STRATEGIES AND RECOMMENDATIONS FOR YOUTH PHYSICAL-ACTIVITY PROGRAMMING: A REVIEW

RESEARCH FROM THE ACE SCIENTIFIC ADVISORY PANEL

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Physical inactivity has become the biggest public health problem of the 21st century, and health and fitness professionals, healthcare providers, school administrators, government officials and parents need to work together to help youth develop and maintain healthy behaviors during the formative years of life.

Public health recommendations call for children and adolescents to accumulate at least 60 minutes of moderate-to-vigorous physical activity daily, including muscle- and bone-strengthening activities at least three days per week. However, without qualified instruction, meaningful learning experiences and directed movement practice, it is unlikely that school-age youth will develop the physical skills and mental readiness to participate in daily physical activity as an ongoing lifestyle choice.

Because the stakes of this pandemic are substantial with far-reaching biomedical, social and economic consequences, qualified health and fitness professionals who genuinely appreciate the physical and psychosocial uniqueness of younger populations are well-positioned to create opportunities for youth to be physically active daily as part of play, sports and planned exercise. While additional research is warranted, current evidence supports the critical importance of primary prevention as part of a comprehensive approach to promoting long-term health and well being.

KEY POINTS

- Physically active lifestyles start to develop very early in childhood, and therefore children and adolescents should have regular opportunities to engage in a variety of physical activities that are developmentally appropriate, meaningful and inherently enjoyable.
- Public health recommendations call for children and adolescents to accumulate at least 60 minutes of moderate to vigorous physical activity daily, including muscle- and bone-strengthening activities at least three days per week.
- Without qualified instruction, meaningful learning experiences and directed movement practice, it is unlikely that school-age youth will develop the physical skills and mental readiness to participate in daily physical activity as an ongoing lifestyle choice.
- Enhancing muscle strength, developing fundamental movement skills, fostering new social networks and promoting physical literacy in a positive and supportive environment are important considerations.
- Health and fitness professionals should focus on the progression of motor skills and fitness abilities early in life because of the high degree of plasticity in neuromuscular development during the growing years.
- Seven principles that will influence the effectiveness of youth fitness programs can be remembered as the PROCESS of youth fitness:
  - ✓ Progression
  - ✓ Regularity
  - ✓ Overload
  - ✓ Creativity
  - ✓ Enjoyment
  - ✓ Specificity
  - ✓ Supervision
- Improved communication between health and fitness professionals and healthcare providers will facilitate the identification and treatment of youth at risk for physical inactivity and hopefully foster sustainable programming that overcomes barriers to safe activity environments that will promote healthy lifestyle choices.

REGULAR PARTICIPATION in physical activity in the context of family, school and community programs is essential for normal growth and development. In addition to enhancing cardiorespiratory and musculoskeletal fitness, routine participation in active play, fitness activities, planned exercise and team sports has the potential to enhance a child's emotional, social and cognitive well-being.[1–4] As the science related to the impact of regular exercise on the prevention and treatment of disease gets stronger,[5] evidence-based interventions and public-health initiatives that focus on developing and reinforcing healthy behaviors may prevent the accumulation of risk factors and pathological processes. Physically active lifestyles start to develop very early in childhood,[6–8] and therefore children and adolescents should have regular opportunities to engage in a variety of physical activities that are developmentally appropriate, meaningful and inherently enjoyable.

Public health recommendations call for children and adolescents to accumulate at least 60 minutes of moderate to vigorous physical activity (MVPA) daily, including muscle- and bone-strengthening activities at least three days per week, in the context of family, school and community events.[9,10] Yet, despite the efforts of researchers, practitioners and public health officials, it seems the critical importance of daily physical activity has yet to garner the medical recognition of other cardiovascular disease risk factors. Physical inactivity has now become the biggest public health problem of the 21st century and efforts in advocacy, policy, workforce training and surveillance are needed to counteract this pandemic.[11,12] Health and fitness professionals, healthcare providers, school administrators, government officials and parents need to work together to help youth develop and maintain healthy behaviors during the formative years of life.

The aim of this article is to examine the link between childhood physical inactivity and disease risk, explore contemporary trends in youth physical inactivity and highlight novel strategies for identifying and treating youth who are not accumulating the recommended amount of MVPA. In this article, the term "child" (or "children") refers to girls and boys (generally up to the age of 11 and 13, respectively) who have not yet developed secondary sex characteristics (e.g., breast development in girls and facial hair in boys). The term "adolescence" refers to a period of life between childhood and adulthood and generally includes girls 12 to 18 years and boys 14 to 18 years. For ease of discussion, the term "youth" refers to both children and adolescents.

