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Gaps in Our Knowledge

Physical Activity and Movement Proficiency: The Need for a Biocultural Approach

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Abstract

"Gaps in Our Knowledge" are discussed in the context of the need to integrate biological and behavioral factors in a biocultural approach to physical activity and movement proficiency. Specific issues considered include outdoor play, organized and informal activity, biological maturation, tracking of activity, development of movement proficiency, and individual differences. Studies considered are largely based on youth in economically better-off, developed countries in the western culture context. There is a need to extend studies of physical activity and movement proficiency to different cultural contexts.

Key Words

outdoor play, motor development, growth, biological maturation, bio-behavioral interactions

Introduction

Physical activity (PA) is generally viewed by biomedical communities as important for health promotion and disease prevention. The objective is an active lifestyle among youth which will improve health and physical fitness (PF), and which will persist into adulthood with associated health and PF benefits. Focus is upon the frequency, intensity, duration and type of PA associated with health and PF (52,65~~71,87~~). PA as a medium for enjoyment, learning and social interactions among youth, and the development of movement proficiency (MP) are often overlooked. Movement of course is the medium of PA.

The purpose of this essay is to highlight the need to integrate biological and behavioral factors in a biocultural approach (42~~52~~) to the study of PA and MP. Correlates of PA and MP are briefly reviewed, followed by an overview of relationships among PA, MP and PF, and of intervention studies with a focus on individual differences. "Gaps in Our Knowledge" that merit more detailed study in a biocultural context are then indicated.

Correlates of Physical Activity

Correlates of physical activity generally include socio-demographic factors, motives and behaviors, parental behaviors and characteristics, peer support, facilities, program access, previous activity among others. Systematic reviews tend to be enumerative and are limited by age ranges and age groups (2,19,60,70~~2,27,81,93~~). Samples are generally classified as children (~3-12 years) and adolescents (~12-18 years). Both age ranges are too broad and confounded by the pubertal transition, ~8-13 years in girls and ~10-15 years in boys, allowing for individual differences in the timing and tempo of sexual maturation and the growth spurt (44~~54~~).

Among correlates across the two age ranges, boys are more active than girls. Primary correlates of PA among younger children (~3-8 years) include parental physical activity -

children with active parents are more likely to be active and parental involvement - if parents are active with their children, children are more likely active. Among youth in the age range of the pubertal transition (19~~27~~), parental support is a consistent correlate of activity, but results for parental activity are equivocal, and those for single-parent families, socioeconomic status (SES) and ethnicity are inconclusive.

Among adolescents, several factors are consistently associated with activity. Adolescents with a history of PA and sport (formal and informal), parental and peer support, and greater self-efficacy (higher self-concept, perceived competence, motivation, achievement orientation, etc.) are more likely to be active.

Except for biological sex (male, female) and BMI (equivocal relationships), potential biological correlates of PA, including PF and MP, are not considered.

Correlates of Movement Proficiency

Several early reviews noted associations among parental attitudes, parent-child and sibling interactions and specific fundamental skills (36,37,41~~45,46,50~~). Among Australian youth, low MP was associated with low SES (girls), non-English speaking cultural backgrounds (boys), and lower levels of PA and cardiorespiratory fitness (CRF), while overweight/obesity (BMI) was associated with low MP in locomotor skills, but not object control skills (20~~28~~). Otherwise, correlates of MP have not received detailed attention.

Movement Proficiency, Activity, Fitness

It is assumed that PA and PF are related (38~~47~~), but measures of PA (parental recall, accelerometry, moderate-to-vigorous physical activity [MVPA]) account for small proportions of variances in health-related fitness among children 6-10 years, 3%-11% (15,48,59~~21, 66,80~~) and youth 9-18 years, 7%-21% (30,34~~38,43~~). By inference, factors other than PA influence PF.

Studies spanning early and late childhood (16,28,33,72,73~~23,36,41,95,96~~) and adolescence (47~~65~~) highlight positive relationships between MP and PA. Proficiency is generally rated on the basis of movement characteristics of locomotor and object-control skills and not in terms of performance outcomes (process of performing ["how"] in contrast to product of performance [distance, speed]). Correlations range from low to moderate, vary with age and indicator of PA, and are often more apparent at the extremes of MP (16,28,73~~23,36, 96~~). The estimated proportion of variance explained by MP after controlling for potential confounders is small, <10% (47,73~~65, 96~~).

