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PHYSICAL ACTIVITY AND HEALTH OF YOUTH

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Abstract

Development of voluntary control of movement begins in infancy and progresses into childhood as the child attains postural, locomotor and prehensile control. With the refinement of walking, control of locomotor and manipulative abilities improves so that a considerable amount of independent action is possible. These basic movement patterns are the foundation upon which other movements and combinations of movements are subsequently developed and refined. And, movement is the substrate of physical activity.

The development of motor competence during early childhood is the outcome of the interaction of the growing, maturing and developing child with his/her environments. Child-environment interactions should be viewed in the context of changing body dimensions and proportions (body scaling) and improving levels of motor competence (action scaling). Body size, proportions and composition change as the child grows, and levels of motor proficiency change as the child develops. These in turn influence the interactions between the child and his/her environments, specifically home, day care and nursery school. An additional factor is the emergence of the child's perception of these environments as they relate to his/her physical and motor characteristics.

There is increasing interest in relationships between proficiency in basic movement skills and habitual physical activity in young children. Evidence indicates that specific motor skill instructional and physical activity interventions are associated with improvements in basic movement skills in preschool children. By inference, improving the motor proficiency of young children has the potential to enhance levels of habitual physical activity beyond the preschool years. Moreover, motor coordination is an important predictor of physical activity during middle childhood.

Given current concern for the worldwide obesity epidemic, the movement proficiency of overweight and obese children is receiving more attention. Although the issue of reduced physical activity in obese children is somewhat equivocal, one can inquire whether proficiency in movement skills influences activity in obese children and adolescents.

The teaching of skills, rules and strategies of a sport is often indicated as an objective of youth sport programs. Observations would suggest that this objective is generally achieved. Specific evidence for participants in youth sports is limited. Relative more emphasis is given to the talented few in contrast to the majority of youth participants. Individual differences are considerable and these are often dependent on the quality of coaching/instruction.

Key words: movement, physical activity, youth sport.

Introduction

Physical activity and sedentary behavior are issues of considerable interest to public health, medicine and education. Public health and biomedical views focus on physical activity in the context of health promotion and disease prevention and physical inactivity as a major risk factor, among others, for degenerative disease. The educational view highlights activity in the context of physical education as a component of the overall school experiences of youth.

Physical activity and sedentary behavior occur in many contexts. Both are important avenues for learning, enjoyment, social interactions and self-understanding. Currently, evidence and opinion suggest an imbalance in the direction of increased inactivity and reduced activity underlying the emergence of metabolic risk factors for cardiovascular disease and current epidemic of obesity in youth.

Physical activity is a multi-dimensional behavior. It is viewed most often in terms of energy expenditure and the stresses and strains associated with weight bearing and ground reaction forces. Fitness (performance- and health-related) and skill (proficiency in a variety of movements) are other important dimensions of activity. Context is an important dimension of physical activity that is often overlooked. Context refers to types and settings of activity, and includes play, physical education, exercise, sport, work, and others. Contexts per se and meanings attached to them vary with age among youth and also among and within different cultural groups (R.M. Malina, 2008).

Sedentary behavior or physical inactivity also has several dimensions. Public health and medicine view inactivity in terms of insufficient energy expenditure, force generation and health-related fitness. Sedentary behavior also has a major cultural component; many forms of inactivity are highly valued by societies - school, study, reading, music, art, television viewing, video games and the like. Motorized transport is a form of inactivity that is also valued by major segments of society.

Physical activity and inactivity represent a repertoire of behaviors performed in a societal context, and both have high valence in society. Physically inactive and active behaviors span the spectrum of minimal to maximal energy expenditure.

It is generally assumed that regular physical activity is essential to support the normal growth and maturation. Studies spanning nearly a century have suggested that regular physical activity, including training for sport, has a stimulatory influence on growth and maturity. In one of the first comprehensive reviews of exercise and growth, it was suggested:

"There seems to be little question that certain minima of muscular activity are essential for supporting normal growth and for maintaining the protoplasmic integrity of the tissues. What these minima mean in terms of intensity and duration of activity has not been ascertained" (G.L. Rarick, 1960, p. 460).

