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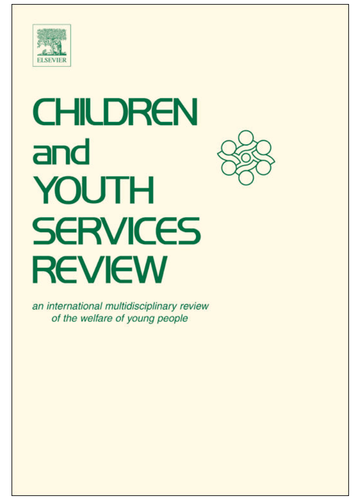

Health-Related Physical Fitness of Children and Adolescents in Portugal

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PII: S0190-7409(20)30326-1
DOI: https://doi.org/10.1016/j.childyouth.2020.105279
Reference: CYSR 105279

To appear in: *Children and Youth Services Review*

Received Date: 1 March 2020
Revised Date: 18 July 2020
Accepted Date: 21 July 2020

Please cite this article as: J. Batista de Castro Pinto, J. Patricia Santos Cruz, T. Maria Pereira de Pinho, A. Sofia Pires de Dias Marques, Health-Related Physical Fitness of Children and Adolescents in Portugal, *Children and Youth Services Review* (2020), doi: https://doi.org/10.1016/j.childyouth.2020.105279

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Title: Health-Related Physical Fitness of Children and Adolescents in Portugal

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Declarations of interest: none.

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Title: Health-Related Physical Fitness and Physical Activity of Children and Adolescents in Portugal

ABSTRACT

Objectives: To establish normative values for health-related physical fitness **(**HRPF) measures in Portuguese children and adolescents. Secondarily, to explore the relationship between the HRPF and physical activity.

Methods: HRPF was assessed in 354 children (6-17 years old, 152 males), through body mass index (BMI), incremental shuttle walk test (ISWT), hand-held dynamometry (HHD), modified sit-and-reach test (MSRT) and timed up and go (TUG). Physical activity was assessed with the "Assessment of Physical Activity Level Questionnaire" (APALQ). Normative values were then calculated as mean (95% confidence intervals) considering gender and four age groups (6-8; 9-11; 12-14; 15-17). Two-way ANOVAs were used to verify the effect of age, gender and age*gender interaction and Pearson's coefficient correlations to assess relationships between HRPF and physical activity.

Results: Except for the MSRT ($p=0.036$), no age*gender interaction effects were observed. The ISWT and TUG test presented a significant difference among age groups ($p<0.05$). Male children presented a better performance in the ISWT ($p<0.001$) and HHD ($p=0.028$) than females. Children had moderate physical activity levels except for the 6-8 age group, and there was a weak but significant association between HRPF tests and physical activity ($-0.243<r<0.312$, $p<0.05$) except for MSRT ($r=0.109$, $p>0.05$).

Conclusions: These normative values will allow physical therapists to identify children with reduced performance and prescribe exercise accordingly. Active lifestyles should be encouraged in this population as better physical activity levels are related to better HRFP.

Key words: Health-related Physical Fitness; Physical activity; Normative values; Children; Physical therapy

Abbreviations

Health-related Physical Fitness **-** HRPF
Body Mass Index - BMI
Incremental Shuttle Walk Test - ISWT
Hand-held Dynamometry - HHD
Modified Sit-and-reach Test - MSRT
Timed Up and Go - TUG
Assessment of Physical Activity Levels Questionnaire - APALQ

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1. INTRODUCTION

Physical therapy aims to develop, maintain and restore maximum movement and functional ability throughout the lives of individuals, communities and population in general, through disease prevention and health promotion.(World Confederation for Physical Therapy, 2011) There is a range of physical therapy interventions which address the five components of health-related physical fitness (HRPF): body composition, cardiorespiratory fitness, muscle strength, flexibility and neuromuscular component.(Andersen, Vinther, Poulsen, & Mellemgaard, 2011; Auld & Johnston, 2014; Hanewinkel-van Kleef, Helders, Takken, & Engelbert, 2009; Horsak et al., 2015; Quinn, Doody, & Shea, 2008; Urquhart et al., 2012) Identifying altered performance in one or more HRPF components is fundamental for developing tailored interventions.

