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Better Health-Related Fitness in Youth: Implications for Public Health Guidelines

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ABSTRACT

International Journal of Exercise Science 10(3): 379-389, 2017. Public health guidelines for physical activity (PA) behaviors are being updated with 2018 as a proposed release date. Currently, ≥60 minutes of daily PA are recommended for youth. Thus, the purpose of this study was to investigate the association between reported days of aerobic PA and health-related fitness (HRF). Participants included 4448 students in grades 6-8. Self-reported days of ≥60 minutes of aerobic PA was obtained. HRF was assessed with FitnessGram. Discriminant analysis indicated that weekly days of aerobic PA related to HRF. Adolescents who participated in ≥5 days of weekly aerobic PA generally had better fitness results than those with ≤4 days. Chi-square analyses indicated the highest percentages of adolescents in the FitnessGram Healthy Fitness Zone™ (HFZ) for each test item were those with ≥5 days of aerobic PA. These findings provided initial support that the impact of aerobic PA on HRF plateaus at 5 days per week. Thus, adolescents may be able to improve HRF even if they do not meet the currently recommended guidelines for daily PA.

KEY WORDS: Adolescents, FitnessGram, physical fitness

INTRODUCTION

Public health physical activity guidelines (PAG) established in 2008 (1) are now being reviewed with proposed release in 2018. The PAG provide information about the amount and intensity of physical activity (PA) needed to positively influence health at all stages of life. For children and adolescents, there is evidence that PA and health-related physical fitness (HRF; e.g., cardiorespiratory fitness [CRF] and muscular strength and endurance) are reciprocally related and indirectly influence each other. Previous research has found a relationship between PA and higher levels of CRF, stronger muscles and bones, and lower body fatness

(12, 19). Santos and colleagues (19) reported that youth who were classified as meeting the PAG and engaged in low levels of sedentary behavior (based on the median value for sedentary time by age and gender) were more likely to achieve a criterion-referenced standard for CRF. Although previous research findings from observational and experimental studies indicates an association between PA and HRF, more information is needed regarding the exact amount of activity (e.g., number of days with ≥60 minutes of aerobic PA) that is associated with healthier levels of HRF. Thus, additional evidence on the doseresponse relationship between the amount of PA and HRF outcomes is needed (9, 16).

The current PAG for children and adolescents is ≥60 minutes of daily PA, which should include ≥3 days of musculoskeletal and bone-enhancing activities. Strong and colleagues (23) provided support for this recommendation after conducting a systematic review of 850 articles. Strong et al.'s recommendation for 60 minutes of daily PA was largely based on the results of intervention studies with overweight and obese children that revealed 30-45 minute bouts of PA on 3-5 days per week improved various health outcomes (9). Sixty minutes of daily PA was chosen to help account for inter- and intra-individual differences in response to PA in free-living situations (9, 23). Strong and colleagues found strong evidence regarding the amount of activity youth needed to improve health and behavioral outcomes, but Dietz (4) indicated that there were still important gaps in the literature. Dietz emphasized that investigating different types (e.g., aerobic PA) and doses (e.g., five times weekly) of PA would likely have varying effects on adverse health outcomes. Addressing these gaps is important as the PAG are currently being reviewed and potentially modified. While there are different types of PA, aerobic PA was the primary focus of the current study because aerobic activities are the most common and have the broadest physiological and health effects (8).

Previous research has indicated that aerobic PA can improve different aspects of HRF (14), but limited information is available regarding the exact number of days of aerobic PA needed for youth to achieve healthier HRF levels and how each additional day of aerobic PA affects fitness outcomes. Further investigation will help identify the actual minimum number of days needed to achieve a fitness level sufficient to accrue health benefits. Ortega and colleagues (15) assessed the relationship between PA and CRF and found that 60 minutes or more of daily PA was associated with higher CRF levels in youth. However, the participants were placed into dichotomous groups based on those who achieved 60 minutes or more of daily PA and those who did not over a 4-day period. Thus, there is currently a need for more information regarding the number of days of aerobic PA that is associated with adolescents achieving HRF. The purpose of this study was to expand on previous research using aerobic PA by investigating the association between the number of days of aerobic PA and physical fitness achievement based on the FitnessGram assessment (i.e., Progressive Aerobic Capacity Endurance Run [PACER] laps, push-ups, curl-ups, trunk lift, and Body Mass Index [BMI]). It was hypothesized that there would be a positive association between the number of days of aerobic PA and each component of HRF (i.e., CRF, body composition, and muscular fitness).