YOUTH PHYSICAL INACTIVITY AND DISEASE RISK

Many diseases that become clinically manifest during adulthood are influenced by lifestyle habits established during childhood. This view is supported by the prevalence of obesity in modern day youth,[13] and the observation that 49 percent of overweight and 61 percent of obese adolescents have one or more cardiovascular disease risk factors in addition to their weight status.[14] The prevalence of type 1 and type 2 diabetes among children and adolescents continues to increase,[15] and the Centers for Disease Control and Prevention[16] estimates that one in three adults could have diabetes by 2050 if current trends continue. Others report that 6 to 10 percent of all deaths from noncommunicable diseases worldwide can be attributed to physical inactivity, and this percentage may be even higher for specific conditions such as heart disease.[17]

In the landmark Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study,[18] strong relationships were found between risk factors and the severity and extent of atherosclerosis measured after death in 15- to 34-year-old individuals who died accidentally of external causes. While there was a striking increase in the severity and extent of disease as the number of risk factors increased in the PDAY report, it is noteworthy that the absence of risk factors was found to be associated with a virtual absence of advanced atherosclerotic lesions.[18] These findings provide strong support for modifying risk factors early in life to retard the development of atherosclerosis.

Observations from the Cardiovascular Risk in Young Finns Study[19] provide additional support for focusing on prevention early in life. In this prospective investigation, researchers examined the relationship between cardiovascular risk factors measured in childhood and adolescence and carotid artery intima-media thickness (IMT), a marker of preclinical atherosclerosis, measured in adulthood. Researchers reported that IMT in adulthood was significantly associated with childhood low-density lipoprotein levels, systolic blood pressure, body mass index and smoking.[20] More recent observations from this ongoing investigation found that physical activity in boys and young adults was associated with carotid artery elasticity later in life, suggesting that higher levels of physical activity in youth may benefit future cardiovascular health.[21]

There is increasing evidence that physical inactivity during childhood may result in a downward spiral of negative health outcomes that will ultimately challenge our healthcare system.[22,23] Since the disadvantageous effects of poor lifestyle choices will not simply resolve themselves in due course, targeted interventions are needed to manage conventional risk factors early in life and establish healthy behaviors that reduce the risk of adverse health outcomes later in life. Data from a longitudinal study revealed that children's weight status negatively influenced future levels of gross motor coordination, and vice versa.[24] That is, lower baseline levels of gross motor coordination early in life significantly predicted body mass index scores later in life. In support of these findings, data from the British Cohort Study[25] found that the level of gross motor coordination at age 10 years was positively associated with physical activity and inversely associated with sedentary behavior at age 42 years.

If the dynamic relationship among motor skill proficiency, physical activity and positive health outcomes can be reinforced over time, which is consistent with the proposed existence of a positive feedback loop, efforts to increase physical-activity participation should begin early in life.[26,27] A change in social mores about the critical importance of daily MVPA during the growing years is desperately needed because the stakes of this global pandemic have far-reaching biomedical, psychosocial, economic and political consequences.

CONTEMPORARY TRENDS IN YOUTH PHYSICAL INACTIVITY

Epidemiological reports indicate that a majority of youth worldwide are not as active as they should be, and the decline in physical activity seems to emerge by age 9.[28,29] Computer tablets and cellular phones have decreased the need and desire to move, and in many urban neighborhoods there are few safe places for youth to engage in outdoor activities and free play. Moreover, a growing number of school districts now view physical education as an expendable part of the school curriculum and only 18 percent of states require primary schools to provide daily recess.[30] At present, 59 percent of states allow required physical-education credits to be earned through online

physical-education courses, and a majority of the states that allow online courses do not require that they be taught by state-certified physical-education teachers.[30]

Without qualified instruction, meaningful learning experiences and directed movement practice, it is unlikely that school-age youth will develop the physical skills and mental readiness to participate in daily physical activity as an ongoing lifestyle choice. Findings from the Youth Risk Behavior Surveillance survey[31] indicate that a vast majority of high school students in the United States are not meeting current recommendations for MVPA, yet nearly one-third play video or computer games for three hours or more on an average school day. From a global perspective, secular trends in MVPA from 32 countries indicate that a majority of youth aged 11 to 15 years do not meet current recommendations for physical activity.[32] In response to growing international concern over physical inactivity among youth, the Active Healthy Kids Canada Report Card was replicated in 14 countries and the results show that the grades for indicators for physical inactivity around the world are generally low/poor.[33] Of note, findings from the United States Report Card on Physical Activity for Youth resulted in a grade of D- because only 25 percent of the sample met current physical-activity guidelines.[34]