In order to tailor these interventions to the individual's characteristics/condition, a number of clinical measures to assess each of these five HRPF components are available, such as body mass index (BMI)(Mei et al., 2002) for body composition; incremental shuttle walk test (ISWT)(Singh, Morgan, Scott, Walters, & Hardman, 1992) for cardiorespiratory fitness; hand-held dynamometry (HHD)(Wu, Wang, & Kennedy, 2013) for muscular strength; modified sit and reach test (MSRT)(Hoeger, Hopkins, Button, & Palmer, 1990) for flexibility and timed up and go test (TUG)(Podsialo & Richardson, 1991) for the neuromuscular component. Several test batteries have been developed to assess HRPF in children and adolescents such as Fitnessgram®,(Morrow, Martin, & Jackson, 2010) Eurofit®(Kemper & van Mechelen, 1996) or ALPHA.(Ruiz et al., 2011) However, when assessing HRPF in children and adolescents with neuromuscular,(Damiano, Dodd, & Taylor, 2002; Jankowicz-Szymanska, Mikolajczyk, & Wojtanowski, 2012; Williams & Physio, 2005) cardiorespiratory(Cox, Follett, & Mckay, 2006; Gomes et al., 2013; Reimberg et al., 2018) or oncologic(Marchese, Chiarello, & Lange, 2004; Takken et al., 2009) conditions, the clinical measures previously identified are commonly used due to their simplicity, low cost, and efficient application in clinical practice without the need for specialized training.(Holland et al., 2014; Mei et al., 2002) Furthermore, those measures can be used to prescribe exercise training in children, adolescents and adults with several conditions.(Andersen et al., 2011; Auld & Johnston, 2014; Fogelholm, Stigman, Huisman, & Metsämuuronen, 2008; Sewell, Singh, Williams, Collier, & Morgan, 2006)

Low HRPF status in children and adolescents has been associated with increased likelihood of adult obesity, increased insulin resistance,(Dwyer et al., 2009) increased cardiovascular risk,(Eisenmann, Wickel, Welk, & Blair, 2005; Lima, Bugge, Ersbøll, Stodden, & Andersen, 2018) and better results in HRPF tests with a lower risk of death later in life.(Ruiz et al., 2009) Hence, this indicator is important when addressing health-related outcomes(Ortega, Ruiz, Castillo, & Sjöström, 2008) not just in children with a health condition but also in those at higher risk of developing unfavorable health outcomes due to their low fitness levels. Nevertheless, the interpretation of HRPF levels requires the availability of normative values.

Although normative values for most of the HRPF measures used in physical therapists' clinical practice are established for the adult population,(Adegoke, Akpan, & Mbada, 2012; Bohannon, 2006; Probst et al., 2012; Tveter, Dagfinrud, Moseng, & Holm, 2014) these are scarcely available in children.(De Miguel-Etayo et al., 2014) Normative values are fundamental to guide physical therapy intervention, and to prescribe exercise training accordingly.(Martínez-Vizcaíno & Sánchez-López, 2008) The available normative data for some of the HRPF measures used in clinical practice has been determined with samples of children/adolescents with different age groups and/or conducted in different countries.(Adegoke et al., 2012; Habib, Westcott, & Valvano, 1999; Haugen, Hoigaard, & Seiler, 2014; Lanza et al., 2015; Macfarlane, Larson, & Stiller, 2008; Nicolini-Panisson & Donadio, 2014) Previous research has shown that, although fitness is in part genetically determined, it can also be greatly influenced by environmental factors such as socioeconomic,