METHODS

Participants

Data were collected from 36 physical education classes at six different schools in a southwestern urban school district. This resulted in a final sample of 4448 middle school students in grades 6-8. The students ranged in age from 10 to 16 years old (M_{age} = 12.52, SD = 1.02). Approximately 55% of the sample was white, 28% was Hispanic, 13% was African American, 3% was Asian, and 1% was American Indian, which was reflective of the demographics of the entire district.

Protocol

Students responded to a single item for aerobic PA that was based on PA items from the FitnessGram and the CDC (14) Youth Risk Behavior Surveillance System. Respondents self-reported the number of days they were physically active (i.e., increased heart rate and breathing hard some of the time) for ≥60 minutes during the past 7 days. These activities included moderate (e.g., walking, slow bicycling, or outdoor play) or vigorous (e.g., jogging, active games, or active sports such as basketball, tennis, or soccer) activity.

The FitnessGram assessments of CRF (i.e., PACER), body composition (i.e., BMI), and muscular fitness (i.e., curl-ups, 90° pushups, and trunk lift) were used to determine HRF. The PACER is a multistage test adapted from the 20-meter shuttle run (17). Participants run as long as possible across a 20-meter course at a specified pace that gets faster each minute. Their VO2max is predicted based on the number of laps they completed (17). Body composition was estimated using BMI, which is an indicator of a person's weight relative to their height [i.e., BMI = weight (kg) / height^2 (m); 17]. For curl-ups, participants attempted to complete up to 75 curl-ups at a specified pace (i.e., 1 curl for every 3 seconds; 17). They lied flat on their backs with their knees bent and arms extended with their palms on the mat. Participants slid their fingers from one side of a measuring strip to the other side and then curled back down. Participants completed the trunk lift by laying prone on a mat with toes pointed and hands placed under their thighs. Participants then lifted their upper body off the floor in a slow, controlled manner to a maximum height of 12 inches. Lastly, participants completed as many 90° pushups as possible at a rhythmic pace (i.e., one push-up for every three seconds; 17). Participants started in a prone position and pushed off the ground until their arms were straight while also keeping their back and legs straight. They lowered their bodies until their elbows were bent at a 90° angle and then pushed off the ground again.

For each test, participants were classified as either in the Healthy Fitness Zone (HFZ) or Needs Improvement Zones (NIZ) based on criterion-referenced standards for gender and age (11, 14), which are the minimal level of fitness necessary to experience health benefits and to protect against diseases associated with sedentary living (17, 18). The CRF and BMI assessments now use two levels for NIZ (i.e., NI and NI-Health Risk; 24). However, participants in either level were placed in the NIZ because the data were collected before the new classifications were established.

Study approval was received prior to data collection from the university Institutional Review Board. Written parental consent and child assent were obtained once the school district and principals at the six middle schools gave permission to conduct the study. Trained research assistants assisted the physical education instructors during data collection at each school for one week to administer the FitnessGram, and students responded to the item that assessed their aerobic PA. Because not all physical education teachers were trained equally to conduct the FitnessGram assessment, a certified FitnessGram administrator supervised all the testing procedures. The presence of a certified administrator has been found to improve accuracy (9) and schoolteachers have been found to record accurate results (13).

Additional individual demographic information was provided by the school district including age, sex, race, and socioeconomic status (SES). Age was determined according to each participant's FitnessGram completion date, and they were labeled as being either white or nonwhite for race. SES level was based on federal guidelines for determining which students qualified for free or reduced lunches at the school based on family income (www.fns.usda.gov/cnd/Lunch/). Participants were categorized into one of the following two groups for SES: receiving a free or reduced lunch or not receiving any assistance. No other identifying information was collected, and students at each school were entered into a drawing for cash prizes as an incentive to participate. Data were collected during the 2010-2011 academic year and analyzed in 2015.