At the same time, concern was also expressed and is still currently expressed about potentially negative influences of physical activity, specifically of intensive training for sport during childhood and adolescence. This issue of training and the growth status of young athletes has been previously addressed (R.M. Malina, 1994, 1996, 1998; see also R.M. Malina et al., 2004). For the present, it is important to note that regular physical activity is not equivalent to training for sport, although sport is a major context of activity for children and adolescents (R.M. Malina, 2008, 2009a).

Scope

The focus of this paper is the potential of regular physical activity to improve the health status and physical fitness of youth. Two questions, among others, that need attention are the following:

(1) What are the health and fitness benefits of regular physical activity for school-age youth?

(2) What type and amount (frequency, intensity, duration) of activity may be needed to bring about beneficial effects on indicators of health and fitness in youth?

The influence of regular physical activity and specific activity programs on several indicators of health and physical fitness school age youth are subsequently summarized. Indicators considered include (1) two components of body composition - adiposity (fatness) and bone mineral; (2) several markers of cardiovascular health - lipids and lipoproteins, blood pressures, heart rate variability; (3) components of the metabolic syndrome - especially insulin and triglycerides; (4) two indicators of health-related physical fitness - aerobic capacity and muscular strength and endurance; and (5) several behavioral variables potentially related to health status of youth - self-concept, anxiety and depression. Physical activity is not without risk. Injuries are associated with an active lifestyle. Evidence dealing with injury is thus briefly reviewed.

The subsequent discussion is drawn in part from several summaries (W.B. Strong et al., 2005; Physical Activity Guidelines Advisory Committee, 2008; R.M. Malina, 2010). The respective reports include a comprehensive summaries and reference lists. More recent data are also included, especially dealing indicators of cardiovascular health and the metabolic syndrome and complications of obesity in youth. In summarizing the available evidence, comparisons of active and less active youth based on cross-sectional and longitudinal studies are initially considered. Then, the influence of specific activity programs on the health indicators is evaluated.

The Evidence

Adiposity: Indicators of adiposity include skinfold thicknesses, Body Mass Index (BMI) and percentage body fat (% Fat). Results of correlation and regression analyses in youth of mixed weight status (normal weight, overweight, obese) indicate a low to moderate relationship between habitual physical activity and adiposity. Statistics are reasonably consistent across studies considering the mix of methods used to measure/estimate activity; they indicate that most of the variance in adiposity is not explained by PA. Nevertheless, youth who engage in more physical activity, specifically vigorous activity, tend to have less adiposity than those who engage in less activity.

Enhanced activity programs in normal weight youth appear to have a minimal effect on adiposity. The issue of activity volume has not been systematically addressed. It is possible that normal weight youth require a greater activity volume as suggested by several studies of obese youth which used 80 min/day of moderate-to-vigorous physical activity. In contrast to normal weight youth, physical activity interventions with overweight and obese youth result in reductions in overall adiposity and in visceral (abdominal) adiposity. These programs include a variety of activities, largely aerobic, of moderate and vigorous intensity, 3 to 5 times per week, for 30 to 60 minutes. The most consistent favorable effects of activity on adiposity were found in studies that used more direct estimates of body composition, specifically dual X-ray absorptiometry (DEXA) estimates of % Fat and magnetic resonance imaging of visceral adiposity, in contrast to the BMI, skinfolds per se estimates or % Fat predicted from skinfold thicknesses (R.M. Malina et al., 2007).

Skeletal/Bone Health: Evidence from a variety of cross-sectional and longitudinal studies indicates a beneficial effect of regular physical activity on bone mineral content in youth. Most data are derived from pre-pubertal children of both sexes and youth in the early stages of puberty, girls more often than boys. Among post-pubertal youth or those nearing maturity, the influence of physical activity, though generally positive, is more variable. In a longitudinal series of

Canadian youth followed through the adolescent growth spurt, youth who are active during the interval of maximal growth have a greater accrual of bone mineral compared to less active youth (D.A. Bailey et al., 1999). This would suggest an enhanced effect of physical activity on bone mineral accrual during the period of rapid growth in both boys and girls.

