Toward an Understanding of Appropriate Physical Activity Levels for Youth

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HIGHLIGHT

Children's Lifetime Physical Activity Model (C-LPAM)

The Health Standard: A Minimum Activity Standard

Frequency	Daily. Frequent activity sessions (3 or more) each day.
Intensity	Moderate. Alternating bouts of activity with rest periods as needed or moderate activity such as walking or riding a bike to school.
Time	Duration of activity necessary to expend at least 3 to 4 kcal/kg/day. Equal to calorie expenditure in 30 minutes or more of active play or moderate sustained activity which may be distributed over 3 or more activity sessions.

The Optimal Functioning Standard: A Goal for All Children

Frequency	Daily. Frequent activity sessions (3 or more) each day.
Intensity	Moderate to vigorous. Alternating bouts of activity with rest periods as needed or moderate activity such as walking or riding a bike to school.
Time	Duration of activity necessary to expend at least 6 to 8 kcal/kg/day. Equal to calorie expenditure in 60 minutes or more of active play or moderate sustained activity which may be distributed over 3 or more activity sessions.

OVERVIEW

In the not so distant past, children were protected from vigorous physical activity. Even leading educators felt that children were incapable of exercise that caused high heart rates. In the last half century science has found that children can safely perform high intensity exercise. However, many of the guidelines for physical activity for children formulated in the last 30 years have been based on what is often called the Exercise Prescription Model (EPM), an approach developed primarily for adults. Since 1985, there has been a shift from the EPM to a Lifetime Physical Activity Model (LPAM) as the basis for establishing activity guidelines for adults. This model suggests that moderate daily lifetime exercise such as walking results in an energy expenditure of 3 to 4 kcal/kg/day (1000 to 2000 calories per week), which is sufficient to produce health benefits. Because high intensity activity is a deterrent to some, this model is offered as a "new strategy" for health risk reduction through physical activity.

Just as the LPAM is more appropriate for many adults than the EPM, the LPAM is better suited for children than the EPM. Like many adults, children often do not respond well to high intensity physical activity. The LPAM standards for minimal activity requirements necessary to gain the health benefits of physical activity (3 to 4 kcal/kg/day) provide the basis for a child-specific physical activity model called the Children's Lifetime Physical Activity Model (C-LPAM). This model suggests that children should, as a minimum, expend the same number of kcal/kg/day as adults. However, it also suggests that optimally, children should be encouraged to do additional physical activity (6 to 8 kcal/kg/day) because children have different needs than adults and it is during childhood that lifetime activity patterns are developed.

PHYSICAL ACTIVITY AND CHILDREN

In 1879 a German physician named Behnke warned of the danger of vigorous physical activity among children (Karpovich, 1937). He cautioned adults to restrict activity among children because of the "natural disharmony" between the development of the size of the heart muscle and the size of the large vessels. He suggested that the blood vessels develop at a relatively slower rate than the heart muscle, making the vessels unable to accommodate the faster growing heart. He concluded that there would be "grave danger" for the exercising child because of high blood pressure and accompanying circulatory problems.

Physical and health educators (Van Hagen, Dexter, & Williams, 1951; Young, 1923) perpetuated this myth as did "experts" in child growth and development (Hurlock, 1967). A widely used textbook in elementary school physical education warned that "...the heart increases greatly in size during this growth period (11–14 years), with veins and arteries developing much more slowly. The heart, therefore, should not be overtaxed with heavy and too continuous activity" (Van Hagen et al., 1951, p. 52). As late as 1967 Hurlock's text on adolescent development indicated that until late adolescence, when the size of the blood vessels catches up with the size of the heart, "...too strenuous exercise may cause an enlargement of the heart and result in valvular disease" (Hurlock, 1967, p. 47). Apparently these experts had cited other experts, each of whom had relied on Behnke or other uninformed sources.