MP may mediate changes in PA and PF with age. For example, children in the highest tertile of motor coordination at 6 years had a higher level of PA which changed negligibly from 6 to 9 years, whereas children in the middle and lowest coordination tertiles at 6 years had lower levels of PA which declined with age (33~~41~~). Proficiency in object control tasks (catch, throw, kick) assessed at ~8-12 years accounted for ~26% of the variance in CRF during adolescence, while proficiency in locomotor tasks (side gallop, vertical jump, hop, sprint run) was unrelated to later CRF (1~~1~~). However, CRF at about 9 years of age was predictive of time spent in MVPA three years later, more so in boys than girls (31~~39~~).

Outcomes of motor performances are also related to PA and PF. Shuttle run and vertical jump performances at ~9 years (but not balance and precision ball throwing) were predictive of time in MVPA three years later (31~~39~~). Among children/adolescents 4-13 years, performances in the standing long jump and throwing and kicking tasks were related to health-related fitness - curl-ups, push-ups, endurance run, grip strength (64~~85~~). Explained variances in PF ranged from 5% to 21% in five age groups except for the jump (38%) at 4-5 years, and jump (26%), throw (39%) and kick (37%) at 12-13 years.

Daily Activities of Youth

Studies of time use highlight changes in daily activities of American youth over time (22-24,27,4330-32,35,53). Across three surveys spanning 1981-2003, time in school increased from 1981 to 1997 and was then stable, while time in physical play (including sport) was replaced by organized activities - sport, arts, academic and social, and non-physical play/leisure time (computer games, media in general). Time in sport declined from 1997 to 2003 among children 6-12 years (22-2430-32); more recent statistics indicate 2.6 million fewer participants 6-12 years in several popular sports between 2008 and 2013 (6890).

More recent societal trends include continued increase in single parent and dual-working parent families, professionalization of parenthood, cultural pressures to raise high achieving children, and persistence of state mandates for standardized testing (6890). Associated trends include an increase in after school classes/tutoring sessions, reduction in school recess and free play, and parental focus on resumé building for their child/children.

The trends suggest an "over-organization of childhood" which has implications for individual autonomy and for MP and PA. This is apparent in the increased prevalence of organized after-school activities (10,11,3214,15,40), which impact discretionary time, specifically opportunities for free play, and may contribute to early specialization in arts, sport and other activities.

Gaps in Our Knowledge - The Need for Biocultural Questions and Approaches

PA is a behavior that requires some level of MP. PA occurs in many contexts - play, physical education, recess, sport, household chores, among others. Meanings and values attached to PA and also MP vary with age and among individuals. Children commonly view sport as fun or play and not necessarily as PA; sport is a venue for practicing movement skills and demonstrating proficiency. Urban adolescents are likely to perceive walking to the metro or bus as a necessity and not as PA per se. Cultural and contextual factors are additional dimensions. The impact of puberty on PA may be quite different for girls in cultures in which participation in sport as an adult female is less tolerated compared to settings in which it is highly valued. A biocultural approach can capture interactions between biological (maturation, growth) and behavioral (meanings, perceptions, values) variables associated with PA and MP.

Play. Biological factors which may directly or indirectly affect PA and MP need attention. Direct effects reflect changes in PA attributable to biology, i.e., complex biological pathways may intrinsically regulate PA (56~~77~~) or may regulate specific behaviors such as active play. For example, polymorphisms in a genetic pathway which contributes to individual differences in dopaminergic responses to PA (i.e., reward) have been reported (18~~26~~).

Play among children is considered a time sensitive, biologically driven behavior that supports maturation of the central nervous system (7,8~~11,12~~). With maturation of the neuromuscular system, active play becomes biologically redundant resulting in a reduced drive to engage in physically active play behaviors. Does this explain why active play declines during adolescence, even among youth who remain physically active (12,49~~17,67~~)? Does advanced maturation underlie the earlier reduction in active play in girls than in boys?

Although play may be biologically driven, it has many functions - PA (movement per se), skill learning (trial and error), social (peer interactions), cognitive (imagery, executive functions), emotional (self-control), among others. Play provides opportunities for applying movement skills in PA in a variety of settings - solitary versus group play, home versus daycare/school, indoors versus outdoors, etc. Time spent outdoors is positively associated with PA and activities performed outdoors are more energetic (50~~69~~).

Time in free play has not received much attention in discussions of PA and MP. Children enrolled in Head Start spend 63 minutes per day outdoors (66~~88~~) while only 58% of children not enrolled in daycare go outdoors daily (67~~89~~). The odds of going outdoors to play among preschool children are higher for boys, with three or more playmates, and with active parents. The odds of going outdoors to play are lower for girls and for children with working mothers and with Asian, Black and Hispanic compared to White mothers (67~~89~~).

