AN OVERVIEW OF CURRENTLY AVAILABLE METHODS AND FUTURE TRENDS FOR PHYSICAL ACTIVITY

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ABSTRACT — ***Background:*** *Methodological limitations make comparison of various instruments difficult, although the number of publications on physical activity assessment has extensively increased. Therefore, systematization of techniques and definitions is essential for the improvement of knowledge in the area.*

Objective: *This paper systematically describes and compares up-to-date methods that assess habitual physical activity and discusses main issues regarding the use and interpretation of data collected with these techniques.*

Methods: *A general outline of the measures and techniques described above is presented in review form, along with their respective definition, usual applications, positive aspects and shortcomings.*

Results and Conclusions: *The various factors to be considered in the selection of physical activity assessment methods include goals, sample size, budget, cultural and social/environmental factors, physical burden for the subject, and statistical factors, such as accuracy and precision. It is concluded that no single current technique is able to quantify all aspects of physical activity under free-living conditions, requiring the use of complementary methods. In not too distant future, devices will take advantage of consumer technologies, such as mobile phones, GPS devices. It is important to perform other activities, such as detecting and responding to physical activity in a real time, creating new opportunities in measurement, remote compliance monitoring, data-driven discovery and intervention.*

INTRODUCTION

There are lots of research studies on physical activity and it is difficult to compare different methods and tools used. When selecting a physical activity assessment methods it is necessary to consider various factors, such as objectives, sample size, budget, cultural, social and environmental factors, physical load and statistical factors, such as accuracy and precision [1]. We assume that in the near future there will more technologies available for monitoring physical activity, such as mobile phones, GPS devices, and others.

METHODS

Up-to-date systematization of methods and definitions is essential for the improvement of knowledge in the area. A variety of techniques exist to quantify levels of habitual physical activity during daily life, including subjective self-reports of physical activity by diaries or logbooks (PA-log) methods and physical activity questionnaires, as well as objective measures, such as doubly labelled water (DLW) technique, direct observation, heart rate monitoring, pedometry, or accelerometry [2].

RESULTS AND DISCUSSION

The ability of accurate quantification of the total activity allows healthcare professionals to help in designing appropriate exercises. Modern systematization of methods and descriptions is essential to improve knowledge in this area.

Self-reports of physical activity by a diary or log method provide a detailed record of an individual's physical activity on a daily basis; these records are generally self-completed prospectively on paper or computer, in form of interview, daily logs or diaries. Strengths of self-reports include low cost of administration, ability to measure large samples, availability of many instruments with evidence of reliability and validity, and ability to tailor the measure to the population and study goals. Individual bouts of activity are recorded in diaries as they occur during the day typically in 15-minute segments that may lead to the omission of some activities, but reducing the period has been shown to be too intensive and lead to non-completion. In contrast, logs capture the time individuals spend in broad categories of activity: inactive, sitting, light, moderate, vigorous and very vigorous and examples of activities in each intensity level are provided [3]. Diaries produce more detailed information, i.e., types of activity, intensity and patterns, but are more burdensome for individuals to complete and the data are more complex to reduce and enter. Correlations with accelerometry were moderate and ranged from 0.26–0.54 depending on the comparisons. Physical activity self-reports mainly assessed leisure or recreational activities, but adults can also be active in their jobs, through the type of transportation they use, and in performing household chores [4].

The International Physical Activity Questionnaire (IPAQ) was developed in 1998 to facilitate surveillance of physical activity based on a global standard [5]. The IPAQ assesses activities in all multiple domains among adults aged 18 to 65 years over the previous week and is adaptable to all cultures and languages in almost 70 countries and has been shown to be as reliable and valid as other self-reports. The IPAQs are the most practical subjective self-report instruments in physical activity research [6,7]. Recent reviews have documented 85 self-administered physical activity questionnaires in several forms of administration (face-to-face, telephone interviews, mailed forms) [8]. There is a clear lack of systematization and standardization of questionnaires, none of them was superior and therefore could not be strongly recommended over others. Several countries have adopted the IPAQ as their national or regional surveillance system and these data contribute to current WHO and European surveillance systems [9,10].