The myth of children being unable to perform vigorous exercise persisted in the literature well into the 1960s even though published data had been presented in 1937 debunking the ideas of Behnke. Karpovich (1937) reexamined Behnke's data and showed that a simple mathematical error had been made. Though the circumference of the artery of children is proportionally small compared to the size of the heart, the blood-carrying capacity of the artery is proportional to increases in heart size. Behnke assumed that the blood-carrying capacity of the artery could be measured using the circumference of the artery when in fact it is the cross-sectional area of the interior of the artery that is critical. Karpovich was not the only one to debunk the "child's heart" myth. Another researcher, Boas (1931), conducted studies with exercising children that led him to conclude that during vigorous exercise the muscles will "flag" so that the child will "collapse before the heart is called for its last ounce of effort."

Even though research discredited the notion that children were incapable of vigorous exercise, many educators were skeptical about prescribing strenuous activity for children well into the 1960s. Texts for elementary school physical educators began to include sections documenting the cardiovascular capabilities of children (Corbin, 1969) and repudiating earlier incorrect statements. Still, not all physical educators were convinced of the capabilities of children as evidenced by the fact that the 600 yard run/walk (introduced in 1958) continued as the measure of cardiovascular fitness for children in the 1965 and 1975 national youth fitness battery (AAHPERD, 1980). Many physical educators continued to believe that children were not physically able to run long distances or to perform endurance activities and thought it was dangerous for them to do so.

Further evidence about the concern for exercising children was the resistance researchers experienced from human subjects committees that were just being organized in the 1960s and early 1970s. An example was an initial rejection by a human subjects committee for a study of the heart rates of children using telemetry during various distance runs (Corbin, 1972). The committee felt that children should be stopped from running if heart rates exceeded 170 bpm and if distances exceeded 600 yards. It was necessary to educate the committee members, including medical doctors. The study was ultimately approved even though heart rates often exceeded 200 bpm and distances were as long as 800 yards.

It was not until 1978 that an American Academy on Pediatrics position paper (cited in AAP, 1991) noted that many children who had previously been screened out of physical education were capable of "full and active" participation. In 1980 longer runs became part of national physical fitness test batteries for children (AAHPERD, 1980).

THE EXERCISE PRESCRIPTION MODEL

The health fitness movement for adults began to gain momentum in the 1960s. Paul Dudley White, physician for President Eisenhower during the 1950s, emphasized the health value of physical activity (Pomroy & White, 1958) and his national visibility brought attention to the health benefits of activity. The classic study of Morris, Hady, Raffle, Roberts, and Parks (1953) of London transportation workers was published, providing good evidence for the health value of physical activity. By the early 1960s, Taylor and colleagues (1962) had added to the body of literature supporting the value of physical activity for health. Rehabilitation programs for cardiac patients using physical activity were gaining credibility due to the work of pioneers such as Hellerstein and Wolffe. The exercise prescription model (EPM) was developed and served as the basis for most cardiovascular exercise for the next two decades.

During the late 1950s and 1960s, considerable work was conducted regarding the EPM in an attempt to define the intensity and frequency of short duration exercise required to promote gains in cardiovascular fitness as measured by VO_2max. Karvonen's classic research (1959) identified the threshold of training and provided a basis for the EPM. By 1966, widely used exercise physiology texts cited Karvonen's formula for fitness development. DeVries (1966), for example, cited the work of Karvonen and noted that exercise must be performed at 60% of heart rate reserve. This guideline was similar to "rules of thumb" advocated for performance improvement by swimming and track coaches of the era. Whatever the original reasons for research concerning the EPM and the related concepts of threshold of training and target zone heart rates, the major emphasis in exercise prescription was on physiological VO_2max and performance improvement.

By the 1970s, the EPM and its focus on higher intensity and shorter duration activity (using percentage of maximum heart rate or O_2 consumption as the criterion for intensity) was firmly established for adults. In 1972, the American Heart Association published an exercise testing and training handbook (AHA, 1972) and by 1978 the emerging American College of Sports Medicine (ACSM, 1978) published its first position statement outlining the frequency, intensity, duration, and mode of exercise prescription necessary to produce cardiovascular fitness gains for the adult population. This statement was updated in 1990 (ACSM, 1990).

