Developmental Differences Between Boys and Girls Result in Sex-Specific Physical Fitness Changes From Fourth to Fifth Grade

Article *in* The Journal of Strength and Conditioning Research · September 2014

DOI: 10.1519/JSC.0000000000000623 · Source: PubMed

CITATIONS
4

READS
761

19 authors, including:

Shawn D Flanagan
University of Pittsburgh
85 PUBLICATIONS **568** CITATIONS
SEE PROFILE

Courtenay Dunn-Lewis
University of Pittsburgh
80 PUBLICATIONS **792** CITATIONS
SEE PROFILE

Disa Hatfield
University of Rhode Island
126 PUBLICATIONS **2,157** CITATIONS
SEE PROFILE

Lindsay J Distefano
University of Connecticut
87 PUBLICATIONS **1,109** CITATIONS
SEE PROFILE

Developmental Differences Between Boys and Girls Result in Sex-Specific Physical Fitness Changes From Fourth to Fifth Grade

Shawn D. Flanagan,[8] Courtenay Dunn-Lewis,[2] Disa L. Hatfield,[3] Lindsay J. Distefano,[1] Maren S. Fragala,[4] Mark Shoap,[5] Mary Gotwald,[5] John Trail,[5] Ana L. Gomez,[8] Jeff S. Volek,[8] Cristina Cortis,[6] Brett A. Comstock,[1] David R. Hooper,[8] Tunde K. Szivak,[1] David P. Looney,[1] William H. DuPont,[1] Danielle M. McDermott,[1] Michael C. Gaudiose,[7] and William J. Kraemer[8]

[1]Human Performance Laboratory, Department of Kinesiology, University of Connecticut, Storrs, Connecticut; [2]Department of Health Sciences, School of Science and Engineering, Merrimack College, North Andover, Massachusetts; [3]Department of Kinesiology, University of Rhode Island, Kingston, Rhode Island; [4]Department of Educational and Human Sciences, College of Education and Human Performance, University of Central Florida, Orlando, Florida; [5]Department of Wellness and Fitness, Chambersburg Area School District, Chambersburg, Pennsylvania; [6]Department of Human Sciences, Society and Health, University of Cassino and Lazio Meridionale, Cassino, Italy; [7]Cumberland Valley Family Physicians, Chambersburg, Pennsylvania; and [8]Department of Human Sciences, The Ohio State University, Columbus, Ohio

Abstract

Flanagan, SD, Dunn-Lewis, C, Hatfield, DL, Distefano, LJ, Fragala, MS, Shoap, M, Gotwald, M, Trail, J, Gomez, AL, Volek, JS, Cortis, C, Comstock, BA, Hooper, DR, Szivak, TK, Looney, DP, DuPont, WH, McDermott, DM, Gaudiose, MC, and Kraemer, WJ. Developmental differences between boys and girls result in sex-specific physical fitness changes from fourth to fifth grade. *J Strength Cond Res* 29(1): 175–180, 2015—To better understand how developmental differences impact performance on a broad selection of common physical fitness measures, we examined changes in boys and girls from fourth to fifth grade. Subjects included 273 boys (age, 9.5 ± 0.6 years; height, 139.86 ± 7.52 cm; mass, 38.00 ± 9.55 kg) and 295 girls (age, 9.6 ± 0.5 years; height, 139.30 ± 7.19 cm; weight, 37.44 ± 9.35 kg). We compared anthropometrics, cardiorespiratory and local muscular endurance, flexibility, power, and strength. A mixed-method analysis of variance was used to compare boys and girls at the 2 time points. Pearson correlation coefficients were used to examine relationships between anthropometric and fitness measurements. Significance was set at $p \leq 0.05$. Weight increased significantly (>10%) in both sexes, and girls became significantly taller than boys after growing 4.9% by fifth grade (vs. 3.5%). Both groups improved cardiorespiratory endurance and power, although boys performed better than girls at both time points. Boys were stronger in fourth grade, but girls improved more, leading to similar fifth-grade values. Girls were more flexible in fourth grade, but their significant decreases (~32.4%) coupled with large improvements in boys (~105%) resulted in similar fifth-grade scores. Body mass index (BMI) was positively correlated with run time regardless of grade or sex. Power was negatively correlated with BMI and run time in fourth grade. In conclusion, sex-specific differences in physical fitness are apparent before pubescence. Furthermore, this selection of measures reveals sexually dimorphic changes, which likely reflect the onset of puberty in girls. Coaches and teachers should account these developmental differences and their effects on anthropometrics and fitness in boys and girls.