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physical activity levels, environmental conditions and distribution of wealth.(Martínez-Vizcaíno & Sánchez-López, 2008; Olds, Tomkinson, Léger, & Cazorla, 2006) Therefore, normative values of HRPF measures should be established for children and adolescents of a specific country considering the well-known differences between genders and age groups to improve the interpretability and clinical usefulness of clinical field tests.(Adegoke et al., 2012; Mak et al., 2010; Marchese et al., 2012; Sahlberg, Svantesson, Thomas, & Strandvik, 2005; Toriola & Minyeki, 2012)

Previous studies have found a positive relationship between physical activity and HRPF, particularly moderate to vigorous physical activity (Aubert et al., 2018; Júdice et al., 2017), although the relationship was, most of the times, weak.(Martínez-Vizcaíno & Sánchez-López, 2008) Nevertheless, there are concomitant beneficial influences of physical activity and HRPF on children's health. Increasing physical activity and physical fitness is crucial to prevent obesity, enhance mental health and improve health-related quality of life.(Gu, Chang, & Solmon, 2016; Morales et al., 2013; Ströhle, 2009) Also, previous literature refers that adoption of physical activity patterns influences physical fitness in the first months (Blair, Cheng, & Scott Holder, 2001; Gu et al., 2016) But habitual physical activity is not the only influencer of HRPF. Bouchard & Shepperd (1994) defined a model where they describe all the contributors of HRPF. In addition to physical activity, heredity, environmental conditions (such as lifestyle behaviors) and health (e.g. morbidity) influence HRPF, and they also influence each other.(Bouchard & Shephard, 1994) As habitual physical activity is a modifiable lifestyle behavior that is usually established in childhood, which may have impact on adult behavior and health status,(Martínez-Vizcaíno & Sánchez-López, 2008) knowledge of the relationship between HRPF and physical activity in children of different ages may help to design of future public health interventions.

The objective of this study was to establish normative values of HRPF measures for

Portuguese children and adolescents, according to their gender and age. A secondary aim was to explore the relationship between components of HRPF and physical activity levels.

2. METHODS

2.1. Design

A cross-sectional study was conducted with children from primary and secondary schools from the centre region of Portugal who agreed to participate after the aims and procedures of the study were explained in an arranged meeting.

2.2. Participants

The sample was obtained from 403 children contacted. It included 354 (87,84%) participants (152 males) who agreed to participate and met the inclusion criteria. Participants were distributed in four age groups: 6-8 years (n=62); 9-11 years (n=56); 12-14 years (n=102); 15-17 years (n=134). The percentage of boys and girls in each age group was the following, respectively: 61.29% and 38.71% in the 6-8 age group; 67.86% and 32.14% in the 9-11 age group; 42.16% and 57.84% in the 12-14 age group; and 24.63% and 75.37% in the 15-17 age group. Sample sizes of at least 100 have been found powerful to determine reference values.(Altman, 2006) Potential participants were identified by teachers and were eligible if they: i) were aged 6 to 17 years; ii) had a signed informed consent form from their legal representative confirming child's will to participate. Exclusion criteria included: i) the existence of neurological impairment; ii) significant cardiorespiratory, metabolic and/or musculoskeletal disorders and/or iii) any significant impairment that could preclude them from performing the physical tests, such as visual or hearing impairments; as it has been done in similar studies.(Lanza et al., 2015; McKay et al., 2017; Reimberg et al., 2018; Ruiz et al., 2009) Ethical approval to conduct this study was obtained from Ethical Committee of the Health

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Sciences Research Unit: Nursing of Coimbra (UICISA: E, n. 246-12/2014). Written information explaining the study and informed consents were provided to the participants before data collection.