The EPM and the exercise guidelines developed based on this model have been useful and effective. For young adults of Western cultures, exercise programs based on the EPM are useful because cardiovascular fitness can be achieved without a major time commitment. Improved fitness can be accomplished by performing continuous exercise in as few as three days per week. This allows busy people to fit moderate to high intensity exercise into their otherwise sedentary lifestyles. In addition, the EPM is particularly effective for athletes and those interested in optimal physical performance.

Ironically, the model for prescribing adult physical activity that gained the greatest attention (EPM) was quite different than the type of activity that seemed effective for public health promotion. Although the epidemiological literature suggested exercise of longer duration and relatively low intensity reduced heart disease risk (Morris et al., 1953; Taylor et al., 1962), the type of exercise prescription gaining notoriety was shorter in duration and of higher intensity.

Because improvement in cardiovascular fitness (rather than the reduction of health risk) was central to the EPM, measures of cardiovascular fitness were of particular importance. The 12-minute run developed by Cooper to test the cardiovascular fitness of military personnel was popularized for the general public in the book *Aerobics* (Cooper, 1968). Shorter runs were developed for children, and in 1980, the health-related physical fitness test which included a mile run was adopted by AAHPERD (1980). By 1985, all of the major national fitness tests included a distance run of at least a mile in length. The capability of children to perform vigorous physical activity was acknowledged. In the absence of specific research to guide recommendations, the EPM was used to design exercise programs for children. Professionals had come full circle. Instead of fearing for the health of children who participated in vigorous exercise, they developed guidelines for physical activity similar to those designed for adults.

A LIFESTYLE PHYSICAL ACTIVITY MODEL: THE NEW STRATEGY*

In July of 1992 the American College of Sports Medicine and the Centers for Disease Prevention and Control (CDC), in cooperation with the President's Council on Physical Fitness and Sports, issued a statement acknowledging the importance of lifestyle physical activity as a means of reducing disease risk. The new recommendation is to accumulate throughout the day a minimum of 30 minutes of moderate intensity physical activity over the course of most days of the week. Examples of such activities are "...walking up stairs (instead of taking the elevator), gardening, raking leaves, dancing, and walking all or part of the way to work. Activity can also come from planned exercise or recreation such as jogging, playing tennis, swimming, and cycling" (CDC & ACSM, 1994, p. 7). Another example of lifestyle exercise that can be used to meet CDC/ACSM guidelines is a two-mile walk daily.

Blair and colleagues have called this "new strategy" the Lifestyle Exercise Model (Blair, Kohl, & Gordon, 1992). Haskell (1994), in his Wolffe lecture to the American College of Sports Medicine, also advocated the adoption of a lifestyle exercise model he calls the Physical Activity Health Paradigm. In this article, this model is referred to as the Lifetime Physical Activity Model (LPAM). Strong scientific evidence exists to support the LPAM (Haskell, 1994). The work of Paffenbarger and colleagues (Paffenbarger, Hyde, Wing, & Hsueh, 1986; Paffenbarger, Hyde, Wing, & Steenmetz, 1984; Paffenbarger, Wing, & Hyde, 1978) showed that the expenditure of 2000 kcals per week resulted in a significant reduction in morbidity and mortality among Harvard alumni. Those who expended 2,000 to 3,500 kcal per week attained the optimal value from their exercise. The studies of Harvard men showed that lifestyle activities such as climbing stairs, walking, doing physically active household activities and participating in active sports helped reduce disease risk not only for heart disease but for cancer and other types of hypokinetic conditions. Leon and colleagues (1987), studying a different group of adults, found that a 1,500 kcal per week expenditure through moderate intensity physical activity produced similar health benefits to those found for the Harvard alums. Haskell (1985), based on a literature review, suggested 150 kcal per day (1,050 kcal per week) as the minimum threshold for lifestyle exercise. These studies have demonstrated that health benefits accrue from lower intensity, longer duration exercise.

