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YOUTH PHYSICAL ACTIVITY: IMPLICATIONS FOR ADULT PHYSICAL ACTIVITY AND HEALTH

INTRODUCTION

Adulthood is built upon a foundation which is initiated prenatally and continues postnatally. To become an adult, the individual must survive prenatal processes that direct fertilization, implantation and embryonic and fetal development, and postnatal growth and maturation including the critical periods during infancy, childhood and puberty; and the transition into adulthood. Hence, it is logical that conditions during this interval of approximately 20-25 years may influence individual status as an adult and the processes associated with aging.

The fetal or developmental origins hypothesis states that events occurring prenatally and early postnatally may program risks for cardiovascular and metabolic diseases in adulthood. The hypothesis stipulates that undesirable prenatal events may affect the development, structure and functions of tissues, organs and systems and in turn result in enhanced biological susceptibility which interacts with diet (maternal, early postnatal), environmental stresses and other factors to cause overt manifestation of diseases many decades after the initial insult [6, 15]. Much of this discussion has focused on nutrition of the mother and birth weight, specifically low birth weight. Low body weight during infancy is an additional concern. Regardless of specific details, the fetal/developmental origins hypothesis highlights the potential consequences of conditions during pre- and early post-natal life across the lifespan.

In addition to potential influences on aging that have their origin in pre- and early post-natal life, conditions during childhood and adolescence may affect health status in during youth and in adulthood including the aging process. This is especially apparent in the emergence of risk factors for cardiovascular and metabolic diseases during childhood and adolescence. Physical activity is of particular relevance because regular activity may prevent the appearance of and/or modify the expression of these risk factors. Physical activity during childhood and adolescence may also influence activity habits in adulthood.

This paper addresses several implications of physical activity during youth for adult activity and health. It briefly summarizes the health benefits of regular activity on risk factors for adult diseases, persistence of health benefits into adulthood, and then the tracking of activity from youth into adulthood.

HEALTH BENEFITS OF PHYSICAL ACTIVITY IN YOUTH

Benefits of regular physical activity and specific activity programs on indicators of health and health-related physical fitness of school age youth have been systematically reviewed recently [18]. The benefits of regular physical activity for youth can be summarized as follows:

Adiposity. Cross-sectional and longitudinal comparisons of skinfold thicknesses in active and less active youth are equivocal. Moderate-to-vigorous activity programs which include a variety of aerobic activities have a minimal influence on adiposity in normal weight youth; however, such programs are associated with a reduction in adiposity in obese youth.

Lipids and Lipoproteins. A variety of intervention studies indicate a weak beneficial effect of physical activity on HDL-cholesterol and triglycerides but no effect on total cholesterol and LDL-cholesterol. The evidence suggests that a sustained volume of activity may be the key factor. School-based programs are not generally effective in improving the lipid and lipoprotein profiles of youth.

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Blood Pressures. There is no clear association between physical activity and blood pressures in normotensive youth. However, experimental activity programs such as those which improve aerobic fitness have a beneficial effect on blood pressures in hypertensive youth. Aerobic programs may also reduce blood pressures in youth with mild essential hypertension.

Metabolic Syndrome. The presence of features of the metabolic syndrome (elevated triglycerides, blood pressure and fasting glucose, insulin resistance, abdominal obesity) have been documented relatively recently in youth. There are limited data relating physical activity to the metabolic syndrome. Observational and cross-sectional studies show a relationship between some elements of the syndrome and physical activity, more so in obese youth among whom activity programs are associated with reduce insulin and triglycerides. Among non-obese youth, a better metabolic profile clusters with higher levels of physical activity and aerobic fitness and with lower levels of inactivity and adiposity.

Type 2 Diabetes. Type 2 diabetes mellitus (NIDDM) is associated with the metabolic syndrome and it is appearing among youth as youth as 9-10 years of age. Data relating activity to NIDDM are very limited. Some data suggest lower levels of activity in adolescents with NIDDM, but the issue of whether increasing activity would affect type 2 diabetes has not been addressed.

Bone Mineral Content and Density. A variety of studies are consistent in showing beneficial effects of regular physical activity on bone mineral content and density in youth, though most data are derived from prepubertal children of both sexes and youth in the early stages of puberty (girls more so than boys). Among post-pubertal youth, the influence of activity is more variable ranging from no effect to a weak positive effect.

Aerobic Fitness. Correlational studies indicate moderate relationships between habitual physical activity and maximal and submaximal indicators of aerobic fitness, while comparisons of active and less activity youth indicate better aerobic fitness in the former. Experimental activity programs with continuous vigorous aerobic activities are associated with a gain of about 10% (3-4 ml/kg/min) in $\dot{V}O_2$ max.