2.3. Measures

Body Composition. Weight and height were measured with a JOFRE® mechanical weight and height scale to the nearest 0.1 kg and 0.5 cm. Measurements were conducted in an isolated room with participants in underwear and without shoes. Height was measured with heels together and after a deep inhalation. This test is commonly used to assess body composition in populations from all ages worldwide.(Y. C. Chen et al., 2014; Ervin, Fryar, Wang, Miller, & Ogden, 2014; Ramos-Sepúlveda, Ramírez-Vélez, Correa-Bautista, Izquierdo, & García-Hermoso, 2016; Tveter et al., 2014) An anthropometric calculator (AnthroPlus Software), available at the World Health Organization website (http://www.who.int/growthref/tools/en/),(World Health Organization, 2007) was then used to determine the BMI percentile for each participant according to their age and gender. BMI has shown strong correlations with body fat percentage ($r=0.83–0.94$; $p<0.0001$) and fat mass ($r=0.83–0.94$; $p<0.0001$) in children.(Lindsay et al., 2001)

Cardiorespiratory component. The Incremental Shuttle Walk Test (ISWT) was used to assess health-related cardiorespiratory fitness.(Singh et al., 1992) An adaptation of the protocol was used as described in Probst et al. (2012), in order to reach the maximal effort since participants were healthy children. Participants were required to walk between two cones (10-meter course; cones were inset 0.5 m from either end to avoid abrupt direction changes) during specific time frames controlled by recorded audio signals. The initial walking speed was 0.5 m/s (1st level) and it increased 0.17 m/s each minute, exceeding the original 12 levels of speed with the possibility of running, if necessary(Probst et al., 2012); a triple beep indicated the speed increment or change of level. The audio signals continued until participants were too breathless or could not perform the distance at two consecutive beeps.(Probst et al., 2012) The levels achieved and the corresponding distance in meters were recorded. The ISWT was performed twice due to the learning effect and the best performance was considered.(Singh et al., 2014) The ISWT was performed twice due to the learning effect and the best performance was considered.(Singh et al., 2014) A 30-minute rest was given to participants between repetitions. Before and after each ISWT, dyspnea and fatigue were measured with the Modified Borg Scale,(Borg, 1982; Wilson & Jones, 1989) heart rate and peripheral oxygen saturation with a pulse oximeter (PULSOX-300i, Konica Minolta Sensing, Inc., Osaka, Japan) and arterial blood pressure with an automated sphygmomanometer (Elite, Medel, Parma, Italy). Heart rate and peripheral oxygen saturation were also monitored during the test, as recommended.(Holland et al., 2014) This field test has shown good reproducibility in pediatric populations.(Coelho et al., 2007; Radtke, Stevens, Benden, & Williams, 2009; Rogers, Prasad, & Doull, 2003; Selvadurai et al., 2003) Excellent reliability (ICC=0.98, 95% CI 0.97 - 0.99) of this test has been reported for children.(Lanza et al., 2015)

Muscle strength. Quadriceps muscle group was chosen to assess children's muscle strength as it has been associated with walking capacity in children with health conditions,(Eek & Beckung, 2008; Sahlberg et al., 2005; Sandstedt, Fasth, Eek, & Beckung, 2013; Wuang, Chang, Wang, & Lin, 2013) and has provided better inter-rater reliability/agreement results in children and adolescents than other muscles of the lower limb.(Daloia, Leonardi-Figueiredo, Martinez, & Mattiello-Sverzut, 2018) Quadriceps isometric muscle strength was assessed using a hand-held dynamometer (HHD) (Hoggan MicroFET2 Muscle Tester, Model 7477, Pro Med Products, Atlanta, GA), with a "make" test, described before by Hébert et al (2011). Participants performed the test in a sitting position, with the knee and hip flexed at 90º and the trunk in upright position. The researcher placed the HHD in the anterior surface of the dominant leg, proximal to the ankle (5 cm above the lateral malleolus). Each participant performed at

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least one practice trial to understand the movement and the adequate stabilization provided by the researcher. This test has shown good reliability results (intrarater reliability: ICC=0.90 95%CI 0.65-0.97; interrater reliability: ICC=0.84 95%CI 0.48-0.96).(Hébert et al., 2011)