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A contemporary corollary of the sedentariness among modern-day youth is a low level of motor-skill competency and muscular fitness.[35–38] Researchers reported the prevalence of low motor-skill competence in a large sample of youth was high, and noted a consistent and clear relationship between low competency in fundamental movement skills (FMS) and inadequate levels of cardiorespiratory fitness.[36] Other researchers examined secular trends in muscular fitness in school-age youth and found declines in measures of muscular strength and power.[35,37,38] Not only do low levels of muscular fitness and motor-skill prowess limit the preparedness of youth for participation in organized and nonorganized activities,[39,40] but habitually low levels of physical activity significantly increase the risk of injury in children during physical education, leisure-time activities and sport.[41]

Longitudinal research has found that children who are not exposed to environments with opportunities to enhance motor-skill proficiency (e.g., jumping, hopping and balancing) tend to be less active later in life.[42,43] These observations are consistent with a longitudinal report on a large sample of twins that found more advanced motor development during childhood was associated with higher leisure-time physical activity in adulthood.[44] Without daily physical activity and qualified instruction during the growing years, children may not develop confidence and competence in their physical abilities, which form the foundation for a lifetime of physical activity. Structured school-based interventions have been found to enhance muscle strength and motor-skill performance in children.[45,46] In the long term, children who participate regularly in supervised intervention programs will be more likely to gain the prerequisite physical abilities that will allow for later learning of more complex movements and sport skills. Conversely, children who do not develop the prerequisite motor skills early in life may not be able to break through a hypothetical "proficiency barrier" that would allow them to catch up with their peers with an average or high level of motor competence.[47–49] In order to alter the current trajectory toward physical inactivity and related morbidities in sedentary youth, special attention is needed to identify and target exercise deficiencies early in life because lifestyle habits become more resistant to change later in life.

EXERCISE DEFICIT DISORDER

Many parents lack awareness of youth physical-activity recommendations and wrongly consider their inactive children to be sufficiently active.[50–52] There is an urgent need to identify physically inactive youth and target them with developmentally appropriate interventions before they engage in unhealthy behaviors and learn bad habits. Screening for physical inactivity should begin early in life, and youth who are not meeting the minimal recommendations for MVPA should be treated with the same energy and resolve as a hypertensive child or a teenage smoker. Public health experts urge health departments to advance universal health through key actions, which include screening for physical inactivity, counseling about physical activity and investing in comprehensive physical-activity promotion policies, action plans and implementation programs.[12,53]

Instead of simply labeling a child as inactive, the term exercise deficit disorder (EDD) more aptly describes a condition that should be identified and treated in order to prevent the progression of risk factors and pathological processes. By definition, EDD is a condition characterized by reduced levels of regular physical activity that are below recommendations consistent with positive health outcomes.[23,54,55] The use of the term exercise in EDD does not suggest that free play is inconsequential, but rather emphasizes the premise that habitual physical activity may need to be "prescribed" by qualified professionals. Viewed from this perspective, participation in play, games, sports, transportation, physical education and planned exercise can all contribute to the physical, psychosocial and cognitive development of children and adolescents. If this window of opportunity to identify inactive youth and promote regular physical activity during the growing years is missed, the eventual decline and disinterest in physical activity will continue to take shape.

The use of the term EDD highlights the gravity of this pandemic and can educate parents and raise public awareness about the importance of regular exercise for the developing body. Moreover, the concept of identifying youth with EDD conveys a contemporary view of this emerging healthcare issue that can be used to inform school administrators and government officials about the exercise–health link. While there are not any clinical markers or laboratory tests that can be used to identify youth with EDD, children can be queried about their "play history" and how many days per week they participate in games, sports, physical education and recreational fitness activities. Asking follow-up questions related to the amount of time they participate in activities that make them "breathe hard" can shed light on both the quality and quantity of daily physical activities. Professionals should consult with parents and caregivers to paint a "family fitness portrait" that describes the type of recreational and sport activities the family enjoys.

Youth who do not meet the current recommendations of 60 minutes or more of MVPA each day (i.e., 420 minutes/week) should receive an exercise plan that targets deficiencies in muscular strength and motor skills. Providing parents with information on school- and community-based programs that meet the needs, abilities and interests of children and adolescents may be an important "first step" in promoting MVPA in inactive youth. At present, a fundamental change in systems for identifying physical inactivity and delivering "fitnesscare" so that physical-activity counseling and referral are expected, documented and reimbursed are warranted.