Blair et al. (1992), based on research at the Cooper Institute for Aerobics Research, have proposed that adults expend 3 kilocalories per kilogram of body weight per day (kcal/kg/day) in physical activity to achieve the benefits of regular physical activity. This standard is similar to the one used by previous researchers to classify people as "very active" (Montoye, 1987) and amounts to approximately 200 kcal per day for a 150-pound person, or 1,400 kcal per week. The kcal/kg/day standard allows individuals to calculate the caloric expenditure (based on their body weight) required to obtain health benefits. The physical activity necessary to expend 1,000 to 2,000 calories per week or 3 kcal/kg/day is the basis on which the CDC/ACSM guidelines for lifestyle physical activity were developed.

*For comprehensive coverage of the scientific basis for the LPAM, readers are referred to articles by Blair (1993), Blair et al. (1992), and Haskell (1994). See References.

The LPAM differs from the EPM in several ways. First, the LPAM focuses on the amount of physical activity necessary to produce health benefits as associated with reduced morbidity and mortality rather than fitness and performance benefits. While the LPAM promotes fitness as it relates to good health, it does not focus on fitness performance as does the EPM. Moderate to high intensity exercise of shorter duration as outlined by the EPM was designed to promote changes on fitness tests such as VO_2max. Second, the LPAM recognizes the value of a wide range of physical activities that expend calories throughout the day rather than requiring continuous moderate to vigorous physical activity done in one exercise bout. Finally, the LPAM acknowledges that some activity is better than none at all, and that up to a point, progressively increasing amounts of physical activity provide added health benefits.

The shift to the LPAM from the EPM does not mean, however, that the EPM is no longer a useful model. For young adults with limited amounts of time, moderate to vigorous physical activity is still an effective approach to achieving health benefits. For those who are interested in enhancing fitness for relatively high-level performance such as sport involvement or active careers (law enforcement, military, etc.), the EPM is also an effective model. However, the type of exercise prescribed in the EPM is not necessarily the best approach for the general population that wants to receive substantial health benefits.

CHILDREN AND THE EPM

Just as most physical activity recommendations for adults have been based on the EPM for the past 20 to 30 years, recommendations for children have been based principally on guidelines evolving from the EPM. Rowland (1985) concluded that children need to follow the same exercise prescription as adults to achieve cardiovascular fitness. Using Karvonen's heart rate reserve method for calculating target heart rates, Sady (1986) estimated a heart rate of 159 as the threshold for aerobic exercise for most children. These results and the findings of other studies have served as the basis for recommendations suggesting that children need to perform 20 to 30 minutes of continuous moderate to vigorous physical activity (MVPA) at least three times a week. Typically heart rate standards are used as the indicator of MVPA. Recommendations vary but, in general, heart rates advocated are 140 bpm and higher.

Using heart rate standards as indicators has caused several researchers to conclude that many, if not most, children are inactive. Some examples illustrate the point. Using heart rates above 140 for 20 minutes of continuous exercise as the criterion of MVPA, Armstrong and Bray (1990) studied children and found 77% of boys and 88% of girls to be inactive by this measure. In a subsequent study of younger children, Armstrong, Balding, Gentle, and Kirby (1991) found 61% of boys and 66% of girls to be inactive. Using observation techniques to assess 20 minutes of MVPA as the standard, Sleap and Warburton (1992) found 86% of children to be inactive, and Baranowski, Hooks, Tsong, Cieslik, and Nader (1987) found 89.6% of children to be inactive. In another study involving 177 trials of daylong monitoring of children averaging 703 minutes a day, Welk (1994) found 17% of children to have heart rates above 140 bpm for 20 consecutive minutes. If EPM were used to evaluate activity, it would be easy to conclude that most children are inactive.

