ANALYTIC REVIEW

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# A Review of the Promotion of Fitness Measures and Health Outcomes in Youth

**Abstract:** *The relationship between physical fitness and health in adults is well established, yet until recently, empirical support for the impact of physical fitness levels on health markers in children has not been thoroughly documented. The aim of this review was to provide a summary of current literature that has examined the linkage between measures of health-related physical fitness (ie, cardiorespiratory fitness, musculoskeletal fitness, flexibility, and body composition) and health markers in youth. Specifically, this review focused on the findings from the recent 2012 Institutes of Medicine report on Fitness Measures in Youth as well as other subsequent review articles related to the topic. In addition, recommendations for health-related fitness assessments in youth populations are presented.*

**Keywords:** youth; health markers; health-related fitness; assessments

## Introduction

Promoting physical fitness in youth in the United States has been a priority for decades. In 1955, President Dwight D. Eisenhower was prompted to create the Council for Youth Fitness in reaction to the noted decline in children's physical fitness.[1] President John F. Kennedy's efforts were also vital to improving the health and well-being of America's youth by promoting the development of youth fitness standards. The first National Survey of Youth Fitness was conducted in 1958, with additional surveys conducted in 1965, 1975, and finally in 1985-1986. Thus, a 30-year span has passed since the last national survey of youth fitness was conducted. Initial youth fitness standards were based on performance in relation to standards of military preparedness.[2] Over time, there was a shift away from performance-related fitness and toward measures of health-related fitness testing because these assessments were thought to be better predictors and facilitators of lifelong health. Interestingly, although the proposed link between fitness testing and health markers/outcomes in youth drove the changes in fitness testing over the decades, this link was never formally established based on research. It is also important to note that secular trends over the past few decades demonstrate decreased health-related fitness levels in youth across the world.[3-5] This decline reiterates the importance of linking aspects of physical fitness to health in youth. In addition, demonstrating a link between fitness levels in youth and adult fitness is important to promote continued health across the lifespan.[6-8]

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The noted decreases in fitness and physical activity levels and increased obesity in youth over the past few decades prompted the Institutes of Medicine (IOM) to convene a committee

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to examine Fitness Measures and Health Outcomes in Youth. The charge of this committee was to review the latest advancements in research related to fitness testing in youth and examine the extent to which health-related fitness is linked to health markers/outcomes in youth. In examining the scientific literature, the committee evaluated the relationships between individual fitness components and health markers/outcomes (eg, cardiovascular disease risk factors, musculoskeletal health, diabetes, obesity, and others).[9] The committee structured their report into 4 classifications of fitness recommendations, which are addressed in the following subsections: (1) body composition, (2) flexibility, (3) cardiorespiratory endurance, (4) musculoskeletal fitness. In addition to the publication in 2012 of the IOM report on Fitness Measures in Youth,[10] additional reviews related to this topic[11-13] have been published, and their findings also have been noted in this report.

## Body Composition

Body composition is a well-established measure of health in youth and adults.[14-16] It is defined as a physiological characteristic that affects an individual's ability to carry out daily tasks with vigor. For the purpose of the IOM review, the committee defined body composition as a marker of health but also noted it as a component of fitness and a modifier of fitness. After an extensive review of fitness test measures related to body composition in youth, the committee identified 10 health-related fitness test batteries (out of a total of 15 in the literature) that used body composition as a component of health-related fitness.

Methods for assessing body composition have generally been developed for adults and have consisted of separating body mass into several elements: fat-free mass, fat mass, total body water, fat-free dry mass, and bone mineral content. Over the past few decades, technology has allowed researchers to analyze body composition more comprehensively. Laboratory tests such as hydrostatic weighing and dual-energy X-ray absorptiometry (DXA) are considered to be highly accurate forms of measuring whole body composition and reduce measurement variations. For the purpose of this review, the methodology used for each test will not be discussed in depth. However, these tests require specific training and expensive equipment. Thus, the use of field-based assessments (eg, skinfolds, body mass index [BMI], and waist circumference), which are noted as valid and reliable in youth, have been preferred for large-scale population-based studies.