Statistical Analysis

Data were managed and analyzed using SPSS® version 22. Descriptive statistics included demographic information (age, sex, race, SES, and school site) and the prevalence of meeting the 2008 guideline for daily aerobic PA. Descriptive discriminant analysis (DDA) was conducted as the primary analysis to determine whether differences existed in the dependent variables (i.e., of PACER laps, push-ups, curl-ups, height of trunk lift, and BMI) as a function of independent variable (i.e., the number of days with ≥60 minutes of self-reported aerobic PA during the past 7 days). Two models were used to investigate this relationship, and alpha level was set at .05. Model 1 assessed the direct relationship between aerobic PA and the dependent variables, and Model 2 examined the same relationship while controlling for age, sex, race, SES, and school site. These covariates were used because previous research has found evidence of these variables influencing health-related fitness (2, 3, 5, 20, 25). Secondary analysis included five chisquare tests to investigate the relationship between days of aerobic PA and Healthy Fitness Zone™ (HFZ) status for each of the five components of the FitnessGram. This included tests for aerobic capacity (i.e., PACER), body composition (i.e., BMI), and muscular fitness (MF; i.e., push-up, curl-up, and trunk lift).

RESULTS

Demographic and descriptive data (i.e., meeting the guidelines for aerobic PA, sex, race, SES, and school site) are presented in Table 1. Means and standard deviations for each component of the FitnessGram are presented in Table 2. To estimate the effect of being more physically active, an effect size was calculated comparing 7 days to 0 days for each fitness variable (Table

2). The effect sizes for PACER, push-ups, curl-ups, and trunk lift ranged from 0.33-0.59, whereas the effect size for BMI was -0.10.

Table 1. Physical activity and demographic variables.

	N [a]	%
2008 PAG		
≥60 min of daily aerobic PA	777	16.8
<60 min of daily aerobic PA	3695	83.2
Days with ≥60 Min of Aerobic PA		
≥5 days	1868	41.8
<5 days	2604	58.2
Sex		
Boys	2347	50.8
Girls	2274	49.2
Race		
White	2585	56.0
Nonwhite	2029	44.0
SES		
Lunch support	1404	40.5
No support	2063	59.5
School Site		
School 1	599	13.0
School 2	846	18.3
School 3	782	16.9
School 4	775	16.8
School 5	870	18.8
School 6	749	16.2

[a]All sample sizes do not equal *N* = 4448 because not all participants completed all phases of data collection.

Table 2. Means and standard deviation of each FitnessGram component[a].

Days[b]	PACER[d]	BMI	Push-ups[e]	Curl-ups[e]	Trunk Lift[f]
0	25.9 (15.1)	21.9 (5.4)	12.4 (8.0)	35.2 (23.5)	8.1 (2.5)
1	27.4 (14.5)	21.8 (5.0)	13.8 (8.5)	37.8 (23.0)	8.6 (2.3)
2	27.2 (14.5)	21.9 (5.2)	14.1 (7.9)	38.2 (22.8)	8.5 (2.4)
3	29.8 (15.5)	21.9 (5.1)	16.6 (8.3)	40.0 (23.3)	8.7 (2.3)
4	30.7 (16.3)	22.0 (5.1)	15.2 (9.1)	42.3 (23.3)	8.9 (2.2)
5	34.0 (16.7)	21.4 (4.4)	16.4 (9.1)	44.2 (22.5)	9.0 (2.4)
6	35.6 (17.6)	21.1 (4.6)	17.2 (10.0)	45.7 (23.0)	9.0 (2.4)
7	34.8 (19.3)	21.4 (4.6)	16.6 (9.3)	44.7 (23.3)	8.9 (2.4)
p	<0.01	<0.01	<0.01	<0.01	<0.01
ES[c]	0.59	-0.10	0.53	0.40	0.33

ES = effect size. *N* = *4329*. [a]Mean is presented with the standard deviation in parenthesis. [b]Days with ≥ 60 minutes of aerobic physical activity. [c](Mean of Days 7 - mean of Days 0) / standard deviation of Days 0. [d]Number of laps. [e]Number of repetitions.[f]Height in inches.