Flexibility. The Modified Sit and Reach Test (MSRT) is a common test applied to assess flexibility.(American College of Sports Medicine, 2013) It is a variation of the Classical sit-and-reach test (SRT) to account for the variability of the individuals' limbs length.(Hoeger et al., 1990) It was chosen because it is a test simple to perform which does not require expensive equipment and it is frequently used in pediatric populations,(Adegoke et al., 2012; Haugen et al., 2014; Mak et al., 2010; Mayorga-Vega, Merino-Marban, & Viciana, 2014) either alone or as a test variation to assess hamstring flexibility in test batteries, such as the Eurofit®.(Kemper & van Mechelen, 1996) The MSRT was performed as reported previously.(Hoeger et al., 1990) Participants were in a sitting position with head, back and hip (90º) against the wall and the plantar surface against a wooden box; one hand was placed over the other. In the initial position, participants were instructed to reach the measurement scale (only scapular abduction was allowed, but head and back had to remain in contact with the wall). The fingertips were placed on the ruler and that point was considered the relative zero point. Then, participants bend their trunk forward reaching the end point in the measuring scale. The final score was the distance between the zero point (initial position) and the point reached in the ending position. This test has shown moderate criterion-related validity results in children (correlation between MSRT and hamstring extensibility r_p=0.67 95% CI 0.55–0.79).(Mayorga-Vega et al., 2014)

Neuromuscular Component. The Timed Up and Go (TUG) test was performed due to its clinical relevance, as it is a quick and useful test in the assessment of the functional mobility of individuals before, during, and after intervention.(Nicolini-Panisson & Donadio, 2014) The TUG has the advantage of incorporating many mobility tasks that are present in children's everyday lives and are specified by the International Classification of Functioning, Disability and Health (ICF), such as changing and maintaining basic body position (e.g., sitting, standing) and walking.(World Health Organization, 2001) Participants performed the TUG as described before.(Habib & Westcott, 1998) They were instructed to start the test in the sitting position with hips, knees and ankles close to a 90º flexion. Then, at the word 'go', participants walked three meters until a mark on the floor, turned and sat on the chair, as fast as possible but without running. Timing started when the participant left the seat and stopped when the participant's back touched the back of the chair. Participants performed the test three times and the test with the shortest time, in seconds, was considered.(Williams, Carroll, Reddihough, Phillips, & Galea, 2005) One study conducted in children aged 3-18 years reported excellent test-retest reliability within the same day (ICC ranging from 0.93 to 0.95) and between days (ICC=0.95).(Nicolini-Panisson & Donadio, 2014)

Physical Activity. Children's physical activity was measured with the Assessment of Physical Activity Levels Questionnaire (APALQ).(Telama et al., 1985) It is a self-report questionnaire and respondents are asked about their physical activity in different contexts: (1) "Outside school, do you take part in organized sport?"; (2) "Outside school, do you take part in non-organized sport?"; (3) "In Physical Education classes, how many times a week do you take part in sport or physical activity for at least 20 minutes?"; (4) "Outside school, how many hours a week do you usually take part in physical activity to the extent that you get out of breath or sweat?"; and (5) "Do you take part in competitive sport?". The questionnaire provides a total score, the physical activity index,(Ledent et al., 1997) which ranges from 5 to 20 points and can be further used to identify four categories: sedentary group (score=5); low activity group (score=5-10); moderately active group (score=10-15) and vigorously active group (score=15-20).(Ledent et al., 1997) It has been used in previous studies to assess physical activity levels in children.(Casterad et al., 2012; Mota & Esculcas, 2002; Risto Telama et al., 2005) The

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reliability and internal consistency of the APALQ in pediatrics has been assessed and excellent test-retest reliability (Intraclass correlation coefficient [ICC]=0.92 to 0.96) and good internal consistency values (Cronbach's α=0.87) were found.(Mota & Esculcas, 2002)

2.4. Procedure

The assessment was conducted at schools or at the university between June 2013 and March 2016. Children were instructed to wear light clothes. Sociodemographic, clinical, anthropometric data, vital signs were first collected to characterize the sample, followed by the physical activity questionnaire. The parents or legal representatives helped children who could not complete the questionnaire by themselves. Then, measures for each HRPF component were collected, by the described order. The assessment session lasted approximately one hour and thirty minutes and children could have breaks if wanted.