The literature indicates that body composition status affects physiological and psychological health in youth in several different ways. Obesity in youth is associated with cardiovascular risk factors such as high blood pressure and abnormalities in left ventricular mass and/or function.[17] Other health consequences such as diabetes and asthma have been linked to the rise in an individual's weight status.[18] Children who are classified as obese also are more likely to exhibit more psychological or psychiatric problems than those children who are nonobese.[18] Specifically, increased BMI is associated with lower self-perceptions of social acceptance and physical appearance.[19-21] Children who demonstrate low perceptions of self-concept also are generally less willing to participate in activities with peers.[22-24] Deficits in cognitive function also have been associated with obesity in children as well as adults.[25]

Body composition status was also considered a modifying factor of fitness by the committee and independently affects an individual's current level of fitness and the continued development of fitness. Being obese promotes a negative cycle of global fitness as individuals with excess body mass have decreased cardiorespiratory fitness and decreased muscular endurance.[26,27] Thus, these individuals are not able to persist in health-enhancing physical activities for as long as other individuals who are more fit. In addition, being obese limits an individual's functional capability to successfully perform many activities that require the manipulation of one's entire body mass,[28-33] which again, decreases time spent in physical activity. Overall, obesity in early childhood perpetuates negative developmental trajectories of fitness and physical activity across middle and late childhood[26-28,30,32,33] and continued obesity into adolescence and adulthood.[34-36]

When assessing body composition across various ages in youth, various moderating factors such as age, sex, and maturation status influence body composition status and should be considered when interpreting the results. Variations in fat-free mass, fatness, and relative fat distribution in late childhood and adolescence also affect body composition status[37] and are important when interpreting results. In addition, the influences of these moderating factors vary by sex. During childhood, an individual has not reached maturity at the cellular level; thus, age differences that coincide with natural growth patterns between boys and girls makes it difficult to adequately assess a person's body composition across childhood.[38,39] Fat mass and fat-free mass are factors that also are affected by age and sex. For girls, fat mass increases more rapidly than for boys during childhood, and this trend continues throughout adolescence. Thus, sex differences create a dispersion of body composition among adolescents.[40] Other important variations in body composition that are influenced by age and sex include weight-for-height, subcutaneous fat, and relative fat distribution.[41-43]

Race and ethnicity also affect the interpretation of body composition assessments. Gender differences among ethnicities are similar; however, elements such as fat-free mass and bone mineral content differ from ethnicity to ethnicity.[44,45] For example, American Indian/Native Alaskan children tend to demonstrate the highest prevalence of obesity, followed by Hispanic and non-Hispanic black children.[46] Overall, differences in body composition status may be affected by many modifying factors.

### Selection of Test

The final task of the committee was to choose the most appropriate measures of body composition for youth populations. Taking into consideration issues with feasibility, cost, training, and validity, the IOM committee recommended 3 measures of body composition that should be used for testing youth on a population-based scale. These recommendations also were based on their relationship to health markers in youth. The tests include skinfold, BMI, and waist circumference assessments.

Sum of skinfolds are considered valid and reliable estimates of subcutaneous fat and predictors of percentage body fat in youth.[47,48] Skinfolds have been measured using several different sites and have been standardized to ensure accuracy. When assessed correctly, the skinfold test is used to estimate the relative subcutaneous fat distribution of the trunk and extremities. The committee recommends the use of the triceps and the subscapular skinfold thickness body composition measurement in youth.[10,49,50]

BMI is an indicator of mass for height and is the most common assessment for weight status used in youth. It is reasonably well correlated with fat mass and percentage body fat in heterogeneous samples of youth.[51] However, this measure has several limitations. It is important to understand that individuals with the same BMI can differ in both fat mass and percentage body fat.[16] This being said, BMI is suggested to be more appropriately used as an indicator of weight status and has the potential to be an indicator of fatness in the general population.[52-54] Because of the sensitivity of the educational setting, the committee only recommends this measurement to be used in the school setting.

Waist circumference has been shown to be a valid measure of central adiposity and a good predictor of body fat distribution in youth.[55-57] Studies have shown that waist circumference is strongly associated with abdominal adiposity in children.[58] Waist circumference also is noted to be a good indicator of abdominal adiposity, which provides information about different dimensions of body composition that are linked to health risks[59]; however, waist circumference may not be the best indicator for percentage body fat or fatness in youth.

### Conclusions

The committee recommends that the interpretations of results of the above-noted body composition measures be approached in 2 ways. First, the committee recommends the use of the Centers for Disease Control's (CDC's) currently established cut-points for underweight, overweight, and obesity. The 2000 CDC BMI-for-age charts are widely used and recommended for children 2 to 20 years old in the United States.[16,60] For the remaining 2 measurements, the cut-points should be set at levels that are analogous to those currently being applied by the CDC for BMI.