Key Words physical activity, pubescence, body composition, longitudinal study, anthropometrics, body mass index

Introduction

Childhood fitness provides a number of important benefits, including improved cardiovascular and skeletal muscle health (14,24), lower adiposity (1,15,24), and positive effects on depression, anxiety, and academic performance (24). Moreover, physical activity, cardiorespiratory fitness, overall adiposity, body composition, and muscular strength appear to track from childhood (17) into adulthood (5,13,27). There is a strong association between physical fitness and both cardiovascular and cancer-related disease (4). Accordingly, childhood physical activity is a standard component of efforts to improve public health.

Address correspondence to William J. Kraemer, kraemer.44@osu.edu.

29(1)/175–180

Journal of Strength and Conditioning Research

Because sex-specific developmental differences can influence physical fitness (18,29), cross-sectional comparisons are difficult to interpret even if boys and girls are of similar chronological age, varying biological age may result in substantial differences in fitness. A better understanding of the sexually dimorphic patterns of change in fitness could serve to enhance exercise prescription, as well as the assessment and comparison of physical fitness performance scores in boys and girls in the relevant age range.

In this investigation, we use a longitudinal approach and a broad set of physical fitness indicators to provide insight on sex-specific differences in physical fitness while accounting for different rates of development. Here, we report our initial work on a cohort of boys and girls who performed physical fitness tests in the fourth and fifth grades. This period of time was selected because it provides insights on an important developmental window, where pubescence often appears in girls. Accordingly, we expected to observe sex-specific changes in height and weight, in addition to unique patterns of physical fitness change.

Methods

Experimental Approach to the Problem

To better understand how sex-specific differences in development affect physical fitness, performance tests were performed in the fourth grade, and then 1 year later in the same boys and girls. A longitudinal approach permitted sex-specific comparisons of physical fitness at each time point, while accounting for individual differences in development that occurred from fourth to fifth grade, where pubescence would be expected to occur in many of the girls. The subjects performed a series of tests, including a timed mile run, 1-minute curl-up repetition maximum, sit and reach, standing broad jump distance, and grip strength. We chose the aforementioned tests because they provide a broad indication of physical fitness, including cardiorespiratory and local muscular endurance, flexibility, and muscular strength and power.

Subjects

Subjects included 273 boys (age, 9.54 ± 0.57 years; height, 139.86 ± 7.52 cm; mass, 38.00 ± 9.55 kg) and 295 girls (age, 9.56 ± 0.53 years; height, 139.30 ± 7.19 cm; weight, 37.44 ± 9.35 kg) from schools in the Chambersburg, PA, district. The study was approved by the institutional review board for use of human subject research in addition to the Chambersburg School Board. Potential subjects and their parents or guardian(s) were informed of the purpose, benefits, and potential risks of the study, and then provided written informed consent to participate.

Procedures

Trained physical education teachers and school nurses performed all fitness tests. Three attempts were given for the sit and reach, standing broad jump, and grip strength tests, and the best of the 3 trials was used for analysis. One attempt was given for the remainder of tests. Tests were performed at a similar time during each academic school year, under similar environmental conditions. At each respective school, subjects used the same running track and gym equipment. Students participated in the Chambersburg Area School District physical education program, which used a similar 2 or 3-day per week curriculum, with some instructor discretion.

Cardiorespiratory fitness was assessed using a timed 1-mile run test on a premeasured track. Before the test, all subjects were led through standardized stretching and warm-up exercises. Subjects were instructed to complete the 1-mile run as fast as possible by either walking or running.