The IPAQ has gradually become the most widely used physical activity questionnaire, with two versions available: the long form (IPAQ-LF) and the short form (IPAQ-SF). Both of them involve 7-day recall of physical activity. The IPAQ-SF records the activity of four intensity levels: 1) vigorous-intensity activity such as aerobics, 2) moderate-intensity activity such as leisure cycling, 3) walking, and 4) sitting, in part because the burden on participants to report their activity is small. It was designed for use in surveillance studies to estimate the time spent performing physical activities (moderate to vigorous) and inactivity (time spent with sitting). The IPAQ-SF can be used for successful estimation of VO2 max as well as submaximal exercise tests. It was concluded that highly active participants could be correctly identified and distinguished from inactive participants using the IPAQ-SF, but other discrimination was poor. A limitation is that the IPAQ-SF does not provide summaries by domain; however, the slightly longer Global Physical Activity Questionnaire (GPAQ) does summarize activities by recreation, occupation, and transportation domains. The correlation between the IPAQ-SF and objective measures of activity or fitness in the large majority of studies was lower than the acceptable standard. Furthermore, the IPAQ-SF typically overestimated physical activity as measured by objective criterion by an average of 84 percent. Hence, the evidence to support the use of the IPAQ-SF as an indicator of relative or absolute physical activity is weak [11]. The IPAQ-LF was developed to obtain internationally comparable data on health-related physical activity. Its reliability and validity results showed correlations with motion detectors of 0.30–0.33. Later a revised IPAQ-LF version has been launched. As different from the first, the revised version does not aim to measure low-intensity physical activity. It asks in detail about walking, moderate-intensity and vigorous-intensity physical activity in each of the four domains. Data collected with the IPAQ-LF can be reported as a continuous measure and reported as median METs-minutes [12].

Direct observation is used most frequently for the assessment of physical activity of groups in specific settings. Advantages of the direct observation include high-quality data, ability to record numerous dimensions of physical activity, and flexible scoring of results. Disadvantages are the expense of human observers, need for training, difficulties of managing and scoring the data. Two widely used observation measures illustrate the method's use. The System for Observing Fitness Instruction Time (SOFIT) was developed to evaluate physical education classes and has been used to evaluate numerous physical education programs for research and non-research purposes. The System for Observing Play And Recreation in Communities (SOPARC) was designed to evaluate how recreation settings are being used [13].

Heart rate monitoring is a measure of the direct physiological response to physical activity to estimate the intensity of activity for people across the age range. The most common used heart rate monitors (HRMs) can detect in principle any type of activity and they can even be used for activities in the water. A single device that simultaneously collects synchronized heart rate and motion (HR+M) data is preferable in order to overcome the inherent limitations. The HR+M monitors compensate for the limitations of separate devices so that all types of activities can be assessed throughout the range of intensities, including sedentary behaviours. Incorporated software enables that individual calibrations based on an individual's heart rate response can be applied to the HR+M data. The devices are simple to carry, equipment needs are minimal and inexpensive, and they can be performed almost anywhere by non-experts [14].

Pedometers are small, belt-mounted devices primarily used for quantifying the daily number of steps accumulated, which is the most common activity. Pedometers are easy to use for participants and evaluators and they accurately assess walking. They are less useful for running, cycling, and water activities and they work less properly for young children who do a variety of activities and for older adults who walk too slowly for accurate measurement. Pedometers provide an inexpensive overall measure of physical activity but are unable to assess intensity, frequency and duration of activity or to estimate energy expenditure. In few studies pedometers correlated highly in terms of both criterion (direct observation) and convergent validity (heart-rate monitor, accelerometer) and can be effectively utilized as a valid determinant of physical activity levels among children and adolescents, particularly in large-scale epidemiological studies [15]. Pedometers serve as motivational tools for promoting physical activity because immediate feedback on accumulated steps, whether incidental or intentional, provides goal attainment information and is a constant reminder to be active [16].