DDA (*n* = 4329) was conducted to determine if differences existed among the number of days that students reported ≥60 minutes of aerobic PA (0 through 7 days) and a created composite variable for physical fitness (i.e., number of PACER laps, push-ups, curl-ups, height of trunk lift, and BMI). Similar to MANOVA, the composite variable created in DDA maximizes group differences and is analogous to predicted scores in regression (22). Only results for Model 1 are presented here because Model 2 (n = 3235), controlling for age, sex, race, SES, and school site, explained only 1% of additional variance and the interpreted results did not change.

The first step for a DDA was to determine if the sample data met the assumption for homogeneity of variance/covariance using log determinants (7). The greatest difference between log determinants was .87, indicating that the assumption was met. The second step was to determine how many of the discriminant functions were worth interpreting. Only the full model test of Functions 1 to 5 was statistically significant, Wilks Lambda = .94, $\chi^2(35) = 270.61$, P <.01, and the squared canonical correlation (i.e., variance accounted for effect size) between the grouping variable and the composite was .06. To determine which variables contributed to group differences, squared structure coefficients (r_s^2; i.e., squared correlation between each dependent variable and the composite variable) and standardized coefficients (i.e., relative importance of each dependent variable) were examined, which are in Table 3. Group differences were primarily due to the number of PACER laps (r_s^2 = .72), push-ups (r_s^2 = .45), curl-ups (r_s^2 = .36), and trunk lift (r_s^2 = .21). BMI explained only 4% of the variance in the composite variable and did not contribute to group differences on the composite. However, both push-ups and curl-ups had lower standardized coefficients compared to their respective structure coefficients, indicating that some of the variance in the composite was being credited to at least one of the other dependent variables. There was a statistically significant (P <.01) correlation between push-ups and PACER laps (r = .57), curl-ups (r = .48), and BMI (r = -.32). The findings were similar for curl-ups (Table 3). The standardized coefficient for PACER was also lower than its structure coefficient, but its standardized coefficient was not affected as much because PACER was more strongly related with the composite than the other variables. Furthermore, BMI had a low standardized coefficient because the little variance that BMI shared with the composite was also shared with the other dependent variables. This was indicated by the significant correlation between BMI and PACER laps (r = -.35), curl-ups (r = -.22), and push-ups (r = -.32).

Table 3. Descriptive discriminant results and Pearson r correlations[a].

	SDFC	r_s^2	PACER	Push-Ups	Curl-Ups	Trunk Lift
PACER	.65	.72	-			
Push-Ups	.26	.45	.57*	-		
Curl-Ups	.18	.36	.48*	.48*	-	
Trunk Lift	.42	.21	.04*	.03*	.08*	-
BMI	.09	.04	-.36*	-.36*	-.22*	.09*

R_c^2 = squared canonical correlation; SDFC = standardized discriminant function coefficients; r_s^2 = squared structure coefficient. [a]R_c^2 = .06. *p < .05.

The group centroids (i.e., mean of each group on the composite) were examined to determine if there was a statistically significant difference among the groups (Table 4). The group centroids for 5, 6, and 7 days of aerobic PA were not significantly different from each other (P ≥.11), but these three group centroids were significantly higher than the group centroids for ≤ 4 days (P <.01; Cohen's d = .18 to .29). The group centroid for 4 days of aerobic PA was significantly higher than those for ≤ 2 days (P <.01; Cohen's d = .27 to .48), but it was not significantly different from 3 days (P <.09). Three days was significantly higher than the group centroids for ≤ 2 days (P = .01; Cohen's d = .16 to .38) and lower than the group centroids for ≥ 5 days (P <.01; Cohen's d = .29 to .40). Two days was not significantly different than 1 day, and 0 days had a significantly lower group centroid than all the other groups (P <.01; Cohen's d = .21 to .76). Since the group centroids for 5, 6, and 7 days of aerobic PA were not significantly different from each other, the percentage of students who reported at least 5 days of aerobic PA and less than 5 days of aerobic PA was also reported in Table 1 to compare with the percentage of students who met the 2008 PAG. Specifically, 41.8% of students reported at least 5 days of aerobic PA, whereas only 16.8% of students reported 60 minutes of daily aerobic PA.

Table 4. Group centroids and 95% CI for Health-Related Fitness composite.