## Flexibility

Flexibility is defined as the range of motion of muscle and connective tissues at a joint or group of joints. Previous literature examining the association between flexibility and any health outcome in adults has been unclear, and research addressing the association of flexibility and health-related markers in youth is limited. Similar to the literature dealing with adults, the links between flexibility and other outcomes in youth are difficult to explain. Secular trends have demonstrated that youth in the present day are less flexible than those in the 1980s.[10] However, these data have not led to the establishment of a link to health markers.

The American College of Sports Medicine suggests that flexibility exercises may enhance postural stability, balance, and functional capacity[61]; however, research results have been inconclusive.[10] Several studies with adults who have health issues have demonstrated improvements in function and pain, but very few have focused on changes in flexibility. Complicating the association between flexibility and health outcomes, research examining flexibility and function in older populations are hard to generalize because of the individual's current physical status.

A literature search screened a total of 6016 studies that addressed some aspect of flexibility in youth. Because of limited resources and time, the CDC did not abstract those articles. Because of the lack of specific evidence, the IOM presented findings from studies conducted in youth regardless of the quality of evidence that supported a relationship between flexibility and health outcomes. Based on the 16 studies included, results demonstrated that programs designed for physical activity in youth improved flexibility even though it was not an intended outcome.[62-64] In addition, research suggests that youth who are less active may have a higher risk for low-back pain, but a direct link to this potential health-related issue has not been established.[65]

A total of 7 studies examined the relationship between flexibility and pain outcomes, but only 1 study directly linked health outcomes that are commonly associated with flexibility. Similar to body composition, differences in flexibility were noted between sex and ethnicities among youth. Women generally are more flexible than men,[66-68] and longitudinal data demonstrate a decrease in flexibility scores in both sexes based on data collected in the 1980s. One recent longitudinal study indicated that girls actually improved their sit-and-reach scores over a 6-year period, whereas boys' performance decreased.[69]

### Selection of Test

Flexibility tests measure joint range of motion (ROM) and generally can be classified into laboratory test and field tests. Unlike other fitness components, flexibility is systemic in nature, yet assessments generally are specific to individual joints. The specificity of flexibility for individual joints of the body makes it difficult to isolate a single flexibility-related factor contributing to health outcomes. In lieu of these issues, the most common fitness batteries have generally used 3 flexibility tests: shoulder stretch, trunk lift, and sit-and-reach tests. The sit-and-reach test, which is the most common test used in youth, has been used to assess low-back and hip flexibility; however, it has been shown to be more of an indicator of hip flexibility rather than low-back flexibility.[10]

### Conclusions

Although validity and reliability of some of the flexibility tests in youth have been established, the degree to which a test, such as the sit-and-reach, is an indicator of overall flexibility is still unclear. Unlike other variables of health-related fitness, flexibility does not relate to other health outcomes in a linear fashion. Because of this lack of evidence, the committee felt that the flexibility component is not a priority when assessing fitness. However, it should be considered when conducting fitness assessments as a whole because of its potential link to health in adulthood. These tests can be used to educate youth as well as parents about their child's overall fitness level.

## Cardiorespiratory Endurance

Cardiorespiratory endurance has been noted as a cornerstone of physical fitness throughout history and is defined as the ability to perform large-muscle, whole-body exercise at a moderate to high intensity for an extended period of time.[70] High levels of cardiorespiratory endurance are associated with a wide range of health benefits in adults, including a lower risk of cardiovascular disease,[71-73] type 2 diabetes,[74] hypertension,[75] certain cancers,[76] and premature mortality from all causes.[7,8,72,] Although health outcomes resulting from the development of cardiorespiratory endurance in adults are well known,[12] relationships between cardiorespiratory endurance and health outcomes in youth are not as well understood.

For the purposes of the IOM report, 4795 studies were initially identified, of whom 260 fit criteria for further consideration. There were 56 experimental, 24 longitudinal prospective, and 29 quasi-experimental studies that were considered high-quality studies and were provided foundational data for the report. The following criteria were utilized to determine high-quality studies: the study must have (1) provided a link between a candidate measure of cardiorespiratory endurance to a positive health outcome; (2) provided a marker or risk factor in either adiposity, metabolic risk, cognitive, or "other"; and (3) presented direct or associational evidence to a health risk factor or outcome. Studies were excluded for the following reasons: poor design, inappropriate population and lack of power, inability to assess the independent effect of dietary intervention, or an insufficient change in the fitness measure of interest.