Accelerometry is the most common objective method used to measure physical activity; it has been used extensively in field settings to monitor activity patterns in subjects of various age [14,17]. Technological advances have resulted in devices that can measure activity accurately over an extended time period and that are small and discrete for people to wear. Accelerometers attached to the waist do not capture upper body movement or cycling and underestimate walking on an incline or carrying heavy loads. Accelerometers provide physical activity measurements, such as activity counts and vector magnitude, energy expenditure, steps taken, activity intensity levels, METs and more. Most of the devices collect data in raw format at a user specified sample rate up to 100 Hz. Filtering and epoch selection are performed after data are collected, allowing users processing datasets multiple times at different epoch selections, even after a study has ended. Some accelerometers can store over 40 days of raw data, having a rechargeable battery capable of providing power for 30 days between charges. Few models are waterproof and can be used for evaluating of water-based activities. The accelerometers appear to be a useful tool for measuring energy expenditure under free-living conditions for both short- and long-term periods [18]. The primary outcome measure of the accelerometry is body acceleration, often expressed as a count value. Secondary outcomes are estimates of bout frequency, duration and intensity of body movement. It has been suggested that establishing the relationship between activity counts and energy expenditure is sometime problematic. Additionally, an accelerometer placed on one body location does not capture activity of other body sites, although there is usually some cross-correlation. Cut-points for defining different intensity levels are somewhat arbitrary and the use of different cut points can have profound impact on the estimate of the physical activity. Laboratory-derived physical activity energy expenditure equations are not all equally suitable to assess physical activity in free-living populations. Laboratory-derived prediction equations have been found to overestimate free-living energy expenditure by 47% in a study using DLW technique [19]. Common phenomenon in accelerometry is that linear relationships derived for rest and ambulation displays much poorer validity in biomechanically diverse activities, e.g. cycling or lifting weights. Advanced statistical methods have been proposed to improve prediction equations. During the past decade the objective assessment of physical activity using accelerometer-based devices has demonstrated substantial potential, especially in documenting the pattern of light-, moderate-, and vigorous-intensity activity throughout the day. However, these devices do not provide information on activity type, location or context [3].

As physical activity monitoring moves into the future, it is incumbent on researchers to be open to new technologies, such as multisensory arrays as well as integrating familiar sensors into new devices. To improve health outcomes it is critical to accurately measure physical activity and sedentary time spent in- and outdoors. GPS devices linked with physical activity monitoring devices enable measurement of where and when individuals are active as well as their energy expenditure and are a promising tool that can improve understanding the spatial context of physical activity [20]. If the validity, reliability, and feasibility of wearable GPS devices are better understood, these devices can become important measurement tools in physical activity research. Several cell phone manufacturers are already building activity monitors into cell phones, with the cell phone service providing the data download. The iPod/iPhone's built-in accelerometer as a measurement of physical activity in order to create a better physical activity recognition program is currently tested [11].

CONCLUSION

We anticipate more modes of activity-sensing technology now and in the not too distant future. No single current technique is able to quantify all aspects of physical activity under free-living conditions, requiring the use of complementary methods. The various factors to be considered in the selection of physical activity assessment methods include goals, sample size, budget, cultural and social/environmental factors, physical burden for the subject, and statistical factors, such as accuracy and precision [21]. In the future, physical activity sensors, which are of low-cost, small-sized, and convenient for subjects, investigators, and clinicians, will take advantage of consumer technologies, such as mobile phones and

GPS devices, to detect location and respond to physical activity in a real time, creating new opportunities in measurement, remote compliance monitoring, data-driven discovery and intervention.

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