a mobility tracker in the clinical segment is a challenge when developing and refining a wearable. Feedback directly given by the patient is both highly desirable and very difficult to assess in clinical trials. Therefore, new approaches are needed to obtain insights supporting the development of a user friendly and accepted wearable sensor technology. We use the actibelt (a mobile data logger worn in a belt buckle) as an example. Different methods to collect unbiased feedback and to perform ecological momentary assessments (EMA) based on bluetooth enabled wearables (actibelt BLU) and mobile phones (special Apps) as well as testing under extreme conditions, are presented. It is shown how this approach can have an impact on the design to improve usability and user acceptance.

4-64 Free-living validity of the Zephyr Bioharness 3 for measuring energy expenditure relative to the Physical Activity Compendium

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Purpose: This study assessed the accuracy of a metabolic equivalent (MET) estimate obtained from the Zephyr Bioharness heart rate, respiration rate, and accelerometry signals compared to the Physical Activity Compendium during free-living ambulatory and sport activities. Methods: Healthy adults (N=28) performed a self-selected pace walk and jog for 77.2 meters, followed by a random selection of sport activities at self-selected intensities: (a) singles tennis for 30m (against a partner of similar skill); (b) driving range golf (50 golf balls with a self-selected club); or (c) road cycling (on a pre-determined course of 4.73 k). Heart rate, respiration rate, and accelerometry measures were collected via the Zephyr Bioharness at 1 -sec epochs and used to calculate a MET estimate based upon a previously published laboratory-based algorithm. The MET estimate was compared to a reference criterion from the Physical Activity Compendium using a single sample t-test. Results: Participants were 70% female, 30.2±5.4 years of age, 1.74±0.08 meters in height, and 72.76±13.74 kg in weight. MET estimates and Zephyr outputs are presented in Table 1. The calculated MET underestimated energy expenditure for jogging (t[df] = -15.0 [27]), p<.001), tennis (t[df] = -4.8 [7]), p<.001), and road bike (t[df] = -19.3 [20]), p<.001); and overestimated energy expenditure for golf (t[df] = 2.6 [3]), p<.001). No differences were observed for walking. Discussion: This study suggests that a calculated MET estimate - derived from heart rate, respiration rate, and accelerometry from the Zephyr Bioharness - does not accurately measure energy expenditure in free-living conditions for these selected activities. Limitations of this work include the use of a standard MET compendium value (vs. measured energy expenditure via indirect calorimetry) and the small selection of free-living activities. Future work should re-develop this algorithm based upon free-living data collected with indirect calorimetry.

4-66 Estimation of physical activity intensity with classifying non-ambulatory and ambulatory activities by a triaxial accelerometer in young children

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Objective: We have developed an algorithm for the classification of ambulatory and non-ambulatory activities using the ratio of unfiltered to filtered synthetic acceleration measured by a triaxial accelerometer (Oshima et al., 2010) and predictive models for physical activity intensity (METs) of these activities in adults (Ohkawara et al., 2011) and in elementary school children (Hikihara et al., 2014). The purpose of the present study was to derive predictive equations for METs with the similar algorithm using a triaxial accelerometer in young children. Methods: Thirty-seven healthy Japanese children attending kindergarten (4 to 6 years old) participated in this study. We selected 5 non-ambulatory activities including low intensity activities (e.g., coloring, throwing a ball) and 4 ambulatory activities (e.g., normal walk), and gathered raw synthetic acceleration using a triaxial accelerometer and energy expenditure by indirect calorimetry during each activity. Respiratory gas sampling was performed using Douglas bag method. The triaxial accelerometer could memorize the synthetic acceleration using the measurement range of ± 6 G and the resolution of 3mG. Results and Discussion: We confirmed strong linear relationships between synthetic acceleration and METs in both non-ambulatory and ambulatory activities except for climbing down and up. For non-ambulatory activity, a quadratic equation was better fit than the linear regression, especially for light intensity non-ambulatory activities. The equations were different from those for adults and elementary school children. The ratios of unfiltered to filtered synthetic acceleration in non-ambulatory activities were different from those in ambulatory activities. Conclusion: Our calibration model with classifying non-ambulatory and ambulatory activities for young children could provide an accurate prediction of physical activity intensity of both ambulatory and non-ambulatory activities, including sedentary behavior.