Overall, the committee concluded that sufficient evidence has established a link between cardiorespiratory endurance and health in youth. Specifically, studies showed linkages between high levels of cardiorespiratory endurance and a wide range of health benefits: (1) adiposity,[76-80] (2) blood pressure,[81-83] (3) blood lipids,[83-85] (4) glucose,[86] and (5) insulin sensitivity.[85,87] Some studies also found a relationship with other pediatric health risk factors, including pulmonary function, depression, a positive self-concept, and bone health. However, the standards for noting risk in each category were not as well established.[80,88,89]

Importantly, the following benefits of cardiorespiratory endurance are continued into adulthood: decreased risk of cardiovascular disease,[71-73] type 2 diabetes,[74,70] certain cancers,[76] and premature all-cause mortality.[7,8,72] It was noted that youth in the lowest 20th percentile of cardiorespiratory endurance demonstrate the highest risk for cardiovascular-related negative health outcomes. The recommendation to use the 20th percentile as a cut-point for determining health risk was derived from its association with morbidity and mortality throughout the lifespan.[72] The 20th percentile is more conservative than the 30th percentile, as suggested by Lobelo et al[90] and Welk et al,[91] and is recommended for use based on the viewpoint that identifying a fit individual as low fit is a greater error than concluding that an individual who is low fit is fit.

### Selection of Tests

Cardiorespiratory endurance capability is the greatest rate at which a person is able to consume oxygen during sustained, exhaustive exercise. The tests noted in the literature that most closely related to this definition and that have shown the greatest association with a positive change in health markers in youth were the shuttle run, treadmill, and cycle ergometer tests. It is important to note that although traditional distance-based fitness tests (eg, 1 or 2 mile runs) have a long history,[86,88,92,] there was limited evidence linking these types of tests to health markers in youth.[49,86,88,92,93]

Shuttle run testing protocols noted in the literature included the 6-minute, 20-m shuttle run and various 20-m multistage incremental tests. The majority of associations to health were with adiposity (measured BMI). Other factors such as blood lipids were noted in some studies, but their correlations were limited because of the location of the studies, most of which took place in a school setting.[94-97] Improvements in bone health, blood pressure, BMI, and blood lipids also were related to increased cardiorespiratory endurance over time increments of 1 to 5 years. The shuttle run has proven to be a safe test that can be effectively administered with an understanding of the procedures for testing and safety. For example, Ruiz et al[98] have reported testing more than 10 000 children, with no safety issues occurring during testing. The 20-m shuttle run (eg, PACER) demonstrates adequate reliability ($r$ = 0.78 to 0.93)[99] and validity ($r$ = 0.87 and 0.72)[100,101] and is the protocol used most often in the literature when compared against $VO_{2max}$ performance.

Treadmill maximal and submaximal endurance testing protocols demonstrate decreased adiposity (skinfold and DXA), BMI, and waist circumference as well as an increase in $VO_{2max}$ with increased test performance.[76-79] Treadmill testing protocols also have proven themselves to be safe and reliable and require a minimal amount of space to perform. Most notably, the effectiveness of treadmill protocols was shown in a longitudinal study by Eisenmann et al,[76] spanning adolescence to adulthood (mean age = 26 years), where the time to reach exhaustion on the treadmill in adolescence was correlated with both adult body fatness and changes in body fatness from adolescence to adults. Treadmill testing also has demonstrated strong validity with other criterion tests ($r$ = 0.84)[100] and is highly reliable, with test-retest correlation coefficients ranging from 0.89 to 0.98.[102,103]

Strong evidence associated cardiorespiratory endurance with adiposity, cardiometabolic risk factors, and blood pressure.[85,87,89,104-108] Specifically, an improvement in cardiorespiratory endurance as well as positive changes in total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and adiposity measures were noted in youth tracked over a 6-year period, spanning from childhood to adolescence.[106,108] Other studies also noted an improvement in depression and positive self-concept that were mitigated by increased fitness.[89,105]

Limited data have addressed the role of several potential important modifiers that may have an impact on the effect of cardiorespiratory endurance on health. These factors include age, gender, race, body composition, and maturation status. Accounting for maturation stage,[77,78] specific ethnicities and gender, and the impact of baseline fitness are important when considering cardiorespiratory fitness levels and their relationship to changes in health markers. Overall, the strongest associated evidence of the effect of independent moderating factors for cardiorespiratory endurance and health-related risk factors was adiposity. Further research is warranted to better understand the role of these modifiers on the relationship between cardiorespiratory endurance and health risk factors.