Activity interventions aimed at augmenting bone mineral are consistent with observations based on comparisons of active and less active youth. These programs generally met 2 to 3 times per week for moderate-to-high intensity activities, weight bearing activities of a longer duration (45-60 minutes and/or high impact activities over a shorter duration (10 minutes). More recent data based on three-dimensional imaging suggest a positive role of physical activity in enhancing bone strength in youth. Accordingly, changes in bone geometry indicate a substantial increase in bone strength. Bone strength is related to habitual physical activity and short bouts of activity may be as effective as sustained activity in youth (H. MacDonald et al., 2006).

Lipids and Lipoproteins: Cross-sectional and longitudinal studies indicate relatively weak associations between level of physical activity and total cholesterol, HDL-C, LDL-C and triglycerides. The relationships, though weak, are best for physical activity and HDL-C and triglycerides. These observational data are consistent with a variety of intervention studies which show a weak, beneficial influence of moderate-to-vigorous physical activity, 40 minutes per day, 5 days per week over 4 months on HDL-C and triglycerides; on the other hand, such programs have no influence on total cholesterol and LDL-C. Of interest, school-based intervention programs were generally not effective in improving lipid and lipoprotein profiles of youth. Intervention studies vary in duration. It is possible that a more sustained volume of activity may be needed to beneficially influence lipids and lipoproteins. Further, school-based programs may be confounded in part by youth who had relatively normal values of lipids and lipoproteins at the start of the intervention.

Blood Pressures: There is no clear association between physical activity and blood pressures in normotensive youth, i.e., youth with normal blood pressures. However, aerobic training programs have a beneficial effect on the blood pressures of hypertensive youth. The programs ranged in duration from 12 to 32 weeks. Aerobic training programs may also reduce blood pressures in youth with mild essential hypertension. Limited data for resistance (strength) training indicate no effect on blood pressures of hypertensive youth.

Other Indicators of Cardiovascular Health: Physical activity may improve other indicators of cardiovascular health among youth but presently available data are limited though increasing. Data relating physical activity to fibrinogen level and C-reactive protein are weak in youth, while data relating physical activity to endothelial function in are inconclusive. On the other hand, evidence suggests that aerobic training increases resting vagal tone in obese youth evident in beat-to-beat variability in the RR interval of an electrocardiogram. It is called heart rate variability and is a marker of cardiac parasympathetic activity. Implications of this change for the development of cardiovascular disease are uncertain, but low parasympathetic activity is a strong predictor of mortality after myocardial infarct. Among adults, parasympathetic activity is relatively low in the obese, is high in the endurance trained, and increases in response to regular training (B. Gutin et al. 2000).

Metabolic Complications: The clustering of risk factors for cardiovascular disease - low HDL-C, high triglycerides, elevated blood pressures, impaired glucose metabolism, insulin resistance, obesity, and abdominal obesity - is commonly labeled as the metabolic syndrome. The syndrome places individuals at elevated risk for type 2 diabetes and cardiovascular morbidity (S.M. Grundy, 2007). Of relevance to the present discussion, risk factors that define the metabolic syndrome is increasingly documented in youth, specifically obese youth (S. Cook et al., 2003, 2008). In largely non-obese sample of youth, a favorable metabolic profile (lower blood pressures, total cholesterol, triglycerides and glycemia; higher HDL-C; lower skinfolds) is independently associated with high physical activity and low physical inactivity and with high aerobic fitness (P.T. Katzmarzyk et al., 1999). Evidence from the European Youth Heart Study, a multi-center, international, cross-sectional study, shows consistent associations between physical activity (measured via accelerometry) and aerobic fitness (cardiorespiratory fitness, maximal power output on a cycle ergometer), on one hand, and a better metabolic profile, on the other (L.B. Andersen et al., 2006, 2008; S.A. Anderssen et al., 2007; S. Brage et al., 2004; N.S. Rizzo et al., 2007; U. Ekelund et al., 2007). Data from the European Youth Heart Study indicate interactions between physical activity and cardiorespiratory fitness affecting the metabolic profile (S. Brage et al. 2004), stronger relationships between cardiorespiratory fitness and reduced metabolic risk than between physical activity and risk (N.S. Rizzo et al. 2007), and also independent inverse associations between aerobic fitness and metabolic risk and between habitual physical activity and metabolic risk (U. Ekelund et al., 2007). Overall, youth who are regularly active and/or who have good aerobic fitness tend to present a favorable metabolic risk profile. Adiposity is an independent risk factor for metabolic risk - youth who are leaner and with less central adiposity (measured indirectly as waist circumference) tend to present a more favorable metabolic risk profile.