BECOMING PHYSICALLY LITERATE

When working with children and adolescents, the goal of the program should not simply be limited to time spent in MVPA. In addition to considering the "dose-response" of physical activity, the importance of the "quality-response" should also be appreciated.[56] Enhancing muscle strength, developing FMS, fostering new social networks and promoting physical literacy in a positive and supportive environment are important considerations. Physical literacy is a conceptual framework that describes an individual's motivation, confidence, competence, knowledge and understanding to engage in physical activities for life.[57] Global efforts have embraced the concept of physical literacy to address declining rates of physical activity among school-age youth.[57]

The concept of physical literacy is comprehensive because it supports the holistic development of youth by encompassing the psychomotor, cognitive and affective domains of learning.[58] Consequently, health and fitness professionals need to balance the fundamental principles of pediatric exercise science with effective pedagogy so participants learn to value the importance of daily physical activity and begin to take responsibility for their own actions. It is a misperception that children innately know how to throw, catch, kick, jump and hop with proper technique and physical effort. Health and fitness professionals need to provide meaningful feedback in game-play environments in order to positively influence skill-development, fitness performance and motivation. Without qualified instruction, deliberate practice and a sensible progression of developmentally appropriate activities, inactive youth are less likely to gain confidence and competence in their physical abilities.

ACTIVATING YOUTH

New insights into the design of youth fitness programs highlight the importance of integrating strength-building and skill-enhancing exercises into exercise classes and sport programs.[40,59,60] Fundamental integrative training (FIT) is a method of conditioning that is purposely designed to enhance both health- and skill-related components of physical fitness.[61] This type of training provides children and adolescents with a needed opportunity to enhance muscle strength, master FMS, improve movement mechanics and gain confidence in their physical abilities. FIT does not require expensive equipment, but rather basic movements and multijoint exercises that are somewhat characteristic of 20th century physical education. By gradually progressing from simple to more complex exercises, children and adolescents are likely to enhance their muscular fitness and motor skill performance, which, in turn, will help to build a strong foundation for future participation in context specific games and sports.

Because muscular fitness is an essential component of motor-skill performance in youth,[62,63] the importance of enhancing muscular strength and power should not be overlooked when designing youth programs. In a prospective study of over 1 million male adolescents who were followed for a period of 24 years, low muscular strength was recognized as an emerging risk factor for major causes of death, including cardiovascular disease.[64] Others reported that higher levels of muscular strength in youth was associated with lower levels of cardiovascular disease risk factors later in life.[65] These findings emphasize the importance of early recognition of low muscle strength in youth and the necessity of targeted interventions to enhance muscular fitness.

Exercise programs that include a variety of strength-building and skill-related activities have proven to be safe, effective and worthwhile for children and adolescents.[66–69] It is likely that youth who participate in supervised FIT programs will gain competence and confidence in their abilities to engage in MVPA as an ongoing lifestyle choice. Brain development during childhood corresponds to an optimal time to expose children to a variety of FIT activities.[70,71] Thus, health and fitness professionals should focus on the progression of motor skills and fitness abilities early in life because of the high degree of plasticity in neuromuscular development during the growing years. Following maturation, the potential for learning complex motor skills may be diminished once selected neural pathways have been established and myelination has progressed past a certain point.[72] In the long-term, youth who become proficient in their physical abilities early in life will be better prepared for learning of more complex movements and sports skills later in life.

THE PROCESS OF YOUTH FITNESS

Youth fitness programs need to be based on fundamental training principles to optimize training outcomes and maximize exercise adherence. Although factors such as age, genetics, training experience and lifestyle habits (e.g., sleep and nutrition) will influence the rate and magnitude of adaptation that occurs, seven principles that will influence the effectiveness of youth fitness programs can be remembered as the PROCESS of youth fitness:

The principle of **progression** states that the demands placed on the body must be progressively increased over time to achieve long-term gains in health and fitness. This does not mean that every exercise session should be more intense than the previous one, but rather that over time the physical demands placed on the growing body should gradually become more challenging to continually stimulate adaptations. Without a more challenging exercise stimulus that is consistent with individual needs, goals and abilities, the human body has no reason to adapt any further. This principle is particularly important after the first few weeks of training, when the threshold for training-induced adaptations in stronger youth is higher.[73]

The principle of **regularity** states that long-term gains in physical fitness will be realized only if exercise is performed on a consistent basis. Although adequate recovery is needed between vigorous exercise bouts or intense sport practice sessions, inconsistent exercise will result in only modest training adaptations. Youth must regularly participate in a variety of games, exercises and sports to make continual gains in physical fitness. Daily MVPA is recommended for children and adolescents.[10]

The **overload** principle simply states that to enhance physical fitness, youth must exercise at a level beyond that at which they are normally stressed. Otherwise, if the exercise stimulus is not increased beyond the level to which the body is accustomed, training adaptations will not be optimized. Although overload is typically manipulated by changing the exercise intensity, duration or frequency, adding more challenging exercises or games to a fitness class is another way to place greater overload on the developing body.

