

ASSESSING AND INCREASING PHYSICAL ACTIVITY

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Increasing physical activity is a crucial component of any comprehensive approach to combat the growing obesity epidemic. This review summarizes recent behavioral research on the measurement of physical activity and interventions aimed at increasing physical activity and provides directions for future research.

Key words: exergaming, measurement, obesity, physical activity, and self-management

The most recent estimates suggest that over half of the United States population is overweight, and an estimated 34% of adults and 17% of children are obese (Ogden, Carroll, Kit, & Flegal, 2012). The prevalence of obesity has increased in recent decades, and the rise in associated health factors (e.g., hypertension, Type 2 diabetes), as well as direct and indirect health-related costs, has increased the need for research aimed at preventing and treating this problem (Normand, 2008).

Regular physical activity reduces many of the risks associated with being overweight or obese in both children and adults (U.S. Department of Health and Human Services, 2012). It is recommended that children and adolescents engage in at least 60 min of moderate to vigorous physical activity each day. For adults, at least 150 min of moderate-intensity activity is recommended each week. The purpose of this review is to describe recent behavioral research on the assessment of physical activity and interventions aimed at increasing physical activity. We also provide directions for future research.

MEASURING ACTIVITY

Mechanical Instruments

Quantitative measures of physical activity may be collected via wearable monitors, such as

pedometers, accelerometers, and heart-rate monitors. Pedometers typically are worn on the waist and use a spring-arm or pendulum mechanism that records steps. Pedometers are relatively unobtrusive and inexpensive, but reliability and validity of the measures produced vary greatly by model (Butte, Ekelund, & Westerterp, 2012). Recent behavioral studies used validated pedometers as the primary source of data (i.e., steps per day or steps per session) in evaluations that focused on increasing physical activity in both children and adults. New Lifestyles 2000 pedometers (Hustyi, Normand, & Larson, 2011; Normand, 2008) and Yamax Digi-Walker Model SW-200 pedometers (VanWormer, 2004) also provided data via digital display, which contributed to the self-monitoring component of the self-management intervention. Pedometers are particularly useful when direct observation is not feasible, including assessments of daylong activity or measurement of activity of multiple individuals at one time. One limitation of pedometers is the lack of memory storage on some models, making it necessary for someone (likely not the experimenter) to record the total number of steps taken at the end of each day. VanWormer (2004), for example, required subjects to self-report the number of steps on the display, and a family member performed reliability checks. Pedometers also may underestimate overall physical activity because they only measure translocation.

Heart-rate monitors (HRMs) also have been used to track physical activity (Larson, Normand, & Hustyi, 2011; McKenzie et al., 1991). HRMs typically measure electrical activity of the heart via a device worn on the chest in

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doi: 10.1901/jaba.2012.45-871

direct contact with the skin. A readout display is available on the accompanying watch. Larson et al. (2011) compared the number of steps taken (measured via pedometer) to beats per minute as measured via an HRM (Polar F-4) while children engaged in structured activities that varied in intensity. The data produced by the HRMs covaried with the increasing intensity of the activities much more so than did the data produced by the pedometers. HRMs (UNIQ Heart Watch) also were used as the primary source of measurement in a similar study demonstrating that heart rate covaried with the intensity of structured activities, ranging from lying down to running (McKenzie et al., 1991). In addition to providing direct measures of heart rate in real time, HRMs also may be calibrated to the specifications of the individual to estimate calories expended. Many modern HRMs have a memory feature that retains data collected for 7 days or more, thus allowing the automatic collection and retention of data while a subject is not in the presence of the experimenter. Donaldson and Normand (2009) used HRMs (Polar F6) with 12-day memory to measure calories expended per day in an evaluation of a self-management intervention. The memory feature allowed weekly meetings with the experimenters to verify the subjects' daily self-reports. It should be noted, however, that although HRMs may allow precise measures of heart rate throughout the day, heart rate may be affected by variables other than activity (Butte et al., 2012).

Accelerometers are relatively new devices that record steps and estimate activity level using chip sensors that record movement in one or more planes. In addition, some accelerometers (e.g., Fitbit) may be worn on several locations on the body, and also may allow wireless uploading of data onto websites that store and graph step and activity data. To date, no published behavioral studies have used accelerometers with online data access to assess and increase physical activity. When using new technology that may not have been validated

yet, experimenters may gather measures of reliability and convergent validity by having subjects wear two devices simultaneously and by comparing the new technology to more established devices. One concern is that individuals other than the research subjects may wear the device when these devices are used to collect data in the absence of the experimenter. Although it may not be feasible to prevent this in all cases, some recent advancement in video cell-phone technology may allow researchers to check in visually with research subjects from a distance.

The studies described above focused on direct measures of physical activity. Weight loss is an important indirect measure that also should be evaluated in future research. Van-Wormer (2004) reported modest weight loss correlated with increased activity levels, but Normand (2008) did not. Donaldson and Normand (2009) reported weight loss in four of five subjects; however, subjects were enrolled simultaneously in a weight management program.

Direct Observation Coding Systems

Mechanical instruments allow the automatic collection of activity-related measures, but they do not provide qualitative information, such as activity type and setting. McKenzie et al. (1991) developed the Behaviors of Eating and Activity for Children's Health Evaluation System (BEACHES) to assess physical activity and eating behavior in a variety of contexts. Observers code behavior and contextual information using a 25-s observation interval followed by a 35-s recording interval. In this validation study that focused on the activity level codes, 19 children were asked to engage in the following activities that corresponded to the five activity codes in BEACHES: (a) lying down, (b) sitting, (c) standing, (d) walking, and (e) very active. HRMs measured exertion, and results indicated that heart rate covaried with the different activity levels.

