RBCDH Revista Brasileira de CINEANTROPOMETRIA e Desempenho Humano

DOI: http://dx.doi.org/10.5007/1980-0037.2015v17n1p1

original article

Handgrip strength as a predictor of physical fitness in children and adolescents

Força de preensão manual como preditor de aptidão física em crianças e adolescentes

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Abstract – The objective of this study was to examine the association between hangrip strength and physical fitness in children and adolescents at different stages of sexual maturation. We measured body composition and handgrip strength in 233 children and adolescents (10 - 17 years-old), who varied in terms of pubertal status. The subjects also performed the vertical jump test, standing long jump and sit-ups, as well as tests of flexibility, agility and speed. The level of energy expenditure was assessed with the international physical activity questionnaire. Handgrip strength differed by pubertal status, regardless of gender, whereas other parameters of physical fitness differed by gender and in the sample as a whole. Handgrip strength was consistently and independently associated with all other physical fitness variables, regardless of gender; some of those were mediated by energy expenditure (i.e., speed in seconds and in meters per second for the sample as a whole). The strength of the association between handgrip strength and physical fitness ranged from 20% (vertical jump test: R^2=.20; P=.001) to 47% (speed in meters per second: R^2=.47; P=.001). Our results support the idea that handgrip strength is consistently associated with several distinct parameters of physical fitness, regardless of age, gender or sexual maturation, suggesting that handgrip strength could be a highly accurate, independent predictor of physical fitness.

Key words: Energy expenditure; Handgrip strength; Maturation; Physical fitness; Pubertal status.

Resumo – *O objetivo deste estudo foi examinar a associação entre a força de preensão manual e a aptidão física de crianças e adolescentes de diferentes estágios de maturação sexual. Foram medidos a composição corporal e a força de preensão em 233 crianças e adolescentes (10 - 17 anos de idade), de diferentes estágios de maturação biológica. Também foram realizados os testes de impulsão vertical sem auxílio dos membros superiores, teste de abdominal, flexibilidade, agilidade e velocidade. O gasto de energético foi avaliado através das respostas ao questionário IPAQ. A força de preensão manual diferiu entre os diferentes estágios de maturação sexual. As outras variáveis de aptidão física diferiram entre os sexos. A força de preensão manual esteve associada com todas as outras variáveis da aptidão física, independentemente do sexo e da maturação sexual. Algumas dessas associações foram mediadas pelo gasto energético. A força da associação entre a força de preensão e de aptidão física variou de 20 % (teste de salto vertical: R^2=0,20, P = 0,001) a 47% (velocidade em metros por segundo: R^2=0,47, P = 0,001). Nossos resultados suportam a hipótese de que a força de preensão manual está associada com vários parâmetros distintos de aptidão física, independentemente da idade, sexo ou maturação sexual, sugerindo que a força de preensão manual pode ser um preditor da aptidão física geral de crianças e adolescentes.*

Palavras-chave: *Força de preensão manual, gasto energético, maturação sexual, aptidão física, estágio púbere.*

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Received: 27 February 2014
Accepted: 21 September 2014

INTRODUCTION

Physical fitness has been associated with health components[1-7] and physical performance[8-10]. There are evidences demonstrating that physical fitness could predict cardiopulmonary and metabolic disorders[4,5], cognitive function[6,7], as well as memory performance[7] with important effects on academic achievement[6].

In the last years, muscle strength has been considerate as a significant component of health regardless of age[2,3,11] and clinical condition[13]. One of the most used methods for assessing muscle strength is the handgrip strength[14], because has a low cost and may be used in a time-efficient manner with unsophisticated equipment, mainly in clinical setting[13]. For these reasons, many studies have employed handgrip strength as a tool for predicting several health outcomes in adults[11] elderly individuals[12,16,17] as well as in individuals living with HIV/aids[18]. In the last years, handgrip strength has also been used for estimating health outcomes[2,3,11,13] and more recently, physical performance[8-10].