Days[a]	Group Centroid	95% CI
0 days	-.44	[-0.53, -0.35]
1 days	-.22	[-0.31, -0.14]
2 days	-.24	[-0.32, -0.17]
3 days	-.07	[-0.15, 0.01]
4 days	.03	[-0.05, 0.12]
5 days	.22	[0.14, 0.29]
6 days	.32	[0.21, 0.43]
7 days	.24	[0.16, 0.32]

CI = confidence interval, HFZ = Healthy Fitness Zone. [a]Days with ≥ 60 minutes of aerobic physical activity.

Table 5. Percentage of students achieving FitnessGram HFZ.

Days[a]	PACER Laps[b]	Push-Ups[c]	Curl-Ups[c]	Trunk Lift[d]	BMI
0 days	38.1	61.3	74.0	42.9	67.1
1 days	55.4	73.2	79.8	50.8	71.9
2 days	51.6	75.7	80.2	49.9	68.4
3 days	59.3	75.7	81.9	53.8	70.1
4 days	61.6	77.9	83.5	58.2	70.3
5 days	65.4	81.8	88.1	57.9	74.3
6 days	72.4	85.0	87.9	62.1	82.8
7 days	65.3	81.3	86.9	56.2	76.6

HFZ = healthy fitness zone, PACER = progressive aerobic cardiovascular and endurance run, BMI = body mass index. [a]Days with ≥ 60 minutes of aerobic physical activity. [b]Total n = 4426. [c]Total n = 4423. [d]Total n = 4416. [e]Total n = 4431. [f]Total n = 4448.

Lastly, five chi-square tests of independence were conducted to examine the relation between the number of days of aerobic PA and HFZ status (i.e., being in either the HFZ or NIZ) for each component of the FitnessGram. These tests were performed because theoretically one group could have significantly lower fitness scores on a component than another group while a similar percentage in both groups could be in the HFZ. The results indicated that the relationship between aerobic PA and PACER laps, [$\chi^2(7, n = 4426) = 146.93$, P <.01], push-ups, [$\chi^2(7, n = 4423) = 95.97$, P <.01], curl-ups [$\chi^2(7, n = 4416) = 60.26$, P <.01], trunk lift [$\chi^2(7, n = 4431) = 46.35$ P <.01], and BMI [$\chi^2(7, n = 4448) = 40.76$, P <.01] was statistically significant. The percentage of students in HFZ for each component can be found in Table 5.

DISCUSSION

Adolescents in the current study who reported 5, 6, or 7 days with ≥60 minutes of aerobic PA per week had similar scores on measures of HRF. In addition, those who self-reported ≤4 days of aerobic PA generally had lower fitness scores than those with ≥5 days, and those with 0 days had the lowest fitness scores. These differences also existed when the control variables were used, which indicated that individual differences due to sex, age, race, receiving a reduced lunch (i.e., low SES), or school site had a small impact on fitness scores. Except for the trunk lift test, the chi-square analysis indicated that the highest percentages of students in the HFZ reported at least 5 days of aerobic PA. Generally, the percentage of students achieving the HFZ presented in Table 4 illustrates a linear increase in performance for each fitness variable across the days of reported PA with a plateauing at 5 days. Overall, the 2008 PAG were supported because a large percentage of students achieving 60 minutes of daily aerobic PA were in the HRF, but 7 days was not necessarily better than 5 or 6 days.

To determine the minimum and optimal amount of aerobic PA, dose-response studies are useful for understanding the relation between PA and health outcomes, such as HRF (9). However, this relationship has not been thoroughly investigated in children and adolescents (16). Janssen (9) argued that this lack of research has hampered the development of PA guidelines because existing PA recommendations for children and youth are not based on adequate evidence. As a result, it is difficult to set a range of minimal and maximal PA for youth. Based on the findings of the present study, a positive association was found between days of aerobic PA and HRF, but students who reported 5 or 6 days with 60 minutes of aerobic PA did not have better scores on the FitnessGram assessments than those who reported 7 days. Janssen and LeBlanc conducted a systematic review of 86 studies that investigated the relation between physical activity, fitness, and health in school-aged children and youth (10). They reported that an average of 30 minutes per day of PA lead to some health benefits, whereas additional health benefits were generally achieved at the higher end of the PA spectrum (10). Thus, those who achieved 5 days of 60 minutes of aerobic PA in the current study were still reporting more PA than 30 minutes per day. In addition, it is important to recognize that the type and dose of PA needed to improve different health outcomes might vary (4). For example, Dietz (4) emphasized that the amount of PA needed to improve health outcomes for cardiovascular disease may differ from that for impacting obesity. Thus, while the current results indicate that ≥5 days of 60 minutes of aerobic PA is sufficient to improve HRF compared to <5 days, more information is still needed for HRF and other health outcomes.