The **creativity** principle refers to the imagination and ingenuity that can help to optimize training-induced adaptations and enhance exercise adherence. In order for youth to remain engaged and interested in MVPA, health and fitness professionals should use creative thinking to facilitate the development of exercise programs that are innovative and challenging. By sensibly incorporating new exercises and novel games into the fitness program, professionals can help youth overcome barriers and maintain interest in exercise and sport. Creative thinking is particularly valuable when designing exercise programs for youth with special needs or those with training experience. Notwithstanding the critical importance of exercise safety and proper technique, novelty and training variety are important for stimulating continual gains in physical fitness.[74]

The principle of **enjoyment** states that youth who genuinely enjoy exercising are more like to adhere to the exercise program and achieve training goals. While encouragement from health and fitness professionals and support from family and friends can influence exercise habits, the enjoyment an individual feels during and after an exercise session can facilitate the sustainability of the desired behavior.[75] Exercise programs should be challenging, yet youth should have the competence and confidence in their physical abilities to perform the exercises or activities with energy and vigor. If the exercise program is too advanced, youth will be anxious and lose interest. Conversely, if the exercise program is too easy, then youth will become bored. As such, enjoyment can be defined as a balance between skill and challenge.[76]

The principle of **specificity** refers to the distinct adaptations that take place as a result of the exercise program. For example, the adaptations to resistance training are specific to the muscle actions, velocity of movement, exercise range of motion and muscle groups trained. The principle of specificity is often referred to as the SAID principle (which stands for "specific adaptations to imposed demands"). In terms of designing youth exercise programs, the adaptations that take place in a muscle or muscle group will be as simple or as complex as the stress placed on them. Children should be exposed to a variety of games, exercises and sports so they develop a wide-ranging movement vocabulary that prepares them for a lifetime of physical activity. The potential benefits of integrating different types of training into youth fitness programs is evidenced by the growing popularity of agility ladders, elastic bands, fitness ropes, medicine balls, stability balls and other devices that can be used to enhance both health- and skill-related components of physical fitness.[77]

The principle of **supervision** states that the safety and efficacy of exercise programs are maximized when qualified health and fitness professionals supervise activities while providing instruction, guidance and encouragement. Not only does supervision reduce the risk of injury, but youth who participate in supervised exercise programs are also more likely to gain competence and confidence in their physical abilities.[78,79] Health and fitness professionals who provide immediate and meaningful feedback while participants are learning exercise technique or sport tactics can help youth negotiate demanding situations and remain engaged in the exercise program. Youth fitness programs are most effective when they are designed and supervised by qualified professionals who understand the PROCESS of youth fitness and genuinely appreciate the physical and psychosocial uniqueness of children and adolescents.

CONCLUSION

Informed interventions and innovative strategies are urgently needed to identify physically inactive youth and promote physical activity as an ongoing lifestyle choice. Without such interventions, new healthcare concerns will continue to emerge as youth become resistant to medical therapy. Improved communication between health and fitness professionals and healthcare providers will facilitate the identification and treatment of youth at risk for physical inactivity and hopefully foster sustainable programming that overcomes barriers to safe activity environments that will promote healthy lifestyle choices.

Since the stakes of this pandemic are substantial with far-reaching biomedical, social and economic consequences, qualified health and fitness professionals who genuinely appreciate the physical and psychosocial uniqueness of younger populations are well-positioned to create opportunities for youth to be physically active daily as part of play, sports and planned exercise. While additional research is warranted, current evidence supports the critical importance of primary prevention as part of a comprehensive approach to promoting long-term health and well-being.