For instance, it was reported that handgrip strength was negatively associated with fasting insulin and the HOMA after controlling for pubertal status, country and BMI or waist circumference[19] and independently associated with metabolic risk in an important European study (HELENA study)[20]. Other significant evidence involving one million adolescents followed over 20 years showed that low muscular strength (measured by handgrip, knee extension and elbow flexion) emerged as a factor for major causes of death in young adulthood, such as suicide and cardiovascular diseases[11].

On the other hand, there are no studies relating to its potential for predicting overall physical fitness. Some available studies demonstrate that handgrip strength is significantly correlated with swimming (R=.78)[9] and tennis performance (R=-.67)[10], but not necessarily with physical fitness. It is also possible to predict adult handgrip strength from childhood and adolescent data with a high accuracy in Gausian maturity groups, but not in skeweed distributions[21]. Most possibly, due to the fact that stature and mass seem to be more important correlates of muscle strength than age, cross-sectional area and maturity[22] in individuals displaced from a normal distribution[23]. Therefore, the purpose of this study was to examine the association between handgrip strength with physical fitness in children and adolescents at different stages of sexual maturation.

METHODOLOGICAL PROCEDURES

Subjects

Children and adolescents were recruited from two public schools in Ilhabela, Brazil. Two hundred and four interested volunteers were invited to the facility to undergo a standard clinical and physical examination prior to being included in the study. The initial evaluation involved a detailed investigation of the current and past health status and determination of body composition. Volunteers who were under treatment for acute or chronic cardiovascular, pulmonary or metabolic disease were excluded, as were those using any drugs known to affect the cardiovascular or respiratory system, those with central or peripheral nervous system disorders, those presenting with malnutrition or obesity, those having undergone surgery in the last three months, those for whom bed rest had been prescribed in the last three months and those with any orthopedic disorder that would limit their physical performance.

We included 233 children from 10 to 17 years of age. Those who agreed to participate in the study were informed of the study objectives, procedures and risks. Written informed consent was obtained from the parents or legal guardians of the volunteers. The study was approved by the research ethics committee of the Universidade Federal de São Paulo (UNIFESP) protocol 0056/10.

Body composition

Height and weight were measured with a stadiometer and a digital scale, respectively, while the volunteers were wearing light clothing without shoes. Body mass index was calculated as weight in kilograms divided by height in meters squared[24]. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest[25].

Body fat was expressed as the average of three measures of the seven skinfolds (biceps, triceps, subscapular, suprailiac, mid-axillary, abdomen and calf) with a Harpenden skinfold caliper. We calculated the arm muscle area (AMA) by arm circumference – (triceps skinfold × 0.314)[26].

Sexual maturation

Sexual maturation was classified on the basis of Tanner staging (self-reported pubertal status) as: prepubescent, pubescent, and postpubescent[27]. Each volunteer entered an isolated room, where, using a set of images exemplifying the various stages of sexual maturation, they categorized the development of their own genitalia (for boys), breasts (for girls), armpits (for boys) and public hair (for both genders); the reproducibility of our data reached 71%.

Handgrip strength

Maximal isometric handgrip strength was measured with an adjustable handgrip dynamometer (TK005; Takei Scientific Instruments, Tokyo, Japan). The handgrip was measured in Newtons (N). We performed the test twice for each hand, alternating between right and left hands to avoid muscle fatigue. Participants were instructed to squeeze the handgrip as hard as possible, with an outstretched arm. The sum of the best result for the right and left hand was used in the analysis.