There were several strengths associated with the current study. First, possible confounding variables were controlled in the DDA analysis, including sex, age, race, SES, and school site. Similar results were found when no covariates were included, which strengthened the finding that at least 5 days of aerobic PA were needed for children to have a statistically significant impact on their overall fitness. Second, the fitness measures from the FitnessGram have previously been found to be valid and reliable (10, 14). Third, the demographics of the sample improved the generalizability of the results to the student population in the district. In addition, the sample was comparable to a national sample from the CDC in regards to the number of days of 60 minutes of PA per week (6).

Despite the strengths of this study, there are limitations. First, the data analysis and the cross-sectional design of the study does not allow for causal relationships to be determined. Second, social desirability bias can influence self-report data (e.g., wanting to appear to be more physically active). To limit the influence of social desirability, PA items were completed after the fitness testing and answered on the reverse side of participants' fitness results cards to prevent other students from seeing their data. Third, there has been limited research using a single-item PA measure with youth. However, a recent study by Scott and colleagues (21) investigated the reliability and validity of a single-item PA measure with adolescents. Similar to the current study, their PA item assessed the number of days that the participants reported at least 60 minutes of PA over the past 7 days. Their findings indicated that the single-item measure had similar test-retest reliability and concurrent validity against accelerometers as another existing PA measure (21). Thus, while the current item does not measure all aspects of PA (e.g., intensity and time of day), there is evidence that a single-item measure of PA can be used in adolescent populations, especially when recruiting large sample sizes or dealing with budgetary restrictions. Lastly, while the survey item was intended to measure aerobic PA, it is possible that some activities may include both aerobic and muscle-strengthening activities (e.g., climbing and gymnastics).

The *2008 Physical Activity Guidelines* (1, 13) also suggest children and youth engage in muscle-strengthening and bone-strengthening activities at least 3 days per week. Future research would benefit from investigating the role of both muscle- and bone-strengthening exercises along with aerobic PA. Although these activities are not always mutually exclusive (e.g., running is an aerobic and bone-strengthening activity), these three types of PA account for the recommended 60 minutes of daily PA. In addition, more experimental research with youth is needed to determine the causal relationship between the number of days with ≥60 minutes of aerobic PA and HRF outcomes. Experimental research would provide additional dose-response evidence regarding the amount of PA that youth need to improve HRF. Finally, it may also be beneficial to consider the role of sedentary behavior during adolescence (e.g., watching TV and using smartphones) and whether decreasing time spent in sedentary behaviors can lead to improvements in HRF in adolescents.

This study adds to the literature on dose-response studies in important ways, particularly as decisions are made regarding modifications in the current PAG. It represents one of the few studies to investigate the relationship between aerobic PA and achieving a criterion fitness standard. Limited research has investigated the dose-response relationship with children and adolescents, which signifies a need for identifying the minimal PA targets for children and adolescents on specific health outcomes, such as HRF. Importantly, results illustrate that the current daily PA recommendation is "sufficient but not necessary" to achieve health-related fitness. This has implications for the upcoming review and possible modification of the public health guidelines for Americans. This study fulfills the United States Department of Health and Human Services request for additional research on the 2008 PAG and provides initial evidence that the impact of aerobic PA on health-related fitness plateaus at 5 days per week.

REFERENCES

1. 2008 Physical Activity Guidelines for Americans. President's Council on Physical Fitness & Sports Research Digest. Washington, DC: 1-8, 2008

2. Aryana M, Li Z, Bommer WJ. Obesity and physical fitness in California school children. Am Heart J 163(2): 302-312, 2012.