Muscular Strength and Endurance. Correlation studies and cross-sectional comparisons of active and less active give equivocal results relating physical activity to strength and endurance, but the data for upper body measures (flexed arm hang) are suggestive. Experimental strength training programs, using a variety of progressive resistance activities, are associated with gains in muscular strength and endurance.

Other benefits associated with physical activity among youth include improved global self-concept and a reduction in anxiety and depression symptoms. Risk of injury is associated with physical activity, but varies with context, e.g., recreational activity versus competitive sports. However, the health, fitness and behavioral benefits of activity for youth far outweigh the risks.

DO HEALTH BENEFITS PERSIST INTO ADULTHOOD?

Benefits associated with physical activity during youth may potentially influence adult health and fitness through the persistence of activity-associated benefits per se and/or the persistence of activity habits and associated benefits from youth to adulthood. This implies tracking, which refers to the maintenance of relative rank or position within a group over time. Longitudinal observations for at least two points in time are needed. Correlations between measurements or observations made at two or more age points are used most often to estimate tracking or stability over time. Other approaches include risk analysis which permit estimates of the risk or odds of maintaining a specific behavior or characteristic over time, and linear models which can use data over unequally spaced intervals and can account for missing values.

Data are perhaps most consistent for bone health. Bone mineral established during youth is a determinant of adult bone mineral status. Adults who were physically active during childhood and adolescence, particular females, had better skeletal health as manifest in bone mineral content [17].

Many indicators of health and fitness are negatively influenced by adiposity and obesity. Indeed, elements of the metabolic syndrome cluster with obesity. As such, the prevention of unhealthy weight gain and accumulation of excess adiposity during youth has potential long term benefits. The body mass index (BMI) is the most commonly used indicator of weight-for-height across the lifespan, and is the criterion for overweight and obesity. Correlations between the BMI at various ages during youth and the BMI in adulthood are moderate during childhood but increase during adolescence. At the extreme percentiles of the BMI, the situation is different. For example, probabilities of adult overweight at 35 years for boys 9-14 years of age with a BMI at the 85th percentile vary between 61% and 73% and for those with a BMI at the 95th percentile vary between 81% and 91%. Corresponding probabilities for adult obesity at 35 years vary between 16% and 22% for those with a BMI at the 85th percentile and between 28% and 46% for those with a BMI at the 95th percentile [7]. Corresponding trends are similar for girls. Given these probabilities, many overweight and obese youth will likely be overweight and/or obese in adulthood. The data highlight the need for prevention of unhealthy weight gain beginning early in postnatal life and regular physical activity has the potential to play a significant role, of course, along with diet and other components of lifestyle. It is not clear, however, how much activity is needed to prevent unhealthy weight gain.

A question of relevance is the role of physical activity and/or inactivity during adolescence as a factor affecting health status in adulthood. Though not extensive, data are suggestive. Leisure time physical activity at 16 years of age is associated with better self-assessed health status and psychological well-being at about 30 years of age [16]. On the other hand, time viewing television, a proxy for inactivity, during youth (5-15 years) is negatively associated with health status and fitness at 26 years of age. Viewing television more than two hours per day during childhood and adolescence is associated with an elevated BMI and serum cholesterol and a lower predicted $\dot{V}O_2$ max at 26 years of age, but has no influence on blood pressure [8]. In contrast, other evidence suggests an association between adolescent aerobic exercise (12-20 years) and diastolic blood pressure at about 50 years of age [9].

Indicators of cardiovascular health and the metabolic syndrome tend to be moderately stable from childhood and adolescence into adulthood. Interage correlations over intervals, on average, from 13 to 25 years and 16 to 27 years for blood pressures, HDL-cholesterol, total cholesterol/HDL-cholesterol ratio, triglycerides, glucose range from 0.14 to 0.78, while correlations for a risk factor index over these intervals range from 0.46 to 0.56 [4, 10]. A question of relevance is the relationship between adolescent activity and/or fitness and the tracking of risk factors. Aerobic fitness (treadmill time) in adolescence is not associated with cholesterol, blood pressure and glucose levels in a small sample of adults [5].