Muscular endurance was assessed using an abdominal curl-up test. Subjects were instructed to complete as many curl-ups as possible in 1 minute. Students lied on their back in the supine position with their knees bent, feet secured to the floor by another student, and arms crossed over their chest. To complete each repetition, students curled up until their elbows touched their thighs; repetitions performed incorrectly were not counted.

Hamstring and lower-back flexibility were assessed with the sit and reach test. Students sat on the floor with their legs positioned together and their knees fully extended with both feet placed against a standard sit and reach box. Subjects were instructed to lean forward and reach toward or beyond their toes while keeping their arms and legs fully extended. A ruler fixed to the top of the box was used to measure flexibility.

Lower-limb muscle power was measured with a standing broad jump test. In the baseline position, subjects were instructed to stand behind a marked line with their feet shoulder width apart. To complete the test, subjects were instructed to bend at the knees, jump as far as possible using a double-arm swing, and land on both feet without falling backwards.

Maximum isometric handgrip strength was measured using a handheld dynamometer (Takei Scientific Instruments Co., Niigata City, Japan). From the anatomical position, subjects were instructed to squeeze the dynamometer as hard as possible with their dominant hand in a neutral position. Dynamometer sizing was adjusted for each subject, in accordance with the manufacturers' guidelines.

Statistical Analyses

Data are presented as mean ± *SD* values. For each fitness test, the procedure was assessed extensively for reliability. Accordingly, inter- and intraclass correlation coefficients for all dependent variables exceeded 0.90. All data met the assumptions for linear statistics. A 2 sex (boys vs. girls) by 2 grade (fourth vs. fifth) mixed-method analysis of variance was used to detect the presence of significant differences for each dependent variable. When significant differences were found, pairwise comparisons were made using Fisher's

Least Significant Difference test. Relationships between anthropometric and fitness measurements were determined using Pearson correlation coefficients. Correlations between fitness measures were also examined using Pearson correlations. Statistical analysis was performed using SPSS software, version 10.0 (SPSS, Inc, Chicago, IL, USA). Significance was set at $p \leq 0.05$.

Results

Table 1 shows the results for all subjects. Unless otherwise noted, all reported comparisons and relationships were significant at the $p \leq 0.05$ level. The mean age for fourth and fifth grade boys and girls was 9.54 ± 0.57 and 9.56 ± 0.53, and 10.70 ± 0.50 and 10.71 ± 0.53, respectively. Height was similar for girls and boys in fourth grade (139.28 ± 7.18 vs. 139.86 ± 7.53 cm, respectively). However, girls were significantly taller than boys in fifth grade (146.23 ± 8.19 vs. 144.82 ± 7.86 cm). Weight and body mass index (BMI) did not differ between boys and girls at either grade level, but these measures increased in both sexes from fourth to fifth grade.

Fitness Test Results

Cardiorespiratory and Local Muscular Endurance. Boys completed the mile run faster than girls in both grades (fourth grade: 9.94 ± 2.39 vs. 10.55 ± 2.20 minutes; fifth grade: 9.27 ± 2.07 vs. 10.28 ± 2.19 minutes). Nevertheless, mile run times improved in both sexes. In fourth grade, boys performed more curl-ups (38 ± 9) than girls (36 ± 9). In fifth grade, however, the number of curl-ups was similar.

Flexibility. Girls scored better on the sit and reach test in fourth grade (10.2 ± 8.1 vs. 6.9 ± 8.6 cm). Boys improved flexibility from fourth to fifth grade (3.6 ± 8.4 vs. 7.4 ± 9.4 cm), whereas girls performed significantly worse (10.2 ± 8.1 vs. 6.9 ± 8.6 cm), resulting in similar values in fifth grade.