### Conclusion

Based on the relationship to health markers and also feasibility for testing in youth, a timed or progressive shuttle run, such as the 20-m shuttle run or PACER test is most appropriate for measuring cardiorespiratory endurance in youth. The submaximal treadmill or cycle ergometer tests were noted as feasible alternative tests if testing limitations did not allow the PACER test.

## Musculoskeletal Fitness

Musculoskeletal fitness, as defined by the IOM committee, is "a multidimensional construct comprising the integrated function of muscle strength, muscle endurance, and muscle power to enable the performance of work against one's own body weight or an external resistance. (p. 155)"[10] Each dimension of musculoskeletal fitness, although integrated, should be assessed independently against health markers and then interpreted collectively to provide an overall understanding of its impact on health.[109] Muscular strength is defined as the ability of a muscle group to develop maximal contractile force against a resistance in a single contraction type (concentric, isometric, or eccentric).[110-112] Muscular endurance is the ability of a muscle group to exert submaximal force for extended periods.[111] Finally, muscle power refers to the ability of the neuromuscular system to produce the greatest possible impulse (ie, force per unit time).[112] The following section discusses how each of these components to musculoskeletal fitness are tested and how each is related to health.

More than 11 different body-region-specific classes of fitness test items (eg, upper-body strength, lower-body strength, abdominal endurance) were identified in the literature dating back to the mid 1970s. In addition, multiple variations of body-site-specific tests (eg, pull-ups, modified pull-ups, and isometric bent arm hang) have been developed.[113-116] Many field-based muscular strength and power tests are not considered to be as physiologically valid as muscle endurance fitness tests in youth because they require one to control the speed of a specific load through a specific number of repetitions.

Of 2642 reports initially screened for muscular strength, 63 satisfied the CDC search criteria. Out of the 63 studies, 23 were classified as experimental, 22 as experimental with no control, 12 as quasi-experimental, and 6 as longitudinal. The muscle endurance search screened 6563 reports, 38 of which satisfied the CDC search criteria. Out of the 38 studies, 12 were classified as experimental, 15 as experimental with no control, 6 as quasi-experimental, and 5 as longitudinal. The committee also considered studies that used field-based power tests that incorporated a single maximal effort at a submaximal speed and a load (vertical and horizontal jump) as they are moderately to strongly related to criterion measures of muscular strength.[117,118] The following criteria were utilized to determine high-quality studies: (1) each study was evaluated against a set of criteria (eg, study design, representativeness of the population, and freedom from bias), and only those of high quality were reviewed further; (2) the evidence was categorized as direct or associational based on the strength of the study design and the rigor of the statistical analysis; and (3) the strength of the evidence was categorized as sufficient or insufficient based on the number of studies with direct or indirect evidence, the study designs, and the statistical significance of the association.

As noted by the IOM committee, currently, there is a lack of high-quality experimental studies that demonstrate a link between performance on any single musculoskeletal fitness test and health outcomes or markers in youth. However, research documenting a variety of health benefits stemming from resistance training programs in youth has emerged in the past 15 years.[119-121] Benefits from resistance training programs include improved (1) body composition,[106,117,122,123] (2) blood glucose and insulin regulation,[122,124] (3) systemic arterial blood pressure in prehypertensives,[106,125] (4) blood lipid and lipoprotein profiles,[106,126] and (5) bone health and management of arthritic pain and disability.[118] Resistance training also has resulted in (6) an increase in functional capacity, (7) improved balance, (8) a decrease in falls, (9) improved quality of life, (10) self-efficacy,[119,127] and (11) decreased levels of depression and anxiety[123,128] into adulthood.

### Selection of Tests

Emerging evidence noted a relationship between handgrip and standing long jump tests with health markers (ie, bone health and body composition) in youth.[106,117,126,129,130] These 2 tests demonstrate acceptable reliability and concurrent validity with lower- and upper-body criterion strength measures while maintaining applicability across a broad age range in both sexes and in both normal and special pediatric subpopulations. Therefore, these 2 tests were summarily recommended for use in youth fitness testing.

The handgrip strength test has shown moderate to strong construct validity ($r$ = 0.52-0.84) with established upper-body and lower-body strength tests (ie, 1-RM bench press and leg press, isometric kinetic knee extensor torque, respectively)[131,132] and strong reliability ($r$ = 0.71-0.90) in children and adolescents.[133-135] There is also minimal test-related learning fatigue effects.[11] Furthermore, this test requires a minimal level of experience to perform, which diminishes the amount of practice needed to achieve an accurate depiction of a person's muscular skeletal strength and power.