TRACKING OF ACTIVITY AND FITNESS

Reviews of the tracking of physical activity and fitness during childhood and adolescence and into adulthood have been reported [12, 13, 14]. Interage correlations for measures of physical activity during adolescence and from adolescence into adulthood are summarized in Table 1. Correlations are moderate over short intervals but decline as intervals between observations increase, and there are no consistent differences between the sexes. Applications of more complex statistical models to longitudinal data spanning adolescence and young adulthood and within adulthood produce slightly higher estimates of tracking for physical activity, although they are still in the moderate range.

Table 1. Average interage correlations for measures of physical activity (PA) during adolescence and into adulthood (adapted from [13])

Cardiovascular Risk in Young Finns, Interage Correlations					Other Studies	
Interval, yrs	PA index	PA intensity	PA frequency	Sport Club	Interval, yrs	Interage r
3	0.49	0.33	0.31	0.52	3-4	0.38
6	0.35	0.24	0.19	0.38	5-6	0.32
9	0.30	0.17	0.15	0.36	7-9	0.18
12	0.18	0.17			≥10	0.15

The unique feature of adolescent sport participation for adult physical activity should be noted. Participation in sports and/or sport clubs by European adolescents tracks better than other forms/contexts of activity and is a significant predictor of being physically active at circa 30 years [18].

Aerobic power and muscular strength and endurance are two important indicators of health-related physical fitness, but longitudinal observations which span adolescence into adulthood are relatively limited. Aerobic power (ml/min/kg) tracks moderately over intervals of 13-21 and 13-27 years (r’s 0.30 to 0.46), while indicators of strength and endurance (arm pull, flexed arm hang, leg lifts) track at higher levels over intervals 13-27 years (r’s 0.46 to 0.75) and 18-30 years (r’s 0.53 to 0.66) [14].

ACTIVITY, FITNESS AND HEALTH WITHIN ADULTHOOD

Data tracking physical activity within adulthood (20+ years) are available largely over the short term, 3-7 years, with only the Harvard alumni study spanning longer intervals. Correlations range from low to high, decrease with longer intervals, and decrease with increasing age [13].

Correlations between measures of physical activity and indicators of fitness in adults vary with intensity of the leisure time physical activity and are confounded in part by age and weight gain. A habitually active lifestyle in adulthood is associated with reduced cardiovascular morbidity and mortality and reduced risk for several cancers, while physical inactivity and low levels of cardiorespiratory fitness are independent risk factors in all-cause mortality and specifically in cardiovascular mortality [1]. Moderate and high levels of physical fitness appear to afford some degree of protection against other independent risk factors, e.g., elevated cholesterol and systolic blood pressure, smoking and abnormal electrocardiogram [2]. Even when risk factors for cardiovascular disease are present, e.g., elevated cholesterol, blood pressure and glucose level, overweight, smoking, moderate and high levels of cardiorespiratory fitness afford some degree of protection from cardiovascular disease mortality [11]. In other words, within each high risk group, more physical fit individuals tend to have reduced risk of mortality compared to unfit individuals.

Data relating activity or inactivity in adolescence to risk in adulthood are limited. Among middle age women, for example, activity during youth does not apparently confer additional protection against coronary heart disease events in active women, but women who were active in youth were more likely to be active [3].

OVERVIEW

Physical activity during youth has favorable implications for activity, fitness and health in adulthood, though the presently available data suggest at best only moderate relationships. The associations, however, need to be considered in the context of the instruments (questionnaire, recall) and contexts of activity. It is likely that indicators of activity in youth do not reflect the same attributes or contexts of activity as in adulthood? Many youth, for example, view activity as sport which is not a primary context of activity as adulthood progresses.

Relationships between youth activity and adult activity, fitness and health are probably more complex that correlations and odds ratios. The relationships may operate indirectly or through intervening steps such as temporally arranged transitions in the life cycle. Childhood and adolescence are dominated by required schooling which includes many socially sanctioned forms of physical inactivity. Biological and social demands associated with the transition from childhood to adolescence entail many biosocial adaptations. The transition from school to the work force entails prolonged adolescence through the college years in many cultures. Adulthood involves job demands, marriage, family life and responsibility for child rearing, and eventually retirement. Superimposed upon these culturally- and biologically-related transitions are factors which may influence the transitions per se or create new ones, e.g., disease, accident, job changes, social and political events, natural events. How are habits of physical activity affected by specific transitions and events in the life span? However, earlier events may predict the present, but they do not predict the future.

In summary, a major portion of the variability in adult activity, fitness and health is not accounted for by activity and fitness during youth. Nevertheless, trends in the available data emphasize the importance of a lifestyle of regular physical activity during youth, which hopefully continues into and throughout adulthood, for the health and well-being of the individual and population.

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