Muscular Power and Strength. Boys jumped further than girls in both grades (fourth grade: 155.24 ± 22.84 vs. 150.91 ± 20.92 cm; fifth grade: 156.76 ± 20.25 vs. 152.15 ± 23.80 cm). However, neither of the 2 groups demonstrated significant changes in power over time. In fourth grade, boys demonstrated greater grip strength (21.94 ± 4.15 vs. 19.71 ± 4.50 kg). Girls increased their grip strength, however (19.71 ± 4.50 vs. 20.86 ± 4.43 kg), whereas boys did not change, resulting in similar fifth-grade values.

Regression Analyses. ***Relationship Between Anthropometric and Fitness Measures.*** Body mass index was positively correlated with mile run time in boys and girls in both grades (fourth grade boys and girls: $r = 0.533$ and 0.410; fifth grade boys and girls: $r = 0.470$ and 0.453). In addition, BMI was negatively correlated with number of curl-ups in fourth grade (−0.231 in boys and −0.195 in girls) and standing broad jump in fourth grade (−0.433 in boys and −0.488 in girls).

Fitness Measures. Mile run time was inversely related to the number of curl-ups performed by boys and girls in both grades (fourth grade boys: $r = -0.259$, girls: $r = -0.128$; fifth grade boys: $r = -0.152$, girls: $r = -0.146$). Regardless of sex, mile run time was negatively correlated with standing broad jump distance in fourth grade (boys: $r = -0.679$; girls: $r = -0.538$). Flexibility was associated with a number of physical performance measures. In girls, lower sit and reach scores were associated with longer mile run times in fourth and fifth grades ($r = -0.162$ and −0.130, respectively). Greater flexibility was also associated with greater muscular power, regardless of grade or sex (fourth grade boys: $r = 0.251$, girls:

Table 1. Anthropometric and fitness performance data in fourth and fifth grade boys and girls.*

	Fourth Grade		Fifth Grade	
	Boys	Girls	Boys	Girls
Age (y)	9.54 ± 0.57	9.56 ± 0.53	10.70 ± 0.50	10.71 ± 0.53
Height (cm)	139.86 ± 7.53	139.28 ± 7.18	144.82 ± 7.86	146.23 ± 8.19†‡
Weight (kg)	38.00 ± 9.55	37.45 ± 9.34	42.56 ± 10.27‡	43.04 ± 11.75‡
Body mass index ($kg \cdot m^{-2}$)	19 ± 4	19 ± 4	20 ± 4‡	20 ± 4‡
Mile run (min)	9.94 ± 2.39†	10.55 ± 2.20	9.27 ± 2.07†‡	10.28 ± 2.19‡
Curl-ups (#)	38 ± 9†	36 ± 9	38 ± 9	38 ± 9
Sit and reach (cm)	3.6 ± 8.4	10.2 ± 8.1†	7.4 ± 9.4‡	6.9 ± 8.6‡
Broad jump (cm)	155.24 ± 22.84†	150.91 ± 20.92	156.76 ± 20.25†	152.23 ± 22.80
Grip strength (kg)	21.94 ± 4.15†	19.71 ± 4.50	22 ± 5	20.86 ± 4.43‡

*Data are reported as mean ± *SD*.
†Significant between-group difference.
‡Significant change from previous year.

$r = 0.185$; fifth grade boys: $r = 0.153$, girls: $r = 0.232$). Finally, a relationship between lower-body power and upper-body strength was apparent, as standing broad jump distance was positively correlated with handgrip strength in fourth grade girls ($r = 0.190$) and fifth grade boys ($r = 0.225$).