Energy expenditure

The International Physical Activity Questionnaire (IPAQ) was used in order to determine the amount of energy expended in various physical activities[28]. Volunteers reported the frequency and duration of light, moderate and vigorous physical activity, defined as expending 3.3 metabolic equivalent of task (MET), 4.0 MET and 8.0 MET, respectively, and those data were combined to give an approximate activity score of energy expenditure per week (kJ). The duration of each activity (in minutes per day) was multiplied by the reported frequency (in days per week); the accumulated MET-min values were then multiplied by body weight (in kg) and converted to $kJ{\cdot}min^{-1}$ on the assumption that 1 MET was equivalent to $4.18\ kJ{\cdot}kg^{-1}{\cdot}hr^{-1}$; the reproducibility of our data reached R=0.70.

Aerobic power

Aerobic power was determined by a submaximal exercise capacity test on a cycle ergometer (Ergomedic; Monark AB, Varberg, Sweden). The test began with a 4-min warm-up period at a workload of 0.5 kg, followed by another 4-min period with an increase in workload of 4% of body weigh[29]; the reproducibility of our data reached R=0.88.

Lower limb strength

To estimate the muscle strength of the lower limbs, we applied horizontal and vertical jump tests. In the horizontal jump (standing long jump) test, subjects were asked to stand behind a line on the floor, with their feet parallel to each other and spread to shoulder width, then jump forward as far as possible. The best of three attempts was included in the analysis. In the vertical jump test, subjects were asked to stand facing a wall, extend their arms in front of them, then jump as high as possible while keeping their arms parallel to the floor (i.e., not using their arms to impel themselves upward). The vertical jump height was defined as the difference between the point level with the fingers when standing and highest point reached (also level with the fingers), and the best of three attempts was included in the analysis; the reproducibility of our data reached R=0.97.

Sit-ups

To evaluate the strength of the trunk, we employed the sit-up test. Subjects were asked to lie on their backs, with their hips and knees flexed and their arms crossed over their chests, and do as many sit-ups as possible during a period of 60 s. Only complete sit-ups (those in which the forearms touched the thighs) were counted; the reproducibility of our data reached R=0.72.

Flexibility

Flexibility was determined with the sit-and-reach test. Subjects were asked to sit on the floor, with their legs straight and their feet against a Wells-type sit-and-reach box, then reach forward with their arms as far as possible along a measuring tape running across the box. The best of three attempts (farthest distance reached) was included in the analysis[30]; the reproducibility of our data reached R=0.91.

Agility

To evaluate agility, we applied a shuttle run test in which subjects attempt to run a 9.14-m course as rapidly as possible, bringing two blocks (one at a time) from the finish line back to the starting line, crossing each line with at least one foot. The best of two attempts was included in the analysis; the reproducibility of our data reached R=0.89.

Speed

We applied a speed test in which the subjects were asked to run 50 m, in a straight line, as quickly as possible in a single attempt. The time and the speed ($m \cdot s^{-1}$) were included in the analysis; the reproducibility of our data reached R=0.92.

Statistical analysis

All statistical analyses were performed using the Predictive Analytics Software, version 17.0 for Windows (PASW, Inc., Chicago, IL). Data are presented as mean ± standard error of mean. All data presented a normal distribution according to the Kolmogorov-Smirnov test. One-way analysis of variance and the Bonferroni post hoc test were used in order to compare gender groups with pubertal subgroups. Unpaired Student's t-tests were used in order to compare handgrip strength by percentile (P_0-P_{50} vs. P_{50}-P_{100}). Using hierarchical multiple regression analysis, we attempted to determined whether and to what degree physical fitness parameters were correlated with age, sexual maturation, arm muscle area, energy expenditure and handgrip strength. Statistical significance was set at $p < 0.05$.

RESULTS

Body mass and body height showed a significant difference with pubertal status, by gender and for the sample as a whole. In regard to body composition, we can suggest that waist circumference and arm muscle area are more suitable discriminators of pubertal status than are other parameters (body mass index, total body fat). Handgrip strength differed by pubertal status, regardless of gender. However, physical fitness parameters were mainly different for boys and for the sample as a whole (Table 1).