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REFERENCES

1. Biddle, S. & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine,* 45, 11, 886–895.
2. Gunter, K., Almstedt, H., & Janz, K. (2012). Physical activity in childhood may be the key to optimizing lifespan skeletal health. *Exercise and Sport Science Reviews,* 40, 1, 13–21.
3. Janssen, I. & LeBlance, A. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavior, Nutrition and Physical Activity,* 7, 40.
4. Lloyd, R. et al. (2014). Position statement on youth resistance training: The 2014 International Consensus. *British Journal of Sports Medicine,* 48, 7, 498–505.
5. Pedersen, B. & Saltin, B. (2015). Exercise as medicine – evidence for prescribing exercise as therapyin 26 different chronic diseases. *Scandinavian Journal of Medicine and Science in Sport,* 25 (suppl 3), 1–72.
6. de Souza, M. et al. (2014). Motor coordination, activity, and fitness at 6 years of age relative to activity and fitness at 10 years of age. *Journal of Physical Activity and Health,* 11, 6, 1239–1247.
7. Rääsk, T. et al. (2015). Tracking of physical activity in pubertal boys with different BMI over two-year period. *Journal of Sport Sciences,* 33, 16 , 1649–1657.
8. Telama, R. et al. (2014). Tracking of physical activity from early childhood through youth into adulthood. *Medicine & Science in Sports & Exercise,* 46, 5, 955–962.
9. United States Department of Health and Human Services (2008). *2008 Physical Activity Guidelines for Americans.* www.health.gov/paguidelines
10. World Health Organization (2010). *Global Recommendations on Physical Activity for Health.* www.who.int/dietphysicalactivity/factsheet_recommendations/en/
11. Blair, S. (2009). Physical inactivity: The biggest public health problem of the 21st century. *British Journal of Sports Medicine,* 43, 1, 1–2.
12. Kohl, H. et al. (2012). The pandemic of physical inactivity: Global action for public health. *Lancet,* 380, 294–305.
13. Ogden, C. et al. (2015). Prevalence of obesity among adults and youth: United States, 2011–2014. *NCHS Data Brief,* 219, 1–8.
14. May, A., Kuklina, E., & Yoon, P. (2012). Prevalence of cardiovascular disease risk factors among US adolescents, 1999–2008. *Pediatrics,* 129, 6, 1035–1041.
15. Dabelea, D. et al. (2014). Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. *Journal of the American Medical Association,* 311, 27, 1778–1786.
16. Boyle, J. et al. (2010). Projection of the year 2050 burden of diabetes in the US adult population: Dynamic modeling of incidence, mortality, and prediabetes prevalence. *Population Health Metrics,* 8, 29.
17. Lee, I. et al. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *Lancet,* 380 (9838), 219–229.
18. Strong, J. et al. (1999). Prevalence and extent of atherosclerosis in adolescents and young adults: Implications for prevention from the Pathobiological Determinants of Atherosclerosis in Youth Study. *Journal of the American Medical Association,* 24, 8, 727–735.
19. Juonala, M., Viikari, J., & Raitakari, O. (2013). Main findings from the prospective Cardiovascular Risk in Young Finns Study. *Current Opinions in Lipidology,* 24, 1, 57–64.
20. Raitakari, O. et al. (2003). Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: The Cardiovascular Risk in Young Finns Study. *Journal of the American Medical Association,* 290, 17, 2277–2283.
21. Pälve, K. et al. (2014). Association of physical activity in childhood and early adulthood with carotid artery elasticity 21 years later: The cardiovascular risk in Young Finns Study. *Journal of the American Heart Association,* 3, 2, e000594.
22. Blair, S. et al. (2012). Exercise therapy – the public health message. *British Journal of Sports Medicine,* 22, 4, e24–28.
23. Myer, G. et al. (2013). Exercise deficit disorder in youth: A paradigm shift towards disease prevention and comprehensive care. *Current Sports Medicine Reports,* 12, 4, 248–255.
24. D'Hondt, E. et al. (2013). A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *International Journal of Obesity (London),* 37, 1, 61–67.
25. Smith, L., Fisher, A., & Hamer, M. (2015). Prospective association between objective measures of childhood motor coordination and sedentary behaviour in adolescence and adulthood. *International Journal of Behavior, Nutrition and Physical Activity,* 12, 75.
26. Faigenbaum, A. et al. (2013). The role of the pediatric exercise specialist in treating exercise deficit disorder in youth. *Strength and Conditioning,* 35, 3, 34–41.
27. Stodden, D. et al. (2014). Dynamic relationships between motor skill competence and health-related fitness in youth. *Pediatric Exercise Science,* 26, 3, 231–241.
28. Metcalf, B. et al. (2015). Exploring the adolescent fall in physical activity: A 10-yr cohort study (EarlyBird 41). *Medicine & Science in Sports & Exercise,* 7, 10, 2084–2092.
29. Tudor-Locke, C., Johnson, W., & Katzmarzyk, P. T. (2010). Accelerometer-determined steps per day in US children and adolescents. *Medicine & Science in Sports & Exercise,* 42, 12, 2244–2250.
30. National Association for Sport and Physical Education & American Heart Association (2012). *2012 Shape of the Nation Report: Status of Physical Education in the USA.* www.shapeamerica.org/advocacy/son/2012/upload/2012-shape-of-nation-full-report-web.pdf
31. U.S. Department of Health and Human Services (2012). Youth risk behavior surveillance—United States 2012. *Morbidity and Mortality Weekly Reports,* 61, 35–36.
32. Kalman, M. et al. (2015). Secular trends in moderate-to-vigorous physical activity in 32 countries from 2002 to 2010: A cross-national perspective. *European Journal of Public Health,* 25 (suppl 2), 37–40.
33. Tremblay, M. et al. (2014). Physical activity of children: A global matrix of grades comparing 15 countries. *Journal of Physical Activity and Health,* 11 (suppl 1), S113–S125.
34. Dentro, K. et al. (2014). Results from the United States' 2014 report card on physical activity for children and youth. *Journal of Physical Activity and Health,* 11 (Suppl 1), S105–S112.
35. Cohen, D. et al. (2011). Ten-year secular changes in muscular fitness in English children. *Acta Paediatrica,* 100, 10, e175–e177.
36. Hardy, L. et al. (2013). Thirteen-year trends in child and adolescent fundamental movement skills: 1997–2010. *Medicine & Science in Sports & Exercise,* 45, 10, 1965–1970.
37. Moliner-Urdiales, D. et al. (2010). Secular trends in health-related physical fitness in Spanish adolescents: The AVENA and HELENA studies. *Journal of Science and Medicine in Sport,* 13, 6, 584–588.
38. Runhaar, J. et al. (2010). Motor fitness in Dutch youth: Differences over a 26-year period (1980–2006). *Journal of Science and Medicine in Sport,* 13, 3, 323–328.
39. Faigenbaum, A. et al. (2015). Citius, Altius, Fortius: Beneficial effects of resistance training for young athletes. *British Journal of Sports Medicine,* DOI: 10.1136/bjsports-2015-094621