Discussion

We observed sex-specific changes in physical fitness from fourth to fifth grade. At both grade levels, boys and girls differed mostly in cardiorespiratory fitness and lower-body power, where boys outperformed girls. From fourth to fifth grade, however, girls experienced improvements in local muscular endurance and upper-body strength, resulting in similar performance on the sit-up and handgrip tests. Conversely, losses in flexibility resulted in similar fifth grade performances on the sit and reach; improved flexibility in boys also partially explains this observation. Since girls became taller than boys by fifth grade, many of the observed differences in physical fitness could be explained by differences in the onset of pubescence. During this period, sex hormone–induced increases in muscle mass would allow for improvements in strength, cardiorespiratory, and local muscular endurance, as we observed. However, disproportionally large increases in lower-body bone length (vs. increases in hamstring muscle length) negatively affected girls' flexibility, as previously shown (21,31). Improvements in physical fitness were generally inversely related to BMI, but otherwise interrelated. This would suggest that increases in height should offset or exceed changes in body mass, and that increased BMI likely reflects increased fat mass in the age range from 9 to 11 years of age, increased BMI likely reflects increased fat mass. Finally, the specificity of sex-specific differences in fitness changes in fourth and fifth grade boys and girls underscores the need to consider developmental status before physical activity prescriptions or fitness assessments are made.

Overall, development from fourth to fifth grade was associated with increased cardiorespiratory endurance, as measured by 1-mile run time. Improvement in cardiorespiratory endurance reflects increases in percent of peak oxygen consumption and the economy of oxygen use, which are accepted components of maturation (8). Boys performed better in the mile run and standing broad jump in both grades, indicating better aerobic fitness and lower-body power when compared with girls, as reported elsewhere (3,7,23). However, improvements in power from fourth to fifth grade were not detected in either sex. Therefore, developmental differences cannot fully explain differences in broad jump distance in boys and girls. Instead, in this age range, explosive lower-body performance may reflect differences in physical activity and the neuronal adaptations that follow.

Since physical activity and fitness are related in grade school children (25), differences in some components of physical fitness may be explained by higher rates of physical activity participation in boys (11). For example, boys aged 4–12 years are typically more active than similarly aged girls (28) and may participate in nearly twice as much moderate and vigorous physical activity (30). Accordingly, more physically active children were recently shown to perform better on a number of jump tests, including the squat jump, countermovement jump, and drop jump (19), where performance is strongly correlated with that on the broad jump, as well as upper-body strength (6). Although beyond the scope of this investigation, if the boys in our study were more physically active, it would explain the observed differences in explosive power and strength. The cause of this divergence warrants further review but appears related to differences in socialization (29).

One-mile run times generally improved in both groups. However, weight and BMI also increased, and higher BMI values were associated with slower mile run times. In children, this may reflect increased adiposity, less physical activity, and lower levels of cardiorespiratory fitness (2). Kim et al. (20) supported this concept after directly comparing overweight incidence with performance on endurance and strength fitness tests. When increases in weight are accompanied by significant increases in height, BMI can be maintained or decreased, which explains why weight was not independently associated with mile run time. This conclusion is supported by the negative relationship between BMI and local muscular endurance and lower-body power, which would be expected to increase if larger BMI values primarily reflected increases in muscle mass. It is important to note that lower-body power and local muscular endurance were also positively associated with faster mile run times. Similar to our observations, Keiner et al. (19) found that a higher BMI was associated with a lower physical activity level, and worse performance on tests of lower-body power.

Physical fitness variables may change unevenly in grade school boys and girls (12,22). In girls, variation in physical fitness can be explained by increased mass and stature, whereas in boys other factors may exist (18). The pubertal growth spurt typically occurs at age 10 in girls and age 12 in boys, resulting in a period where girls are commonly taller than boys, as we observed (26). Although 9 year-old boys demonstrated greater grip strength in this investigation, previous work has suggested that until age 10 to 12, boys and girls perform similarly. After this point, however, a gender discrepancy is usually apparent (10,16). Thus, the lack of difference in handgrip strength and local muscular endurance in fifth grade boys and girls may be attributable to an earlier growth spurt in girls. This is supported by an average body mass increase of nearly 6 kg, in addition to nearly 7 cm of growth, making girls taller than boys in fifth grade. Changes in height may also explain the decrease in flexibility observed in girls at this point. Although others have shown greater flexibility in girls (23), it is important

to note that fifth and sixth graders (10.8 ± 0.4 years) were used, and at boys were both taller and heavier, which likely eliminated a transient advantage that occurred with the onset of pubescence in girls. Before puberty, sex-specific factors that could affect physical fitness are not as pronounced (9). Interestingly, puberty may affect physical activity differently in boys and girls (17), and this represents an important area for future work.