When we used handgrip strength values to stratify the subjects into the upper and lower ends of a muscle strength continuum, most of the variables demonstrated significant differences. The values for anthropometric and physical fitness variables (except for agility and speed) were highest for the subjects in the stronger group. However, age, flexibility and energy expenditure were comparable between the two strata (Table 2).

Table 1. Mean and standard error of general characteristics by pubertal status*

Variable	BOYS			GIRLS			WHOLE SAMPLE		
	Prepubescent[a]	Pubescent[b]	Postpubescent[c]	Prepubescent[a]	Pubescent[b]	Postpubescent[c]	Prepubescent[a]	Pubescent[b]	Postpubescent[c]
	n = 27	n = 91	n = 10	n = 20	n = 79	n = 6	n = 47	n = 170	n = 16
Age (years)	12.3 ± 0.3	11.7 ± 0.1	12.0 ± 0.7	11.5 ± 0.3	11.7 ± 0.2	12.7 ± 0.9	11.9 ± 0.2	11.7 ± 0.1	12.3 ± 0.6
Body mass (kg)	29.2 ± 1.5[bc]	41.6 ± 1.3[c]	61.0 ± 4.8	30.5 ± 1.8[bc]	43.7 ± 1.4[c]	60.5 ± 3.6	29.8 ± 1.2[bc]	42.7 ± 1.0[c]	60.8 ± 3.2
Height (cm)	130.4 ± 2.2[bc]	149.1 ± 1.1[c]	164.1 ± 1.6	130.2 ± 2.2[bc]	150.3 ± 1.1[c]	166.3 ± 2.3	130.3 ± 1.6[bc]	149.7 ± 0.8[c]	165.0 ± 1.3
Body mass index (kg·m^2)	17.0 ± 0.6[c]	18.4 ± 0.4[c]	22.6 ± 1.6	17.8 ± 0.8	19.1 ± 0.5	21.8 ± 0.8	17.4 ± 0.5[c]	18.8 ± 0.3[c]	22.3 ± 1.1
Total body fat (mm)	8.7 ± 0.8	10.2 ± 0.6	13.6 ± 2.1	10.0 ± 1.1	12.3 ± 0.7	12.6 ± 1.3	9.2 ± 0.6[c]	11.2 ± 0.5	13.3 ± 1.4
Waist Circumference (cm)	55.6 ± 1.3[bc]	62.5 ± 0.9[c]	70.4 ± 3.2	57.2 ± 2.9[c]	62.8 ± 1.2	69.5 ± 1.7	56.3 ± 1.5[bc]	62.7 ± 0.7[c]	70.1 ± 2.0
AMA (cm^2)	21.6 ± 1.4[b]	30.3 ± 1.9	37.7 ± 3.2	19.3 ± 1.0[bc]	25.8 ± 1.0[c]	39.4 ± 7.5	20.6 ± 0.9[bc]	28.2 ± 1.1[c]	38.4 ± 3.7
Handgrip strength (N)	271.7 ± 17.4[bc]	413.9 ± 13.8[c]	671.0 ± 45.9	272.2 ± 15.5[bc]	393.2 ± 13.8[c]	626.2 ± 101.5	271.9 ± 11.9[bc]	404.1 ± 9.7[c]	654.2 ± 45.9
Energy expenditure (kJ·wk^{-1})	2850 ± 962	7887 ± 2360	———	11672 ± 5363	8594 ± 3884	———	6564 ± 2462	8208 ± 2158	———
Vertical jump (cm)	24.6 ± 2.1	26.3 ± 0.6	29.8 ± 2.2	21.5 ± 1.0[c]	25.0 ± 0.7	31.0 ± 3.7	23.3 ± 1.3[c]	25.7 ± 0.5[c]	30.2 ± 1.9
Standing long jump (cm)	108.8 ± 6.2[bc]	131.5 ± 2.8[c]	163.6 ± 14.8	106.6 ± 4.7	123.6 ± 3.3	136.2 ± 15.0	108.7 ± 4.0[bc]	127.6 ± 2.2[c]	152.6 ± 11.0
Sit-ups (reps)	22.0 ± 2.2[bc]	28.0 ± 1.0	32.2 ± 4.3	22.5 ± 2.0	24.9 ± 1.3	31.0 ± 5.1	22.2 ± 1.5[c]	26.4 ± 0.8	31.7 ± 3.2
Flexibility (cm)	25.2 ± 0.8	23.9 ± 0.6	24.7 ± 3.2	26.8 ± 0.9	25.8 ± 0.7	24.8 ± 5.3	25.9 ± 0.6	24.9 ± 0.5	24.7 ± 2.7
Agility (s)	14.3 ± 0.4[bc]	12.9 ± 0.1	11.9 ± 0.3	14.4 ± 0.3[b]	13.1 ± 0.1	13.8 ± 0.9	14.3 ± 0.2[bc]	13.0 ± 0.1	12.6 ± 0.4
Speed (s)	10.8 ± 0.3[bc]	9.7 ± 0.1[c]	8.7 ± 0.3	10.6 ± 0.2	10.0 ± 0.1	9.3 ± 0.7	10.7 ± 0.2[bc]	9.8 ± 0.1[c]	8.9 ± 0.3
Speed (m·s^{-1})	4.7 ± 0.1[bc]	5.2 ± 0.1[c]	5.9 ± 0.3	4.7 ± 0.1[c]	5.1 ± 0.1	5.5 ± 0.5	4.7 ± 0.1[bc]	5.2 ± 0.1[c]	5.7 ± 0.2