The preceding studies are cross-sectional and demonstrate important associations between physical activity and metabolic risk. What is the influence of physical activity programs on metabolic risk factors individually or clustered? Trends in studies of several individual risk factors were noted above, e.g., adiposity, lipids and lipoproteins and blood pressures.

Increasingly, evidence shows that experimental physical activity programs improve the metabolic risk profile of overweight and obese youth - reduction in adiposity, insulin and triglycerides; improved insulin sensitivity, lipid profile and cardiorespiratory fitness; increased heart rate variability; and reduction in inflammation indicators (B. Gutin et al., 2000; 2008; L.M. Bell et al., 2007; A.L. Carrel et al., 2005; G.P. Nassis et al., 2005). However, the favorable responses to regular activity are lost when obese youth are no longer involved in regular physical activity (A.L. Carrel et al., 2007), i.e., the youth relapse to a lifestyle without or with reduced physical activity. The results highlight the need for physical activity on a regular basis.

Aerobic Fitness: Data from both cross-sectional and longitudinal studies indicate higher levels of aerobic fitness, measured as maximal aerobic power ($\dot{V}O_2$ max) or endurance runs, in active youth than in less active youth. Some longitudinal data suggest an enhanced effect of physical activity during the interval of maximal growth on $\dot{V}O_2$ max (R.L. Mirwald and D.A. Bailey, 1986). In experimental studies of youth 8 years through adolescence, continuous, vigorous physical activity has a favorable effect on maximal aerobic power. Programs generally involved continuous, vigorous activity (e.g., 80% of maximal heart rate) for 3 days per week at 30 to 45 minutes per session. The associated gain in $\dot{V}O_2$ max was about 10% (3-4 ml/kg/min).

Muscular Strength and Endurance: Cross-sectional and longitudinal data are equivocal regarding the association of physical activity with muscular strength and endurance among youth with one exception. Longitudinal observations indicate better upper body muscular strength and endurance (flexed arm hang) in active compared to less active boys (G.P. Beunen et al., 1992). Experimental data show significant gains in muscular strength and endurance in children and adolescents with resistance training programs involving a variety of progressive activities that incorporate reciprocal and large muscle groups. Most programs involved sessions of 30 to 45 minutes duration 2 or 3 days per week with a rest day between sessions. Programs were generally 8 to 12 weeks in duration. Results of resistance programs with youth show some degree of specificity. Larger strength gains are associated with protocols of relatively high resistance and low repetitions, while greater muscular endurance gains are associated with protocols of relatively low resistance and high repetitions. An essential ingredient in the safety of strength training protocols is adult supervision (R.M. Malina, 2006).

Behavioral Health: Self-concept and symptoms of anxiety and depression are common concerns among youth, particularly adolescents. Evidence dealing with physical activity and these concerns in youth is limited from several perspectives. A variety of outcome measures are used which limits comparisons. Sample sizes are small and largely of convenience, and many are limited to adolescents. This may reflect biological and behavioral interactions as youth adjust to or cope with changes and social demands during the transition into and progress through puberty. Studies looking at the potential influence of physical activity are largely associational, although some quasi-experimental data are available. Variable contexts or modes of physical activity are considered, e.g., sport, aerobic and dance separately or in combination. Activity together with cognitive behavioral modification is also considered.