Practical Applications

School-based physical fitness tests can serve as a valuable tool to assess physical activity outcomes and the risk of health-related consequences in sedentary children. Our data indicate that sex-specific differences in physical fitness are apparent as early as the fourth grade. Furthermore, at this age, boys and girls do not generally exhibit the same patterns of change in physical fitness, despite similar increases in weight and BMI. From fourth to fifth grade, where many girls reach pubescence, sex-specific differences in development can affect physical fitness to varying degrees. Boys might be expected to display greater cardiorespiratory endurance and power at all time points, but girls improve aerobic capacity and gain the ability to produce similar local muscular endurance and force. Furthermore, although superior to boys in fourth grade, large increases in height may result in the temporary loss of flexibility, with similar values in fifth grade. These findings should be considered when physical fitness tests are conducted, compared, and used to prescribe exercise and physical activity in this age group.

Acknowledgments

The authors wish to thank the children and parents who participated in this study and the medical, nursing, physical education faculty, and administrators who made this study possible. The authors also thank the Chambersburg Area School District Department of Health and Wellness for their collaboration and support. The Summit Health Endowment Fund provided funding for this study.

References

1. Ara, I, Vicente-Rodríguez, G, Jimenez-Ramirez, J, Dorado, C, Serrano-Sanchez, JA, and Calbet, JAL. Regular participation in sports is associated with enhanced physical fitness and lower fat mass in prepubertal boys. *Int J Obes Relat Metab Disord* 28: 1585–1593, 2004.
2. Baranowski, T, Chen, TA, Mendoza, JA, O'Connor, T, Baranowski, J, and Jago, R. Prospective BMI category change associated with cardiovascular fitness change. *Med Sci Sports Exerc* 45: 294–298, 2013.
3. Beets, MW and Pitetti, KH. One-mile run/walk and body mass index of an ethnically diverse sample of youth. *Med Sci Sports Exerc* 36: 1796–1803, 2004.
4. Blair, SN, Kohl, HW, Paffenbarger, RS, Clark, DG, Cooper, KH, and Gibbons, LW. Physical fitness and all-cause mortality. A prospective study of healthy men and women. *JAMA* 262: 2395–2401, 1989.
5. Boreham, C, Robson, PJ, Gallagher, AM, Cran, GW, Savage, JM, and Murray, LJ. Tracking of physical activity, fitness, body composition and diet from adolescence to young adulthood: The Young Hearts Project, Northern Ireland. *Int J Behav Nutr Phys Act* 1: 14, 2004.
6. Castro-Pinero, J, Ortega, FB, Artero, EG, Girela-Rejon, MJ, Mora, J, Sjostrom, M, and Ruiz, JR. Assessing muscular strength in youth: Usefulness of standing long jump as a general index of muscular fitness. *J Strength Cond Res* 24: 1810–1817, 2010.
7. Coksevim, B and Caksen, H. Evaluation of exercise performance in healthy Turkish adolescents. *Int J Neurosc* 115: 1033–1039, 2005.
8. Cureton, KJ, Sloniger, MA, Black, DM, McCormack, WP, and Rowe, DA. Metabolic determinants of the age-related improvement in one-mile run/walk performance in youth. *Med Sci Sports Exerc* 29: 259–267, 1997.
9. Dallman, PR and Siimes, MA. Percentile curves for hemoglobin and red cell volume in infancy and childhood. *J Pediatr* 94: 26–31, 1979.
10. De Smet, L and Vercammen, A. Grip strength in children. *J Pediatr Orthop B* 10: 352–354, 2001.
11. Eaton, WO and Enns, LR. Sex differences in human motor activity level. *Psychol Bull* 100: 19–28, 1986.