Total body fat: total skinfold thickness (subscapular + suprailiac + middle axilary + abdominal + biceps + triceps + middle calf) divided by seven; AMA: arm muscle area; Handgrip strength: right + left handgrip strength; *Shading indicates significant differences in comparison with the other categories (indicated by superscript letters).

We performed pairwise multiple regression for age, sexual maturation, arm muscle area and energy expenditure (Table 3). Regardless of gender, handgrip strength was consistently associated with all physical fitness variables, except for flexibility and sit-up capacity (sample as a whole). Some of those associations were mediated by energy expenditure (i.e., speed in seconds and in meters per second for the sample as a whole). Otherwise, the association between handgrip strength and physical fitness was independent and ranged in strength from 20% (vertical jump: $R^2 = 0.20$; $p = 0.0005$) to 47% (speed in meters per second: $R^2 = 0.47$; $p = 0.0005$), as shown in Table 3.

Table 2. Mean and standard error of general characteristics by handgrip strength.

Variable	Handgrip strength (Newtons)		T (p)
	< 372.78 (n = 116)	≥ 372.79 (n = 117)	
Age (years)	11.7 ± 0.1 (10.0-17.0)	11.9 ± 0.1 (10.0-17.0)	.822 (.412)
Body mass (kg)	33.3 ± 0.8 (20.2-57.2)	49.3 ± 1.2 (24.5-99.2)	−10.844 (.001)
Height (cm)	138.1 ± 1.1 (110.0-167.0)	155.4 ± 0.9 (116.7-175.0)	−12.872 (.001)
Body mass index (kg·m²)	17.3 ± 0.3 (10.5-26.0)	20.2 ± 0.4 (10.7-39.1)	−5.976 (.001)
Total adiposity (mm)	10.0 ± 4.7 (4.5-23.0)	12.0 ± 6.5 (4.2-33.2)	−2.729 (.007)
Waist circumference (cm)	57.9 ± 0.8 (49.0-82.5)	65.6 ± 0.9 (37.0-106.8)	−6.005 (.001)
Arm muscle area (cm²)	22.8 ± 6.4 (11.1-48.7)	31.7 ± 17.5 (1.7-172.3)	−5.029 (.001)
Handgrip strength (N)	284.5 ± 5.3 (137.3-363.0)	500.4 ± 12.6 (372.8-1059.5)	−15.404 (.001)
Energy expenditure (kJ·wk⁻¹)	7939.9 ± 1719.6 (37.5-77037.4)	6821.8 ± 969.0 (175.2-36474.3)	.561 (.576)
Vertical jump (cm)	23.3 ± 0.6 (14.0-69.0)	27.8 ± 0.6 (16.0-45.0)	−5.278 (.001)
Standing long jump (cm)	111.5 ± 2.0 (51.0-163.5)	138.7 ± 3.0 (72.0-274.0)	−7.380 (.001)
Sit-ups (reps)	22.2 ± 0.9 (1.0-40.0)	29.3 ± 1.0 (1.0-60.0)	5.043 (.001)
Flexibility (cm)	25.3 ± 0.5 (10.0-44.0)	24.9 ± 0.6 (9.0-40.0)	.434 (.664)
Agility (s)	14.0 ± 0.1 (11.4-17.7)	12.5 ± 0.1 (10.0-17.0)	8.019 (.001)
Speed (s)	10.6 ± 00.1 (8.4-13.5)	9.4 ± 0.1 (6.6-14.3)*	7.846 (.001)
Speed (m·s⁻¹)	4.8 ± 0.1 (3.7-5.9)	5.4 ± 0.1 (3.5-7.6)*	−8.086 (.001)

