Physical Activity

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Physical activity (PA) can be defined as any bodily movement produced by skeletal muscles that results in energy expenditure above resting levels. Regular PA and exercise are associated with numerous physical and mental health benefits. Since PA is a multidimensional behavior that does not exist in a vacuum, its definition should be situated in several related constructs such as sedentary behavior, energy expenditure, and physical fitness. PA, therefore, may be operationally defined as "the behavior that involves human movement, resulting in physiological attributes including increased energy expenditure and improved physical fitness" (Pettee Gabriel, Morrow, & Woolsey, 2012, p. S15).

PA can be categorized by its predominant physiologic effect into aerobic and anaerobic activities, muscle and bone-strengthening activities, balance and flexibility training. These categories are not mutually exclusive. More specifically, aerobic activity refers to any activity that uses large muscle groups, can be maintained continuously, and is rhythmic in nature (e.g., brisk walking, swimming); anaerobic activity indicates a higher intensity/greater power version of exercise that breaks down glucose as a fuel in the absence of oxygen (e.g., sprinting, heavy power training). Muscle-strengthening activities employ a major muscle group to work or hold against external force or weight (e.g., stair climbing, squats); bone-strengthening activities are movements that produce an impact or tension force on the bones (e.g., basketball, weightlifting); balance training refers to a neuromotor exercise intended to improve the ability to control and stabilize the body's position (e.g., tai chi, yoga); flexibility training is intended to improve the range of motion and the ability of one's joints to move freely (e.g., stretching, Pilates).

The intensity of PA can be classified as absolute or relative. Absolute intensity refers to the rate at which PA is being performed. A widely used and standardized measurement unit is the metabolic equivalent (MET). One MET refers to the amount of oxygen consumed while sitting quietly. For a typical adult, one MET would approximate an oxygen uptake of 3.5 millilitres per kilogram per minute. The intensity of PA will thus be expressed in multiples of METs. For a typical adult, vigorous intensity PA requires six METs or more (e.g., soccer, jumping ropes); moderate intensity PA requires 3–6 METs (e.g., floor vacuuming, shooting a basketball); and light intensity PA requires between 1.6 and 3 METs (e.g., shopping, cooking). PA requiring 1–1.5 METs is described as sedentary activity. MET cut points for children, elder people, and people with disabilities will differ by age groups.

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Relative intensity is specific to the individual's level of physical fitness and is based on the individual's maximum capacity of exercise. Methods for measuring the relative intensity of PA include percentage of aerobic capacity, VO_{2max} (the maximum rate of oxygen consumption measured during incremental exercise), percentage of maximal heart rate (HR_{max}), and percentage of heart rate reserve (HRR). Relative intensity can also be self-assessed as a subjective perception of how difficult it is to perform the PA; the Borg rating of perceived exertion scale (RPE scale) (Borg, 1982) is an instrument designed for such assessments which has variations for different populations and has been found to correspond well to objectively measured absolute intensity.

PA measurement is crucial for researchers and practitioners. In general, measurement instruments can be categorized as subjective or objective. Subjective instruments are frequently self-reported or proxy-reported survey questionnaires or diaries completed by the individual themselves or an observer of the person carrying out the PA. Such measurements are usually highly feasible to use but may lack validity.

PA is also objectively measurable using various devices of different size, efficiency, and accuracy levels. For example, the doubly labelled water (DLW) method and indirect calorimetry are considered as the gold standards for assessing energy expenditure. The DLW method is highly suitable for measuring total free-living energy expenditure. In a typical DLW protocol, a subject is given a dose of labeled water (H_2O) containing stable isotopes deuterium (^2H) and oxygen-18 (^{18}O). Over a period of days and weeks, samples from saliva, urine, or blood are assessed for the elimination rates of ^2H and ^{18}O (equivalent to the rate of CO_2 production), which can be converted to average daily total energy expenditure. Indirect calorimetry via a metabolic cart is widely used in clinical settings. It typically adopts the breath-by-breath method to measure oxygen consumption and carbon dioxide production during individual activities, from which energy expenditure is calculated as an indirect assessment. While the DLW method has been considered as the most accurate method for assessing energy expenditure in a free-living individual over a prolonged period, its feasibility is relatively low. Indirect calorimetry, on the other hand, has the advantage of providing estimates of energy expenditure over shorter periods of time.