40. Morgan, P. et al. (2013). Fundamental movement skill interventions in youth: A systematic review and meta-analysis. *Pediatrics,* 132, 5, e1361–1683.

41. Bloemers, F. et al. (2012). Physical inactivity is a risk factor for physical activity-related injuries in children. *British Journal of Sports Medicine,* 46, 9, 669–674.

42. Barnett, L. et al. (2008). Does childhood motor skill proficiency predict adolescent fitness? *Medicine & Science in Sports & Exercise,* 40, 12, 2137–2144.

43. Lopes, V. et al. (2011). Motor coordination as a predictor of physical activity in childhood. *Scandinavian Journal of Medicine and Science in Sport,* 21, 663–669.

44. Aaltonen, S. et al. (2015). Motor development and physical activity: A longitudinal discordant twin-pair study. *Medicine & Science in Sports & Exercise,* 47, 10, 2111–2118.

45. Cohen, K. et al. (2014). Physical activity and skills intervention: SCORES cluster randomized controlled trial. *Medicine & Science in Sports & Exercise,* 47, 4, 765–774.

46. Löfgren, B. et al. (2013). An increase in school-based physical education increases muscle strength in children. *Medicine & Science in Sports & Exercise,* 45, 5, 997–1003.

47. D'Hondt, E. et al. (2014). A longitudinal study of gross motor coordination and weight status in children. *Obesity (Silver Spring),* 22, 6, 1505–1511.

48. Fransen, J. et al. (2014). Changes in physical fitness and sports participation among children with different levels of motor competence: A 2-year longitudinal study. *Pediatric Exercise Science,* 26, 1, 1–21.

49. Seefeldt, V. (1980). Developmental motor patterns: Implications for elementary school physical education. In: K. Nadeau, K. Newell & G. Roberts (Eds.) *Psychology of Motor Behavior and Sport* (pp. 314–323). Champaign, Ill.: Human Kinetics.

50. Corder, K. et al. (2010). Perception versus reality awareness of physical activity levels of British children. *American Journal of Preventative Medicine,* 38, 1, 1–8.

51. Debastiani, S. et al. (2014). Awareness and knowledge of the Youth 2008 Physical Activity Guidelines for Americans. *Journal of Physical Activity and Health,* 11, 3, 495–501.

52. Trigwell, J. et al. (2015). Parental views of children's physical activity: A qualitative study with parents from multi-ethnic backgrounds living in England. *BMC Public Health,* 15, 1, 1005.

53. Institute of Medicine (2013). *Educating the Student Body: Taking Physical Activity and Physical Education to School.* Washington, D.C.: The National Academies Press.

54. Faigenbaum, A., Stracciolini, A., & Myer, G. (2011). Exercise deficit disorder in youth: A hidden truth. *Acta Paediatrica,* 100, 1423–1425.

55. Stracciolini, A., Myer, G., & Faigenbaum, A. (2013). Exercise deficit disorder in youth: Are we ready to make the diagnosis? *Physician and Sports Medicine,* 41, 1, 94–101.