Shading indicates significant associations p<.05

Table 3. Association between handgrip strength and other physical fitness variables

			β (significance level)				
Variable	Group	Model summary	Age	Sexual maturation	Arm muscular area	Energy expenditure	Handgrip strength
Vertical jump height	Boys	R^2=.20; P=.0005	-.118 (.513)	-.100 (.705)	.076 (.676)	-.161 (.384)	.505 (.064)
	Girls	R^2=.36; P=.0005	-.065 (.745)	.079 (.721)	.045 (.832)	-.186 (.344)	.536 (.024)
	Total	R^2=.29; P=.002	-.081 (.516)	-.030 (.851)	.074 (.552)	-.183 (.144)	.511 (.002)
Standing long jump	Boys	R^2=.46; P=.0005	-.115 (.438)	-.054 (.803)	.115 (.445)	-.126 (.404)	.686 (.004)
	Girls	R^2=.44; P=.0005	.074 (.694)	-.147 (.487)	-.024 (.905)	.115 (.533)	.744 (.002)
	Total	R^2=.46; P=.0005	-.057 (.600)	-.115 (.409)	.079 (.472)	-.066 (.548)	.717 (.001)
Curl up	Boys	R^2=.25; P=.062	-.084 (.727)	-.004 (.989)	.055 (.827)	-.252 (.289)	.362 (.187)
	Girls	R^2=.20; P=.187	.045 (.816)	-.164 (.562)	.096 (.624)	.102 (.604)	.547 (.062)
	Total	R^2=.24; P=.010	-.043 (.755)	-.083 (.632)	.094 (.497)	-.212 (.127)	.467 (.010)
Flexibility	Boys	R^2=.01; P=.648	-.153 (.429)	-.025 (.930)	.009 (.965)	-.351 (.082)	.057 (.839)
	Girls	R^2=.05; P=.089	-.108 (.664)	-.013 (.964)	-.185 (.480)	-.105 (.664)	.214 (.442)
	Total	R^2=.04; P=.655	-.144 (.322)	-.001 (.995)	-.086 (.557)	-.182 (.215)	.083 (.655)
Agility	Boys	R^2=.32; P=.001	.091 (.565)	-.060 (.796)	-.087 (.590)	.080 (.619)	-.539 (.026)
	Girls	R^2=.38; P=.0005	-.003 (.988)	.092 (.706)	-.109 (.638)	-.111 (.605)	-.481 (.060)
	Total	R^2=.25; P=.0005	.062 (.607)	.007 (.964)	-.089 (.464)	.008 (.944)	-.531 (.001)
Speed at seconds	Boys	R^2=.40; P=.0005	.107 (.538)	.018 (.944)	-.003 (.986)	-.003 (.986)	-.584 (.028)
	Girls	R^2=.34; P=.0005	.149 (.440)	.090 (.672)	-.087 (.667)	.289 (.131)	-.616 (.008)
	Total	R^2=.38; P=.0005	.141 (.229)	.063 (.671)	-.034 (.773)	.237 (.046)	-.637 (.001)
Speed at meters per seconds	Boys	R^2=.41; P=.0005	-.076 (.642)	-.062 (.796)	.001 (.997)	-.002 (.988)	.679 (.008)
	Girls	R^2=.46; P=.0005	-.156 (.382)	-.083 (.675)	.069 (.712)	-.274 (.123)	.691 (.002)
	Total	R^2=.47; P=.0005	-.124 (.259)	-.083 (.547)	.026 (.816)	-.218 (.050)	.716 (.001)