Factors which influence opportunities for outdoor play require further study in the context of MP and PA, including cultural perceptions of play and activity, and variation in rearing. Studies should be extended to daycare and preschool settings, and to caregivers/teachers as factors affecting motor development and PA of young children.

Informal and Organized Activities. Data addressing PA and MP in organized and informal activities are lacking. Estimated intensities (diaries and accelerometry) of activities of boys in unstructured than structured ball games were, respectively, 2.0 vs 1.9 calories/minute at 10-11 years and 3.4 vs 2.5 calories/minute, at 12-13 years. Corresponding estimates for girls were, respectively, 2.3 vs 1.9 calories/minute at 10-11 years and 3.2 vs 2.6 calories/minute at 12-13 years (35~~44~~). In contrast, MP of adolescents of both sexes was related to time in organized PA more so in girls than boys, but was not related to time in non-organized PA (47~~65~~).

Biological Maturation. The influence of biological maturation on PA among adolescents likely reflects an indirect effect, i.e., a third factor influences changes in PA attributable to biological maturation. Observations suggest that beliefs, self-perceptions, social interactions and expectations, evaluations and reactions of others, and/or more subtle societal and cultural factors mediate relationships between inter-individual variation in maturation and PA (12,13,53,62,63~~17,19,72,83,84~~). The inverse relationship between maturation and PA in adolescent girls is mediated by physical self-concept; early maturing girls perceive themselves as less attractive, less competent at sports and less physically fit (14,25,2620,33,34). The potential to modify psychosocial correlates, e.g., behavior modification, with the goal of improving PA among youth merits attention.

The preceding focuses largely on youth 11-15 years. Biobehavioral studies need to consider earlier ages in the pubertal transition and to follow youth longitudinally across this interval. The extent to which culture impacts these relationships should be considered; the impact of early maturation on PA and MP in adolescent females may be different in cultures where the transition to adulthood is a more valued and positive experience.

Tracking Activity. The fact that individuals with a history of PA as children are more likely to be active as adolescents, and those active as adolescents tend to be more active as young adults relates to tracking (39,4048,49). Determinants of tracking and/or non-tracking of PA need study. What factors, biological, behavioral and/or cultural, influence the tracking of PA from childhood into adolescence and young adulthood? What is unique about those individuals in whom PA tracks compared to those in whom it does not track? What is unique about the inactive child or adolescent who becomes an active adolescent or young adult, respectively? The question can be reversed to address the active child and adolescent who subsequently become inactive.

Development of Movement Proficiency. Two trajectories are involved: development and refinement of basic movement patterns (fundamental motor skills), and integration of these patterns into more complex and specialized movement skills and sequences. Associated variables which may influence these processes - correlates of MP, and intra- and inter-individual variability need consideration.

Changes in growth that occur concurrently with the development of fundamental movement skills during infancy and childhood include the following. Rate of growth in height decreases, while rate of growth in weight is reasonably stable or shows a slight increase. Children are getting bigger but at a slower rate. The legs grow more rapidly than the trunk, proportions change, and position of the center of gravity shifts. The differential growth rates of height and weight result in a reduction in weight-for-height. The decline in the BMI reaches a nadir at about 6-7 years and then increases. The increase is commonly labeled the “adiposity rebound” (44~~54~~), but evidence indicates that growth in lean tissue mass is characteristic of the rebound (9,54~~13,73~~). Are these changes in size, proportions, weight-for-height and composition related to the development of MP? Assuming they are, to what extent?

It has been suggested that the biological drive for active play involves primarily locomotor activities, is strongest in early childhood, and reaches a peak at about 5 years (51~~70~~). This is also the interval when basic movement patterns are developing and some are nearing the mature stage (21,61~~29,82~~). As with growth-related changes, the development of basic movement skills in the context of play, specifically outdoor play, merits study.

Currently used tests of fundamental motor skills (46,69,71~~64,92,94~~) are largely qualitative, focusing on specific components defining mature movement patterns (mastery) for several locomotor (run, jump, gallop, skip, etc.) and object-control (throw, catch, kick, etc.) skills. A variable number of criteria describe the mature pattern for each skill. Performances are rated in terms of the presence or absence of specific criteria. As generally used, the tests evaluate status - level of MP at the time of observation.