Using data from the same studies but applying standards that are more consistent with the LPAM, a different conclusion is reached. When minutes of physical activity during the day are determined for these same studies, the data of Armstrong and Bray (1990) show that on the average boys were active 45 minutes and girls 31 minutes of each day (above 140 but not consecutive minutes). A second study (Armstrong & Bray, 1991) found younger boys were active 68 minutes and girls 59 minutes each day. Similarly, children studied by Baranowski, Hooks, Tsong, Cieslik, and Nader (1987) performed 60 to 70 minutes of activity per day even though 89% would be classified as inactive by the EPM standard. Eighty-six percent of the children Sleap and Warburton (1992) studied were inactive in terms of EPM exercise yet, on average, they participated in 88 minutes of activity. Data from Welk's study (1994) using activity and heart rate monitors at the same time showed that 99% of boys and 98% of girls exceeded an energy expenditure of 4 kcal/kg/day, a standard that is slightly higher than the 3 kcal/kg/day advocated by proponents of the LPAM.

It is apparent that the same children who fail to meet activity standards based on the EPM generally meet standards established for the LPAM. Rather than judge children as inactive based on MVPA data, it seems more reasonable to suggest the EPM is an inappropriate model for judging activity levels of most children. Children are sporadic exercisers who alternate between vigorous activity and rest. They are high volume exercisers who generally do not engage in continuous high intensity exercise. See Table 18.1 for a listing of concepts and implications concerning physical activity and children.

TABLE 18.1

Physical activity and children: Basic concepts.

Concept	Implication
Young animals, including humans, are inherently active.	Children will be active if given encouragement and opportunity.
Children are concrete rather than abstract thinkers.	Children are often unwilling to persist in activity if they see no concrete reason to do so.
The relationship between activity and fitness is weak among children.	Children may receive little feedback for their efforts in some activities.
Childhood activity is often intermittent and sporadic in nature.	Children will not likely do prolonged exercise without rest periods.
Total volume is a good indicator of childhood activity.	Given the opportunity, many children will perform relatively large volumes of intermittent physical activity.
Physical activity patterns vary with children of different developmental and ability levels.	Young children are not attracted to high intensity exercise but highly skilled older children may see its value for enhancing performance in sports.

THE CHILDREN'S LIFETIME PHYSICAL ACTIVITY MODEL (C-LPAM)

Evidence suggests that among adults 3 to 4 kcal/kg/day is a good minimum standard for producing the health benefits of physical activity. A similar minimum standard for children (3 to 4 kcal/kg/day) seems appropriate in light of recent evidence that shows active children have a more beneficial coronary risk profile than their sedentary counterparts (Raitakara, Porkka, Taimela, Telama, Rasanen, & Viikari, 1994) and that many children already meet this standard (Blair, Clarke, Cureton, & Powell, 1989; Welk, 1994). Also, it is a standard that inactive children, those who need activity the most, can achieve with a modest commitment to childhood games and activities or lifestyle activities appropriate for children such as walking or riding a bicycle to school and performing physical tasks around the home.

It is not unreasonable, however, to establish a goal for children of expending 6 to 8 kcal/kg/day. Unlike adults, children have the time and energy for activity above the minimum standards if they see a reason to be active. There are at least five reasons why this goal of higher energy expenditure is appropriate.

1. During childhood children learn basic motor skills that provide the basis for lifetime activity. Proper skill development requires substantial practice time and energy expenditure. If motor skills are not learned early in life such skills may never be developed and the opportunities for lifetime activity will be limited.

2. Lifetime physical activities learned early in life (such as walking, riding bicycles, and doing active physical tasks around home) contribute to active lifestyles and help obese children maintain healthy body fat levels later in life (Epstein, Wing, Koeske, Ossip, & Beck, 1982).

3. Children need activity for the development of all parts of health-related physical fitness including aerobic fitness, muscle strength and endurance, flexibility, and desirable level of body fatness, as well as activity to promote a high peak bone density. To promote fitness development and to learn appropriate activities for development of these fitness parts, physical activity is essential.

4. Given the opportunity and encouragement, most children will choose to be active. This is especially true if time is provided for activity.