Physical activity is positively associated with measures of global self-concept and two sub-domains, physical self-concept and perceived sport competence. The influence of physical activity on perceived sport competence is generally positive but there is considerable variation that is likely associated with winning (positive) and losing (negative) and the quality of adult supervision and involvement in sport. In contrast, there is no consistent association between physical activity and the appearance, social/emotional and academic domains of self-concept.

Data are less extensive for the relationship between physical activity and symptoms of anxiety and depression and the trends are variable. Overall, sport, aerobic, and aerobic plus other activities have a small positive effect on anxiety and depression symptoms in youth, but physical activity in conjunction with cognitive behavioral modification tends to have a stronger positive effect on anxiety and depression symptoms.

Risk of Injury: Potential for injury is inherent in many physical activities, but information is very limited for school, recreational and free time activities. Data are available for specific sports (R.M. Malina, 2009b), which of course are major forms of recreation and leisure activities. Most information, however, is derived from case series based on convenience samples from hospital emergency departments or sports medicine clinics, accident reports, insurance records, interviews, and retrospective questionnaires. As such, they are of limited utility in estimating injury rates or risk due in part to variable definitions of an injury and lack of exposure statistics. Limited evidence indicates a very low risk of injury associated with physical education programs of moderate-to-vigorous activity, 3 days per week (W.B. Strong et al., 2005). A recent study monitored physical activity (parent-complete diary) and injuries requiring first aid attention over a one year period in 744 children 4-12 years of age (A.B. Spinks et al., 2006). About 79% of 504 recorded injuries occurred in the context of physical activity and of these, about 80% occurred outside of school and about one-third required medical treatment. The estimated injury rate for injuries outside of school hours was 1.7 per 10,000 hours of exposure. Rates of injury were 2.4 and 1.6 per 10,000 hours of exposure in organized and non-organized physical activity, respectively.

Overview

The "business of growing up" through childhood and adolescence places many demands on the individual and some of these demands are conflicting from the perspective of physical activity. Many of the demands placed upon youth are socially sanctioned forms of physical inactivity, e.g., school, home work, non-school reading, television and video games, extra-curricular classes (tutoring, music, art), and probably others. In addition, motorized transport is highly valued. There is a need for systematic study of physical inactivity or sedentary behaviors in their many forms and contexts. Both inactivity and activity have different meanings and contexts in childhood and adolescence, and they are generally independent of each other. A confounding factor in evaluating the effects of physical activity on youth is individual differences in normal growth and maturation. Many of the variables of interest change with normal growth and maturation and are influenced by individual differences in growth and maturity status, especially timing and tempo of sexual maturation and the adolescent growth spurt. Moreover, several variables of interest (e.g., bone mineral content, aerobic fitness, HDL-C, adipose tissue) have their own growth patterns and some have adolescent spurts which vary in timing and tempo (Malina et al., 2004).

The beneficial effects of physical activity on indicators of health, fitness and behavior appear to differentiate between "healthy" and "unhealthy" youth. Among "healthy" children and adolescents (i.e., normal weight, normotensive blood pressure), the evidence base is strongest for skeletal health, aerobic fitness, and muscular strength and endurance, with relatively small effects on lipids, adiposity and blood pressures. It is possible that a greater volume of activity may be needed to induce greater effects in healthy youth. On the other hand, beneficial effects of systematic physical activity are generally more apparent among "unhealthy" youth - the obese, hypertensive, and those with features of the metabolic syndrome. Among "unhealthy youth," physical activity programs have a beneficial effect on adiposity in the obese, blood pressures in the hypertensive, and insulin, triglycerides and adiposity in obese youth with the metabolic syndrome. Evidence for beneficial effects of physical activity programs in conjunction with cognitive behavioral modification on anxiety and depression is suggestive.