The technological development has rapidly revolutionized the field of PA measurement devices and it is now possible to easily find such devices ranging from research-grade triaxial accelerometers and heart rate monitors to consumer-grade smartphone and watch apps. While these measures tend to have a better balance between feasibility and validity than subjective measures, each also has its limitations, thus no single best device exists for measurement of PA. The key is to determine the type of measurement of PA one needs after weighing each device's strengths and limitations.

Numerous studies have indicated the benefits of regular PA, including a reduction in the likelihood of multiple types of cancer, chronic diseases, and premature death as well as an improvement in mental health. In fact, even small amounts of PA can result in substantial benefits. According to the 2018 Physical Activity Guidelines, adults should do 150–300 min of moderate PA or 75–150 min of vigorous PA per week, or an equivalent combination of both types of activities; children between the ages of 6 and 17 should do at least 60 min of moderate to vigorous PA every day; and preschool children

between the ages of three and five should be physically active throughout the day (2018 Physical Activity Guidelines Advisory Committee, 2018).

However, people in the United States suffer from a dramatic decrease in PA between childhood and adolescence and this decline continues with age. Less than half of children between 6 and 11 years obtain 60 min of PA, 8% of adolescents achieve the same level and less than 5% of adults exercise 30 min per day (Troiano et al., 2008).

Sedentary behaviors (SB) comprise any waking behavior performed in a sitting, reclining, or lying posture (Tremblay et al., 2017), thus usually constitute between 1 and 1.5 METs. SB are a risk factor for multiple adverse health outcomes in adults. Sedentary screen time, an important component of SB, is one of the best documented causes of obesity among children and adolescents (Robinson et al., 2017). Children and young adults are easily immersed in engaging media and technologies, which may have positive and negative effects on their development. New media guidelines have been proposed for children and families.

What motivates people to participate and adhere to PA? Trost, Owen, Bauman, Sallis and Brown (2002) have identified five major categories of psychosocial variables. In terms of *demographic and biological factors*, participation is consistently higher in men than women and is inversely associated with age. Overweight and obesity remain consistent negative influences on PA. In terms of *intrapersonal variables involving psychological, cognitive, and emotional factors*, self-efficacy, or a person's confidence in their ability to be regularly active, is consistently correlated with exercise behavior. As for other *behavioral attributes*, past exercise habits consistently predict the current activity and positive associations were found with healthy diet. In terms of *social and cultural factors*, social support is consistently associated with PA behaviors. Last, but not least, researchers have identified access to exercise facilities and home equipment, satisfaction with exercise facilities, and enjoyable scenery as key *physical environment factors*.

While there are many strategies to increase PA, most PA interventions among children have not achieved long-term effects, with lack of access and motivation as key challenges. Innovative ways are needed to improve people's PA and/or reduce their SB to achieve a healthy balance for energy expenditure. One potential solution is to replace sedentary screen time with active screen time.

Active video games (AVGs) are "interactive video or electronic games that feature player movement, such as would occur in 'real-life' exercise participation" (Bailey & McInnis, 2011, p. 597). Players engage in real-world actions, such as jumping or dancing, to play the games. AVGs may serve as an effective, enjoyable, and accessible method to increase PA. Around two-thirds of people in the United States play video games daily in 2018. Over 90% of U.S. children play games and 87% have a game console at home. All major console game companies offer AVG devices.