The standing long jump has been used as a test of lower-body muscular strength, power, and explosive strength. In youth, this test demonstrates a moderate correlation with 1-RM leg press/body weight (0.39)[132] and isokinetic quadriceps torque ($r$ = 0.50)[131] and a strong correlation with total-body isometric strength (0.77).[136] Additionally, the SLJ correlates strongly ($r$ = 0.70-0.91) with other lower- and upper-extremity field-based power tests such as vertical jump, countermovement vertical jump, and upper-body explosive throw in youth (ages = 6-17 years) while controlling for gender, age, and BMI or weight.[132,136] Controlling for height and body mass with both the standing long jump and grip strength provides a more valid assessment of lower-body strength and power across all ages.[132,136]

Other musculoskeletal tests such as the push-up, modified pull-up, curl up, and more recently, the isometric knee extension also have been examined in youth studies; however, there was limited evidence linking these types of tests to health markers.

### Limitations

The vast majority of studies examined in the IOM review were not designed to answer questions about the specific test used and their effects on health markers. Many studies also were underpowered in relation to their ability to detect significant relationships, and many studies examined narrow age ranges. Furthermore, a majority of the studies failed to consider potential study confounders (eg, a combination of endurance, strength, and power exercises without a focus on a particular dimension), leaving the researchers to make indirect inferences relating to the test's ability to affect health markers. Finally, many studies were limited to isolated regions of the body (eg, modified pull-up focusing on upper-body strength), removing the ability to accurately infer results related to total-body musculoskeletal fitness levels.

### Conclusions

The committee's review concluded that there currently exists a sufficient amount of evidence asserting that musculoskeletal fitness is related to health in humans. This conclusion was based on the importance of musculoskeletal fitness, especially muscle strength and power, to health markers in adults. Handgrip and standing long jump have been shown to have a growing base of evidence supporting their association to musculoskeletal fitness in youth. Overall, additional high-quality research is needed to link any of the aforementioned musculoskeletal tests to independent health risk factors in youth.[126,137-143]

Resistance training in youth is safe[144-150]; however, training programs must be implemented with caution because children generally do not have experience with various types of resistance training. Resistance training in a youth population requires a properly designed program that is professionally supervised to ensure safety and optimal benefits for youth. A properly designed and supervised resistance training program can (1) enhance the muscular strength and power, (2) decrease cardiovascular risk, (3) improve motor skill performance, (4) contribute to enhanced sports performance, (5) increase a young athlete's resistance to sports-related injuries, and (6) help promote and develop exercise habits during childhood and adolescence.[145] It is recommended that youth resistance training programs focus on effectively manipulating one's own body mass (eg, push-ups, pull-ups, bodyweight squats, body weight lunges) before adding external resistance, specifically with consideration for developmental status.[151]

## Future Implications

A global understanding of the predictive utility of physical fitness testing on health markers/outcomes in youth has not yet been fully demonstrated by the existing literature (ie, flexibility and musculoskeletal endurance). The following recommendations were designed to help fill the eminent need for understanding in this area and to help guide the design of future studies:

1. Well-designed research studies aimed at advancing understanding of the associations between fitness components and health in youth are needed.
2. Longitudinal studies should be conducted to provide empirical evidence concerning how health markers related to fitness track across the lifespan.
3. Randomized controlled trials and longitudinal studies should be designed to address the relationship between body composition and fitness tests and

the potential effects of modifying factors (ie, age, gender, body composition) on the relationship between a change in a health-related fitness component and health markers in specific populations.
4. National surveys of health-related physical fitness in youth should include measures of cardiometabolic health, bone health, psychological health and neurocognitive function.
5. Once a health marker is confirmed, research should be conducted to establish and validate health-related cut-points for that test that can be used across all ages in youth.[10,144]

Finally, effective communication of test results is vital when the goal is improved fitness of the test taker, so that a child or adolescent is not derailed from a path of achieving a positive goal. Improved fitness should be one goal of any fitness intervention or program; however, across a continuous background of interpretation, communication that is intended to be encouraging could be interpreted as belittling and could derail a child from a path of future fitness. Understanding that a positive attitude should be displayed at all times and how to communicate an interpretation of an individual's test results in a manner that is appropriate to attaining achievable fitness goals is paramount to the success of sustainable, lifelong fitness.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. AJLM

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