The Observational System for Recording Physical Activity in Children-Home (OSRAC-

H; McIver, Brown, Pfeiffer, Dowda, & Russell, 2009) also allows the coding of environmental and social contexts while physical activity is measured using activity codes. Measures also include indoor and outdoor activity contexts, social groups, and topography of activity. Activity codes include (a) stationary or motionless; (b) stationary with limb or trunk movements; (c) slow, easy movements; (d) moderate movements; and (e) fast movements. Observers use momentary time sampling with a 5-s observation interval followed by a 25-s recording interval. McIver et al. (2009) evaluated the activity levels of 13 preschool children while they were engaged in unstructured play. Overall, more than 66% of the activities were coded as sedentary (Codes 1 and 2 combined), and only 7% as moderate-to-vigorous physical activity (MVPA, Codes 4 and 5 combined); higher levels of MVPA occurred when children were outside. Hustyi, Normand, Larson, and Morley (2012) used the OSRAC activity coding system to study the effect of different outdoor activity contexts on physical activity in four preschool children. Results indicated that fixed equipment produced the highest percentage of MVPA. Although MVPA occurred at some level in the outdoor toys and open space conditions, MVPA rarely occurred in the table play condition (in which children were seated). Combinations of OSRAC activity codes have become common practice (see also Hustyi et al., 2011), but Larson et al. (2011) evaluated the validity of the individual codes by instructing four children to engage in activities associated with each of the codes while exertion was measured with pedometers and HRMs. Differential levels of heart rate were observed with each level of activity, suggesting that experimenters should use all five individual OSRAC activity codes. However, only one activity per code was evaluated, and additional elements of the behavioral definitions warrant further investigation.

The studies that used the entire BEACHES and OSRAC systems have reported acceptable

interobserver reliability; however, observer training was intensive. In addition, the coding systems use momentary time sampling, which only estimates the actual level of activity. These observation methods provide important qualitative information, but it may be prudent to combine these observations with more direct measures of activity (e.g., pedometers). In addition, future research should consider assessment of the validity of self-reports so that data on qualitative aspects of physical activity could be gathered in the experimenters' absence.

INTERVENTION

Recent behavioral interventions aimed at increasing physical activity have included self-management and exergaming. Normand (2008) used self-management to increase physical activity of four nonobese adults. Results indicated that self-monitoring, goal setting, and feedback were successful at increasing total number of steps per day. A similar treatment package also was used to increase the daily calorie expenditure of five obese adults (Donaldson & Normand, 2009). Results indicated that all subjects were successful in increasing calorie expenditure during intervention phases. In both studies, feedback was in the form of daily e-mails, which required subjects to submit data via e-mail. A similar treatment package was used in an evaluation to increase daily steps taken by three overweight adults (VanWormer, 2004). The experimenters conducted a component analysis that indicated that self-monitoring alone (without the feedback via e-mail) was effective for all subjects, and e-mail feedback produced further improvements for only one subject. Hustyi et al. (2011) evaluated self-monitoring, goal setting, and reinforcement to increase the physical activity (steps per session) of two obese children. Results indicated modest or no increases in physical activity; however, the authors noted that the rewards used may not have functioned as reinforcers.

Overall, self-management appears to be a promising intervention to address increased physical activity. Learned skills such as self-monitoring and goal setting may be maintained past the subjects' involvement in research, which may contribute to sustained increases in activity levels. However, such long-term effects have yet to be evaluated. In addition, few studies have conducted component analyses of self-management treatment packages, and only one study evaluated the effects of contrived reinforcers other than feedback from the experimenter. Additional research is needed to identify effective reinforcers to increase physical activity when self-monitoring, goal setting, and feedback are not sufficient. This may be particularly important in research with children. In addition, contingency management (e.g., Petry, Barry, Pescatello, & White, 2011) may be a promising approach for increasing day-long physical activity.

Exergaming, an interactive area of video game technology aimed specifically toward exercise, has been evaluated in several recent studies. Fogel, Miltenberger, Graves, and Koehler (2010) compared the level of physical activity in exergaming sessions and typical physical education sessions in four overweight and sedentary children in the fifth grade. A similar study was conducted with four active third-grade boys (Shayne, Fogel, Miltenberger, & Koehler, 2012). Observers recorded physical activity, defined as moving large muscle groups during an assigned task (excluding transition or waiting time). Results of both studies indicated that exergaming sessions were associated with higher levels of physical activity. In addition, exergaming equipment provided more opportunity for physical activity. Results of Shayne et al. (2012) also indicated which specific video games were associated with the highest levels of activity. Future research should evaluate the effects of exergaming on physical activity with other populations and in other settings (e.g., the home). Finally, methods of assessing and increasing activity levels of children during

recess may be an important area of research, because many schools have reduced formal physical education to once or twice per week, whereas recess remains a daily component of the school day (Leviton, 2008).

In conclusion, increasingly precise and widely available devices allow lay individuals and researchers to collect data on physical activity. Less common, however, are details regarding how these data could be used to change behavior. Self-management and contingency-management programs, as well as exergaming and other exercise alternatives, have shown some promise in the behavioral literature. Still, additional research is needed to advance behavioral interventions that are aimed at increasing physical activity, which is a socially significant behavior for all individuals.

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Received March 28, 2012

Final acceptance May 24, 2012

Action Editor, Dorothea Lerman