Many AVGs, though, are perceived to be less enjoyable than sedentary games and are less likely to be played over time. Most gamers do not complete their games as they often lack long-term motivational appeal. Novel and interdisciplinary approaches are needed to sustain AVG play.

Narratives may possess unique motivational properties that encourage increased AVG play. While narratives appear in many video games, few AVGs capable of achieving moderate to vigorous PA have incorporated them. Researchers have tested the

ability of added narratives to induce PA through AVG play. Lu et al. (2016) interspersed brief, animated narrative video clips in an existing AVG without a narrative and found that 8–12-year-old children in the narrative condition had 40% more objectively measured steps than their non-narrative counterparts. Hwang and Lu (2018) found similar results in college students, for whom the narrative resulted in 57% more time spent at moderate to vigorous intensity PA and 23% more steps.

The narratives effectively implement some behavioral change theories widely used in motivating PA: theory of planned behavior (TPB), social cognitive theory, and self-determination theory (SDT). The TPB (Ajzen, 1991) posits a person's behavior is a function of the intention to perform that behavior, which in turn is a function of the attitude toward performing the behavior, subjective norms, and perceived behavioral control. Attitude toward performing the behavior refers to the positive or negative value that an individual associates with performing the behavior; subjective norm refers to the perceived pressure from other people to perform (or not to perform) the behavior; and perceived behavioral control refers to people's perception of their ability to perform a given behavior. With their immersive process, narratives may make the PA seem fun (changing attitudes), may show other characters engaged in PA (which may affect social norms), and can make the behavior seem easy to do (increasing perceived behavioral control), especially when the persuasive messages are conveyed through AVG play, which is an inherently engaging activity.

Social cognitive theory (SCT; originally called social learning theory) describes a system of triadic determinism of behavior that is governed by personal, environmental, and behavioral factors. It highlights observational learning, or vicarious acquisition of knowledge from the social environment, as a primary source of information (Bandura, 1977). A narrative has the potential through character actions to convey observational learning by showing useful strategies and demonstrating how to exercise, thus increasing one's motivation to perform PA. Narratives may also be especially useful in enhancing self-efficacy, a key construct of SCT and a similar concept to perceived behavioral control in TPB, through two determinants: vicarious experiences and emotional arousal. Narratives enable people to cognitively rehearse the process and enjoy the benefit of seeing someone else performing PA. Cognitive rehearsal may help people organize, remember, and engender a greater sense of confidence that the PA can be reproduced when necessary.

The SDT considers human behavior to be driven by individual (intrinsic) and external (extrinsic) motivations (Ryan & Deci, 2000). Intrinsic motivation predicts the initial and continued performance of a behavior while extrinsic motivation relies on external rewards and punishments. Narrative enjoyment through AVG play can be an intrinsically rewarding activity sought by people independent of extrinsic rewards by providing intriguing internal incentives for players who, in the role of characters, feel immersed in the story. Embedding narratives into behavioral change AVGs could potentially promote the development of autonomous motivation to complete the game and adopt the behavior promoted in the game.

The past decades of PA intervention work indicate that efforts to promote individual-level PA can be most effective when the intervention is based on behavioral change theories. The aforementioned theories are but a subset of the theories and

conceptual frameworks related to PA promotion and sedentary behavior reduction. The advancements in media and technology offer additional theoretical and methodological approaches of audience engagement and innovative potential and opportunities to enhance PA and reduce SB. Additional investigations of the individual and interactive effect of PA and SB in different populations across the developmental spectrum are needed. Systematic empirical investigations in PA and exercise behavior promotion should help determine as well as illuminate innovative ways of health and well-being promotion.

SEE ALSO: Effects of Video Games on Child/Youth Cognitive Skills and Knowledge Gain; Exergames, Energy Expenditure, and Obesity; Identification; Immersion; Involvement; Measuring Behavior in Media Psychology; Media Use and Obesity; Presence; Transportation; Wearable Devices for Health-Related Data

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