Intervention and experimental studies of the influence of physical activity on indicators of health and fitness are generally focused on the effects of the respective programs. Unfortunately, the studies do not address the issue of the amount of activity that is needed to maintain the beneficial effects of activity programs on the health and fitness indicators in question. In general, beneficial effects of associated with systematic physical activity are lost or markedly reduced when the program stops.

Many indicators of health and fitness, in particular metabolic risk factors are affected by obesity in children and adolescents. A key issue, therefore, is the prevention of unhealthy weight gain in youth, specifically in the context of reducing the risk of overweight/obesity and associated complications. Given the individuality of growth rate and the timing and tempo of growth and maturation during the adolescent growth spurt, it may be difficult to specify "unhealthy weight gain." Limited longitudinal data indicate smaller gains in the BMI in physically active youth (C.A. Berkey et al., 2003). Maintenance of smaller gains in the BMI through physical activity over time may prevent unhealthy weight gain and in turn reduce risk of overweight/obesity. Two longitudinal studies suggest an important role of physical activity in the prevention of excess weight gain in different phases of growth: more active children between 4 and 11 years have less fatness in early adolescence and may also have a later adiposity rebound (L.L. Moore et al., 2003), and an increase in physical activity during adolescence may limit the accrual of fat mass in males though not females (C.A. Mundt et al., 2006).

The majority of intervention and experimental studies used programs of moderate to vigorous physical activity for 30-45 minutes, 3 to 5 days per week. It is likely that a greater amount of activity is necessary to achieve similar beneficial effects in youth under ordinary daily circumstances, which often involve intermittent and unsupervised activities. It was recommended that school age youth in the United States should participate daily in 60 minutes or more of moderate-to-vigorous physical activities that are developmentally appropriate and enjoyable, and involve variety (W.B. Strong et al., 2005).

Most of the experimental protocols used a continuous activity program, with the exception of studies of bone health and muscular strength and endurance. Activities of children, especially young children, however, are primarily intermittent. There is a need for data that examine the effects of high intensity, intermittent activity protocols on indicators of health and aerobic fitness. Further, activity needs vary with age during childhood and adolescence. It is likely that emphasis during childhood should be on general physical activity with an emphasis on movement skills. As children make the transition into puberty and adolescence, their capacity for continuous activities increases and activity can be more prescriptive with emphasis on health and fitness (R.M. Malina, 1991)

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MONITORING OF SPRET EFFECTS ON SENIOR ELEMENTARY SCHOOLBOYS AND SCHOOLGIRLS INVOLVEMENT IN RECREATION

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Abstract

Purpose. Development of technology facilitates the production and communication, but at the same time reduces physical activities necessary for pupils in order to ensure them proper growth and development in biological, motor and social terms. The model of sporting-recreational competitions of pupils, SPRET, fosters self-organization and it is based on public records of participating students in those activities that they themselves created.

Methods. In a sample, consisting of 89 boys and 82 girls, SPRET model was experimentally applied for a period 21 day. Each individual participation is marked and additional points are given for successfulness in competitions and contribution to the organization. There is only a team placement that is based on participation of an individual from a particular class. The project object is the degree of pupils' engagement in extracurricular sporting-recreational activities. We monitored the effects of SPRET model application on increase of the volume of extracurricular activities of elementary school pupils during the experimental realization of the project and three months later.

Results. Girls' involvement in recreation raised after the SPRET model application from 17.1% to 31.7% in those female pupils who are regularly engaged in recreation (at least three times a week), and three months after the number of these pupils decreased slightly to 28.0%. Statistically significant difference compared to the initial measurement is p = 0.00, the value of $\chi 2$= 24,713 at 8 degrees of freedom. In boys, involvement in recreation raised from 39.3% to 40.4% after the project, i.e., 41.6% three months later, in those pupils who are regularly engaged in recreation. Statistically significant difference is on the level p = 0.02, the value of $\chi 2$ = 18,212 at 8 degrees of freedom.