Total= both sexes.

DISCUSSION

Our preliminary results seem to demonstrate an important role of handgrip strength to predict physical fitness variables. The strength of the association between handgrip strength and physical fitness ranged from 20% (vertical jump test: R^2=0.20; P=.001) to 47% (speed in meters per second: R^2=.47; P=.001). These results support the idea that handgrip strength is consistently associated with several distinct parameters of physical fitness, regardless of age, gender or sexual maturation, suggesting that handgrip strength could be a highly accurate, independent predictor of physical fitness.

Therefore, handgrip strength should be included as a component of the multidimensional health evaluation of children and adolescents. Most possibly, through population-based reference values of handgrip strength based on physical size and body composition[1-3], clinicians could detect earlier low levels of physical fitness in order to prevent future health problems[1-7,12,13]. However, certainly, handgrip strength should not be used in isolation, especially in a clinical setting, where other markers (lipid profile, electrocardiography findings, etc.) have considerable predictive power. In this ways, there are some studies corroborating our hypothesis in which handgrip strength could also be used as a predictive factor for health outcomes in a clinical context for children[19,20], adults[11,13], elderly individuals[12,16,17], as well as for individuals living with HIV/aids[18].

Moreover, handgrip strength should also be employed for identifying potentially talented athletes[8-10] and our results possibly suggest an important predictor factor for physical performance. Most recently, it was demonstrated that handgrip strength was significantly correlated with swimming performance (R=.78) in national-level Portuguese swimmers in the four competitive swimming strokes[9]. Other study also showed that handgrip strength is significantly correlated (R=-.67) with tennis performance in 12 male aged 13.6 ± 1.4 years[10]. Adult handgrip strength may also be predicted by an elevated accuracy from childhood and adolescent data in individuals with a normal maturational distribution[21]. In skeweed distribution, it is possible that stature and mass could be produce a certain bias level[22.23].

Our findings should be viewed with caution because is possible that the number of subjects in some categories of self-reported pubertal status, as well as the fact that the direction of the associations could not be fully defined, narrowing some observations. On the other hand, handgrip strength correlated significantly with the performance variables (e.g., agility and vertical jump capacity), as well as with the fitness variables (e.g., sit-ups and speed). The characteristics of our subjects are representative of a school-based sample, which could be interpreted as external validation of our results. Further studies are needed in order to determine the stability of handgrip strength as a marker of physical fitness in individuals whose characteristics (level of physical activity, physical fitness and health status) vary substantially from those of our sample. On the other hand, our results seem to confirm other available evidences demonstrating that age, cross-sectional area or maturity do not represent important correlates of muscle strength during childhood or adolescence[22,23].

CONCLUSIONS

In conclusion, our results support the idea that handgrip strength is consistently associated with several distinct parameters of physical fitness, regardless of age, gender or sexual maturation, suggesting that handgrip strength could be a highly accurate, independent predictor of physical fitness. Therefore, handgrip strength should be included as a component of the multidimensional health evaluation of children and adolescents in school and clinical settings.

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