3. Dencker M, Thorsson O, Karlsson MK, Lindén C, Eiberg S, Wollmer P. Gender differences and determinants of aerobic fitness in children aged 8-11 years. Eur J Appl Physiol 99(1):19-26, 2007.

4. Dietz W. Physical activity recommendations: Where do we go from here? J Pediatr 146(6): 719-720, 2005.

5. Fahlman M, Hall H, Lock R. Ethnic and socioeconomic comparisons of fitness, activity levels, and barriers to exercise in high school females. J Sch Health 76:12-7, 2006.

6. Fakhouri THI, Hughes JP, Burt VL, Song M, Fulton JE, Ogden CL. Physical activity in U.S. youth aged 12-15 years, 2012. NCHS Data Brief, 2014.

7. Huberty CJ, Lowman LL. Group overlap as a basis for effect size. Educ Psychol Meas 60: 543–563, 2000.

8. Institute of Medicine. Educating the study body: Taking physical activity and physical education to school. Washington, D.C., 2013.

9. Janssen I. Physical activity guidelines for children and youth. Appl Physiol Nutr Metab 32(S2E): S109-121, 2007.

10. Janssen I, LeBlanc A. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act 7(40): 1-16, 2010.

11. Mahar MT, Rowe DA. Practical guidelines for valid and reliable youth fitness testing. Meas Phys Educ Exerc Sci 12(3): 126-45, 2008.

12. Marques A, Santos R, Ekelund U, Sardinha LB. Association between physical activity, sedentary time, and healthy fitness in youth. Med Sci Sports Exerc 47: 575-580, 2015.

13. Morrow JRJ, Martin SB, Jackson AW. Reliability and validity of the FITNESSGRAM®: Quality of teacher-collected health-related fitness surveillance data. Res Q Exerc Sport 81: S24-S30, 2010.

14. Morrow JRJ, Tucker JS, Jackson AW, Martin SB, Greenleaf CA, Petrie TA. Meeting physical activity guidelines and health-related fitness in youth. Am J Prev Med 44(5): 439-44, 2013.

15. Ortega FB, Ruiz JR, Hurtig-Wennlöf A, Sjöström M. Physically active adolescents are more likely to have a healthier cardiovascular fitness level independently of their adiposity status. The European youth heart study. Rev Española Cardiol 61(2): 123-129, 2008.

16. Physical activity guidelines advisory committee report, 2008. U.S. Department of Health and Human Services. Washington, DC: 501-519, 2008.

17. Plowman SA, Meredith MD. FITNESSGRAM® /ACTIVITYGRAM® reference guide. 4th ed. Dallas: The Cooper Institute; 2013.

18. Plowman SA, Sterling CL, Corbin CB, Meredith MD, Welk GJ, Morrow JR. The History of FITNESSGRAM®. J Phys Act Heal 3(Suppl. 2): S5-S20, 2006.

19. Santos R, Mota J, Okely AD. The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. Br J Sports Med 48: 1508-1512, 2014.

20. Saygin O, Zorba E, Karacabey K, Mengutay S. Gender and maturation differences in health-related physical fitness and physical activity in Turkish children. Pakistan J Biol Sci 10(12):1963-1969, 2007.

21. Scott JJ, Morgan PJ, Plotnikoff RC, Lubans DR. Reliability and validity of a single-item physical activity measure for adolescents. J Paediatr Child Health 51(8): 787-793.

22. Sherry A. Discriminant analysis in counseling psychology research. Couns Psychol 34(5):661-683, 2006.

23. Strong WB, Malina RM, Blimkie CJR. Evidence based physical activity for school-age youth. J Pediatr 146(6): 732-737, 2005.

24. Welk GJ, Going SB, Morrow JRJ, Meredith MD. Development of new criterion-referenced fitness standards in the FITNESSGRAM® program: Rationale and conceptual overview. Am J Prev Med Prev Med 41(4 Suppl 2): S63-S67, 2011.

25. Welk GJ, Meredith MD, Ihmels M, Seeger C. Distribution of health-related physical fitness in Texas youth: A demographic and geographic analysis. Res Q Exerc Sport. 81(Suppl 3): S6-S15, 2010.