56. Pesce, C. (2012). Shifting the focus from quantitative to qualitative exercise characteristics in exercise and cognition research. *Journal of Sport and Exercise Psychology,* 34, 6, 766–786.

57. Aspen Institute (2015). *Physical Literacy: A Global Environmental Scan.* www.aspeninstitute.org/sites/default/files/content/images/sports/GlobalScan_FINAL.pdf

58. Society of Health and Physical Educators (2014). *National Standards & Grade Level Outcomes for K-12 Physical Education.* Champaign, Ill.: Human Kinetics.

59. Lloyd, R. et al. (2015). Long-term athletic development-Part 1: A pathway for all youth. *Journal of Strength and Conditioning Research,* 29, 5, 1439–1450.

60. Myer, G. et al. (2011). When to initiate integrative neuromuscular training to reduce sports-related injuries and enhance health in youth? *Current Sports Medicine Reports,* 10, 3, 155–166.

61. Bukowsky, M., Faigenbaum, A., & Myer, G. (2014). FUNdamental integrative training (FIT) for physical education. *Journal of Physical Education Recreation and Dance,* 85, 6, 23–30.

62. Behringer, M. et al. (2011). Effects of strength training on motor performance skills in children and adolescents: A meta-analysis. *Pediatric Exercise Science,* 23, 2, 186–206.

63. Malina, R., Bouchard, C., & Bar-Or, O. (2004). *Growth, Maturation and Physical Activity* (2nd ed.). Champaign, Ill.: Human Kinetics.

64. Ortega, F. et al. (2012). Muscular strength in male adolescents and premature death: Cohort study of one million participants. *British Medical Journal,* 345, e7279.

65. Grøntved, A. et al. (2015). Muscle strength in youth and cardiovascular risk in young adulthood (the European Youth Heart Study). *British Journal of Sports Medicine,* 49, 90–94.

66. Eiholzer, U. et al. (2010). High intensity training increases sponteneous physical activity in children: A randomized controlled trial. *Journal of Pediatrics,* 156, 242–246.

67. Faigenbaum, A. et al. (2015). Benefits of strength and skill based training during primary school physical education. *Journal of Strength and Conditioning Research,* 29, 5, 1255–1262.

68. Faigenbaum, A. et al. (2011). Effects of integrated neuromuscular training on fitness performance in children. *Pediatric Exercise Science,* 23, 573–584.

69. Meinhardt, U. et al. (2013). Strength training and physical activity in boys: A randomized trial. *Pediatrics,* 132, 6, 1–7.

70. Kushner, A. et al. (2015). Training the developing brain Part II: Cognitive considerations for youth instruction and feedback. *Current Sports Medicine Reports,* 14, 3, 235–243.

71. Myer, G. et al. (2015). Sixty minutes of what? A developing brain perspective for activating children with an integrative exercise approach. *British Journal of Sports Medicine,* DOI:10.1136/bjsports-2014-093661

72. Hands, B. (2008). Changes in motor skill and fitness measures among children with high an low motor competence: A five year longitudinal study. *Journal of Science and Medicine in Sport,* 11, 155–162.

73. Keiner, M. et al. (2014). Strength performance in youth: Trainability of adolescents and children in the back and front squats. *Journal of Strength and Conditioning Research,* 27, 2, 357–362.

74. Harries, S., Lubans, D., & Callister, R. (2014). Systematic review and meta-analysis of linear and undulating periodized resistance training programs on muscular strength. *Journal of Strength and Conditioning Research,* 29, 4, 1113–1125.

75. Keats, M., Emery, C., & Finch, C. (2012). Are we having fun yet? Fostering adherence to injury preventive exercise recommendations in young athletes. *Sports Medicine,* 42, 3, 175–184.

76. Csikszentmihalyi, M., Abuhamdeh, S., & Nakamura, J. (2005). Flow. In: A. Elliot (Ed.) *Handbook of Competence and Motivation* (pp. 598–698). New York: The Guilford Press.

77. Myer, G. et al. (2011). Integrative training for children and adolescents: Techniques and practices for reducing sports-related injuries and enhancing athletic performance. *Physician and Sports Medicine,* 39, 1, 74–84.

78. Bedoya, A., Miltenberger, M., & Lopez, R. (2015). Plyometric training effects on athletic performance in youth soccer athletes: A systematic review. *Journal of Strength and Conditioning Research,* 29, 8, 2351–2360.

79. Coutts, A., Murphy, A., & Dascombe, B. (2004). Effect of direct supervision of a strength coach on measures of muscular strength and power in young rugby league players. *Journal of Strength and Conditioning Research,* 18, 316–323.