5. People who do no physical activity are at increased risk of disease and death compared to those who are physically active. The largest decrease in risk is associated with the expenditure of approximately 3 to 4 kcal/kg/day. Additional risk reduction is associated with increased amounts of physical activity (6 to 8 kcal/kg/day). To a point, activity beyond 6 to 8 kcal/kg/day produces additional benefits, but the relative benefits decrease as more activity is performed. The 6 to 8 kcal/kg/day standard seems a reasonable one for children. Evidence suggests that people become less active as they grow older (Rowland, 1990) and that people who are active when they are young are more likely to be active in later life (Raitakara et al., 1994). This being the case, meeting a higher caloric expenditure as a child may interpret into greater activity as an adult.

For a summary of activity recommendations, see the section below, "Activity Recommendations for Children."

HIGH PERFORMANCE STANDARDS

As children grow older the EPM may become more important, especially if students make personal choices to perform high intensity physical activity designed to achieve optimal levels of fitness. For example, adolescents may wish to do EPM exercise to increase their chances of success in school or community sports. As noted earlier, children can participate in high intensity activity safely. However, the effort/benefit ratio (Fox & Biddle, 1988) for children is not good. To ensure persistence in physical activity, children must believe the benefits of the activity are equal to or greater than the amount of effort expended. Because children are concrete thinkers they often see little benefit to high intensity training, which makes their perception of effort high. Thus EPM exercise often produces a poor effort/benefit ratio.

Some children express a personal interest in EPM training. If their interest is strong and they perceive the benefits as great enough, they may successfully use the EPM exercise formula. However, because response to training is less in childhood compared to adolescence, there is some danger that children may lose interest in high intensity exercise. This is because of the lack of feedback from performance improvements. Learning skills through physical practice is often more rewarding and likely to enhance effort/benefit ratios for children. Generally, EPM physical activity designed to enhance high-level performance in fitness is more appropriate and successful for adolescents and young adults than for children. Interestingly, evidence exists to suggest that the relationship between physical activity and aerobic fitness is not strong among children (Pate, Dowda, & Ross, 1990) or adolescents (Morrow & Freedson, 1995).

IMPLICATIONS

Determining Activity Levels of Children

The best evidence suggests that children are among the most active segment of the population. Yet, using adult EPM standards, some have concluded that large numbers of children are inactive. This occurs in spite of the fact that the same children usually meet adult health standards for activity based on the scientifically documented LPAM. The C-LPAM is proposed as a more suitable model for judging the activity of children. National studies of the activity levels of children are needed, especially in an attempt to determine if children are meeting appropriate standards.

Activity Recommendations for Children

As is inevitably the case, guidelines that gain national acceptance provide the basis for recommendations to be used in schools and other programs. In the case of physical activity, EPM guidelines have provided the basis for recommendations for children in schools as well as in community sports programs. Following the lead of scholars who have applied EPM guidelines to children, some professionals have advocated implementing programs that elevate heart rates of children to 140 or higher for 20 or more consecutive minutes. In some cases, heart rate monitors have been recommended to ensure that exercise intensity levels are achieved among children (Strand & Reeder, 1993a; Strand & Reeder, 1993b).

Although programs using continuous high intensity (high heart rate) activity are not physiologically harmful to children, they are not the most appropriate for children. It is possible, given what we know about effort/benefit ratios and developmental needs of children that such activity can decrease rather than increase motivation for future activity. A more reasonable recommendation is that children perform C-LPAM activity as outlined here. In physical education programs, youth sports programs, or any other program designed to encourage current and lifetime activity for children, there are five guidelines that seem important:

1. Activity for children should focus on high volume and moderate intensity that includes sporadic activities such as active play performed in several activity sessions daily.
2. Lifestyle activity such as walking or riding bikes to and from school or performing active physical tasks at home (e.g., yardwork) should be encouraged.
3. Opportunities to learn basic motor skills and develop all parts of health-related physical fitness through appropriate moderate intensity activity should be included in the activity program.
4. Children should be afforded opportunities to begin developing behavioral skills that lead to lifetime activity.
5. EPM guidelines can be applied to individuals who are especially interested in high-level physical performance, but only when it is developmentally appropriate.

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