Status reflects the outcome of interactions among neuromuscular maturation, growth, and the environments and prior movement experiences of children. This begs several questions. What are the characteristics (size, composition and proportions, prior movement experiences, outdoor play history, etc.) of children who progress through stages of a specific movement pattern quickly compared to those who progress slowly? What is the role of instruction, practice and/or play in progress through stages? What is the relationship between the age at reaching mastery and subsequent performance, PA and PF? Does mastery in fundamental movement skills enhance PA or does PA (perhaps in the form of play) enhance attainment of mastery? Are ages at attaining mastery in different skills related? Data addressing potential genotypic contribution to the acquisition of commonly studied skills are lacking. A study of twins 6-9 and 11-15 years suggests a genotypic component in the kinematic structure of running a dash (6~~10~~). These and other questions should add to our understanding of the development of basic movement skills and MP.

Motor performances tend to improve, on average, from childhood through adolescence in boys and to a lesser extent in adolescence among girls (44~~54~~). Percentages of children attaining mastery or near mastery of fundamental movement skills tend to increase with age from 6-15 years (5,46~~8,64~~), but many youth, girls more than boys, 9-15 years, do not show near mastery or mastery of six fundamental skills - run, vertical jump, throw, catch, strike, kick (5~~8~~). This begs several questions. What are the growth, maturation and behavioral characteristics of those who have and have not reached mastery? Adolescence presents additional dimensions. Several motor performance tasks have reasonably well-defined growth spurts which vary relative to the growth spurt in height (44~~54~~). Is level of mastery related the timing of the spurts? Are behavioral changes during adolescence related to the attainment of mastery?

Discussions of associations between PA and biological maturation need to be extended to MP during adolescence. Although skeletal age alone or interacting with body size accounts for relatively small portions of variances in motor coordination (17~~24~~) and performances (3,4,29~~4,5,37~~) in children and adolescents, variation in some items is apparent at the extremes of maturation in adolescent boys but not girls (44~~54~~).

It is suggested that individuals deficient in motor competence (presumably MP) are lacking in perceived competence which increases the risk for reduced PA and increased obesity, and that individuals with good MP have better perceived competence and in turn are more active and healthier (55~~75~~). Potential variation in MP and perceived competence associated with individual differences in growth and biological maturation was not considered. While motivational paradigms based on the need to demonstrate competence can predict motivated behavior, they are limited in scope and do not recognize the broader range of intentions which underlie self-determined behaviors, e.g., the need for autonomy and relatedness (58~~79~~). It is important to address why MP is personally meaningful to some youth and not others, and/or why movement skills are voluntarily pursued by some youth and not others. A youngster who is competent at running but perceives the act as less relevant within his/her social context and/or does not run because of personal choice might be expected to be less active than a youngster who is less competent at running but views the activity as personally meaningful and chooses to run by personal choice. There is a need to look beyond the relationship between MP and perceived competence per se. Further, PA is only one factor in the complex origins of obesity.

Individual Differences

Individuality of responses to intervention and specific PA and MP programs is not ordinarily considered. Two studies highlight this individuality.

A combined sample of 35 boys and girls 10.9 to 12.8 years were exposed to a 12 week endurance training program. Mean peak VO_2 increased by 6.5±5.1%, 44.7 to 47.6 ml/kg/min, but changes in individual youth ranged from -2.4% to +19.7% (5778). Similarly, a 12 week aerobic program did not alter body mass and percentage fat in 15 overweight and obese girls (13.1±1.8 years), but had variable effects on indicators of insulin sensitivity (4563). Area under the insulin curve decreased by 23%, while glucose area under the curve decreased by 7%. Area under the insulin curve decreased in 11 girls (circa -11% to -62%), showed a small change in one girl (circa +3%), and increased in three girls (circa +22% to +44%), while glucose area decreased in six girls (circa -8% to -35%), changed slightly in seven girls (circa -3% to +5%), and increased in one girl (circa +20%).

Though limited, the observations highlight the importance of individuality of responses to specific programs. Similar variability likely occurs in responses to motor, sport and instructional programs

Summary

PA and MP cannot be approached in isolation from daily demands placed upon children and adolescents, and changes associated with physical growth, biological maturation and behavioral development. A biocultural approach provides a more comprehensive framework that considers potential interactions of biological and societal demands with outcome variables of interest. Studies considered were derived largely from children and adolescents in developed, economically better-off countries in a western culture context. Given interest in international comparisons of health, physical activity, physical fitness and motor proficiency of youth, there is a need to extend studies to include the unique features of different cultural contexts that may influence the variables of interest.

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