4-68 Detection of Obstructive Sleep Apnea Events from a Wearable Sensor Using Dynamical Analysis

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Introduction: Obstructive Sleep Apnea is a major risk factor for cardiovascular disease, stroke and sudden death. Unfortunately the current gold standard for OSA detection (laboratory based polysomnogram (PSG)) is expensive, time-consuming, and not easily accessible by most patients. The purpose of this study was to explore a portable solution that uses a Zephyr Bioharness 3 (Medtronic, Annapolis, MD) with machine learning algorithms to detect sleep apnea events. Methods: Patients (n=17) aged 35-60, BMI 27-35 kg/m2, with no previous diagnosis of OSA, continuous positive airway pressure therapy, and no comorbid neurologic or sleep disorder were invited for a PSG examination. During the visit, participants wore the Zephyr BioHarness 3, a chest-worn physical activity monitor that measures heart rate, breathing rate, breathing amplitude, ECG, and triaxial accelerometry at the rate of 1Hz, while a trained PSG technician monitors for any sleep apnea events. The PSG data was used as criterion measure for sleep apnea events. Results: The following features were used to classify sleep apnea: a) a sliding-window of raw time-series data, b) statistical features such as mean, and variance per each sliding-window, c) a phase space transformation of the raw data. These feature are then classified using various classifiers: a) support vector machine (SVM), b) logistic regression, and c) multi-layer perceptron. Statistical features performed better than raw time-series data, while phase space transformation gave the best results giving an accuracy of over 72% in detection of sleep apnea. Discussion: Portable and reliable sleep apnea event detection would go a long way in early detection and intervention for OSA. The initial results using Zephyr Bioharness are promising and we hope to

improve them further by considering more sophisticated geometric features from phase-space transformed signals and using nonlinear time-series alignment techniques for matching time-series.

4-70 Characterizing Sleep Quality Outcomes for Children Using a Wrist-Worn Accelerometry-Based Activity Monitor

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Research has shown that indices for sleep quality can vary between methods of monitoring (polysomnography vs accelerometry), as well as between analytical algorithms. Purpose: The purpose of the present study was to characterize repeated measurements of several commonly reported sleep quality variables in children using an accelerometry-based physical activity monitor (AM) that is validated for physical activity monitoring. Methods: 22 children - 10 boys (Mean[SD]: 8[1] yrs) and 12 girls (7[1] yrs) - wore an Actical AM on the same wrist for 3 separate 7-day periods about 6-weeks apart (Sept, Oct, Dec 2015). The raw AM data (15-sec epochs) were then transformed and processed using analytical steps reported in the research literature. Briefly, this algorithm included transforming the data into 30-sec epochs; converting the 30-sec epoch data with a weighted activity score (WAS); searching the WAS data according with a "low" sensitivity threshold for 15-min data strings to indicate sleep onset and offset. Sleep outcomes generated from the resulting analyses included averaged summary variables for both weekday (WD) and weekend (WE) nights: Total sleep time (TST), sleep efficiency (SE), wake after sleep onset (WASO), and the total number of sleep bouts detected during TST. Outcome variables for both WE and WD nights were compared separately using 1-factor RM ANOVA and Tukey's post-hoc (alpha=0.05). Results: For WD, TST values were significantly higher in Sept (10.0[1.1] hrs; P=0.005) than for Dec (9.1[0.7] hrs), but not from TST in Oct (9.3[0.8] hrs). Values for SE (87.0-87.9%), WASO (1.1-1.3 hrs), and sleep bouts (15.1-15.5 bouts/night) were similar. For weekends, there were no significant differences between months (P=0.18-0.64) for TST (9.1-10.2 hrs), SE (86.5-88.7%), WASO (1.2-1.5 hrs), and sleep bouts (14.6-15.3). Conclusions: The use of a wrist-worn AM for sleep monitoring in children was effective at detecting minor trends in sleep quality outcomes over 3 months.