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Reliability and validity of a new accelerometer-based device for detecting physical activities and energy expenditure

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Objective Objective assessments of sedentary behavior, physical activity (PA) and the associated energy expenditure (EE) using accelerometer-based wearable devices are ever expanding, given their importance in the global context of health maintenance. However, among these numerous devices, the different underlying algorithms and available output parameters make it difficult to determine their accuracy. Furthermore, the function and accuracy of those devices may significantly differ between the different wearing locations (i.e., wrist-worn, waist-worn or thigh-based), where the center of the body (hip or thigh) is the optimal recommendation. Thus, a thigh-based device that has the possibility to differentiate between sedentary behavior, PAs, and EE is required to optimize research in PA. This study aimed to determine the reliability and validity of a new accelerometer-based analyzer (Fibion) with two-fold: First, to assess the reliability of the Fibion as compared to a designed repeated protocol and ActiGraph GT9X (one of the most widely used devices with favorable validity and reliability) in a laboratory re-test protocol; Second, to determine the validity of the Fibion in differentiating PAs and estimating EE throughout a simulated 12-hour free-living day.
Methods Fibion (Fibion Inc, Jyväskylä, Finland) is a new 3-axial lightweight (20g, L•W•T = 30•32•10mm) accelerometer-based device, which was designed to follow the orientation and movement of the thigh. Thus, it can be worn either on the thigh (FT) or in the front pocket of the trousers (FP). According to information provided by the manufacturer, it is able to detect no-wear time and differentiates between different types (sitting, long sitting, standing, walking, and cycling) and intensities (LPA, MVPA, and VPA) of PA and the associated EE through the use of proprietary algorithms.
The study consisted of two parts: a reliability (n=18) and validity (n=19) test, respectively. All 37 participants were young and healthy volunteers, who were normal weight (i.e., BMI < 25 kg/m^2) and recreationally physically active. Exclusion criteria included acute and chronic diseases, which would prevent participants from prolonged sitting and/or standing or would interfere with the basic metabolic rate. All participants were informed about the study procedures and provided written informed consent prior to commencing with testing. The study was carried out in accordance with the Declaration of Helsinki and the local Ethical Committee (ML16027).
Reliability was assessed by a designed 15-min protocol by repeating sitting, standing, and walking (a total of 90 min = 15 min *3 types * 2 repeats) using both Fibion (FT) and ActiGraph. Validity was assessed by a prolonged 12-h protocol which was designed as simulated free-living conditions with two criteria. Criterion 1: Direct observation of the 12-h continuous sequence of tasks with measurement logs, to determine the duration of different types (sitting, standing, walking, and cycling) and intensities (light [LPA], moderate-to-vigorous [MVPA], and vigorous [VPA])) of PA. Indirect calorimetry served as the criterion 2 for EE estimation. Pulmonary gas exchange of the participants was continuously measured throughout the 12-h guided sequence of tasks by a portable

breath-by-breath gas analyzer (Cosmed K4b2, Rome, Italy). During the entire 12-h protocol, two Fibion devices (worn both on the thigh (FT) and in the pocket (FP), respectively) and K4b2 were used simultaneously.
Results Reliability. Fibion located on the thigh (FT) (ICCs: 0.687-0.806) provided similar reliability for EE estimation as the Actigraph (ICCs: 0.661-0.806). However, the measurement error for FT indicated an underestimation of activity times by 5.1 ± 1.2%, 3.8 ± 0.3% and 14.9 ± 2.6% during sitting, walking, and standing, respectively. Furthermore, low correlations were observed between subsequent measurements with both devices (ICCs 0.189-0.459), especially in low intensities (sitting). **Validity.** During the prolonged 12-h simulated real-life conditions, FT but not FP showed a moderate agreement with the direct observation in assessing the duration of sitting, long sitting, LPA, MVPA, and VPA ($p>0.05$, ICCs: 0.071-0.537), but the low correlations between Fibion and the criteria (ICCs FT: 0.016-0.638; FP: -0.046 to 0.650) indicate that the measurement error is random. Similarly, FT but not FP showed a moderate agreement with the K4b2 for EE estimation of standing, LPA, MVPA, and VPA ($p>0.05$, ICCs: 0.673-0.894).
Conclusions In summary, the location of the accelerometer is essential for accurately assessing PA and EE. FT appeared to detect sitting and walking with a small measurement error, similar to that of the Actigraph. Considering the random error observed in our study, further studies with larger populations are needed to confirm the practical usability of Fibion (FT) for estimating different types and intensities of PA.