12. Falk, B, Cohen, Y, Lustig, G, Lander, Y, Yaaron, M, and Ayalon, J. Tracking of physical fitness components in boys and girls from the second to sixth grades. *Am J Hum Biol* 13: 65–70, 2001.
13. Guo, SS and Chumlea, WC. Tracking of body mass index in children in relation to overweight in adulthood. *Am J Clin Nutr* 70: 145S–148S, 1999.
14. Gutin, B, Yin, Z, Humphries, MC, Hoffman, WH, Gower, B, and Barbeau, P. Relations of fatness and fitness to fasting insulin in black and white adolescents. *J Pediatr* 145: 737–743, 2004.
15. Gutin, B, Yin, Z, Humphries, MC, and Barbeau, P. Relations of moderate and vigorous physical activity to fitness and fatness in adolescents. *Am J Clin Nutr* 81: 746–750, 2005.
16. Hager-Ross, C and Rosblad, B. Norms for grip strength in children aged 4-16 years. *Acta Paediatr* 91: 617–625, 2002.
17. Janz, KF, Dawson, JD, and Mahoney, LT. Tracking physical fitness and physical activity from childhood to adolescence: The muscatine study. *Med Sci Sports Exerc* 32: 1250–1257, 2000.
18. Jones, MA, Hitchen, PJ, and Stratton, G. The importance of considering biological maturity when assessing physical fitness measures in girls and boys aged 10 to 16 years. *Ann Hum Biol* 27: 57–65, 2000.
19. Keiner, M, Sander, A, Wirth, K, and Schmidtbleicher, D. Is there a difference between active and less active children and adolescents in jump performance? *J Strength Cond Res* 27: 1591–1596, 2013.
20. Kim, J, Must, A, Fitzmaurice, GM, Gillman, MW, Chomitz, V, Kramer, E, McGowan, R, and Peterson, KE. Relationship of physical fitness to prevalence and incidence of overweight among schoolchildren. *Obes Res* 13: 1246–1254, 2005.
21. Loko, J, Aule, R, Sikkut, T, Ereline, J, and Viru, A. Motor performance status in 10 to 17-year-old Estonian girls. *Scand J Med Sci Sports* 10: 109–113, 2000.
22. Marshall, SJ, Sarkin, JA, Sallis, JF, and McKenzie, TL. Tracking of health-related fitness components in youth ages 9 to 12. *Med Sci Sports Exerc* 30: 910–916, 1998.
23. Marta, CC, Marinho, DA, Barbosa, TM, Izquierdo, M, and Marques, MC. Physical fitness differences between prepubescent boys and girls. *J Strength Cond Res* 26: 1756–1766, 2012.
24. Ortega, FB, Ruiz, JR, Castillo, MJ, and Sjostrom, M. Physical fitness in childhood and adolescence: A powerful marker of health. *Int J Obes (Lond)* 32: 1–11, 2008.
25. Pate, RR, Dowda, M, and Ross, JG. Associations between physical activity and physical fitness in American children. *Am J Dis Child* 144: 1123–1129, 1990.

26. Rikli, RE, Petray, C, and Baumgartner, TA. The reliability of distance run tests for children in grades K-4. *Res Q Exerc Sport* 63: 270–276, 1992.

27. Ruiz, JR, Castro-Pinero, J, Artero, EG, Ortega, FB, Sjostrom, M, Suni, J, and Castillo, MJ. Predictive validity of health-related fitness in youth: A systematic review. *Br J Sports Med* 43: 909–923, 2009.

28. Sallis, JF, Prochaska, JJ, and Taylor, WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc* 32: 963–975, 2000.

29. Thomas, JR and French, KE. Gender differences across age in motor performance a meta-analysis. *Psychol Bull* 98: 260–282, 1985.

30. Trost, SG, Pate, RR, Dowda, M, Saunders, R, Ward, DS, and Felton, G. Gender differences in physical activity and determinants of physical activity in rural fifth grade children. *J Sch Health* 66: 145–150, 1996.

31. Wild, CY, Steele, JR, and Munro, BJ. Musculoskeletal and estrogen changes during the adolescent growth spurt in girls. *Med Sci Sports Exerc* 45: 138–145, 2013.