2.5. Data analysis

Data were analyzed using IBM SPSS Statistics version 22. Descriptive statistics were used to characterize the sample. Children were divided into the following age groups: 6-8, 9-11, 12-14 and 15-17 years to consider the age and gender differences throughout childhood.(Marchese et al., 2012; Nicolini-Panisson & Donadio, 2014; Souza, Baptista, Benedicto, Pizzato, & Mattiello-Sverzut, 2014) Two-way analysis of variance (2-way ANOVAs) were used to verify the effect of age, gender and age*gender interaction. The age*gender interaction aimed to identify potential differences in subgroups,(Field, 2009) i.e., differences that occurred between genders in specific age groups but not in others (e.g., differences between boys and girls in the 6-8 age-group). If the age*gender interaction was significant, a simple effects analysis was performed to identify which specific subgroup(s) presented significant differences. If only one age group or gender were significant, pairwise comparisons using the Scheffé's test were performed to identify the groups with statistical differences.(Field, 2009) The normative values were reported as means and 95% confidence intervals (95%CI).

Pearson's coefficient correlations were used to determine relationships between the HRPF tests and APALQ continuous scores. The results of each HRPF test were also compared among the different physical activity groups using one-way ANOVA.

Statistical analyzes were considered significant at $p<0.05$.

3. RESULTS

Information about children's anthropometrics, vital signs and physical activity levels are presented in Table 1.

TABLE 1

Characterization of male (n=152) and female (n=202) children aged 6-17 years old.

		6-8 (n=62)	**9-11 (n=56)**	**12-14 (n=102)**	**15-17 (n=134)**	**p-value†**
Height (m)	**Male** (n=152)	1.26 (0.09)	1.41 (0.08)	1.59 (0.10)	1.72 (0.07)	0.003*
	Female (n=202)	1.23 (0.09)	1.45 (0.10)	1.56 (0.07)	1.65 (0.08)	
Weight (Kg)	**Male** (n=152)	27.15 (7.34)	34.84 (5.41)	50.19 (12.15)	63.51 (8.66)	0.035*
	Female (n=202)	25.75 (5.91)	38.43 (8.35)	49.11 (9.16)	58.14 (9.42)	
HR (bpm)	**Male** (n=152)	86.16 (13.16)	85.13 (12.51)	80.72 (13.79)	76.79 (8.57)	0.995
	Female (n=202)	91.25 (14.14)	89.00 (17.60)	84.61 (14.89)	81.02 (15.93)	
RR (bpm)	**Male** (n=152)	21.58 (4.55)	22.32 (4.20)	20.30 (3.31)	20.66 (3.38)	0.968
	Female (n=202)	21.29 (3.14)	22.33 (3.65)	19.80 (3.58)	20.66 (4.29)	

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SBP (mmHg)	**Male** (n=152)	105.92 (14.85)	109.24 (23.97)	117.12 (16.41)	127.31 (13.77)	0.505
	Female (n=202)	105.46 (16.09)	110.39 (12.85)	115.53 (15.28)	120.79 (14.26)	
DBP (mmHg)	**Male** (n=152)	69.66 (8.57)	69.95 (12.23)	73.30 (9.85)	74.76 (10.17)	0.316
	Female (n=202)	69.62 (11.28)	70.44 (13.12)	72.10 (11.46)	72.13 (8.79)	
SpO_2 (%)	**Male** (n=123)	97.53 (0.87)	97.41 (0.71)	97.84 (1.11)	98.29 (1.05)	0.410
	Female (n=189)	97.21 (0.89)	97.58 (1.08)	98.14 (1.12)	98.21 (0.82)	
APALQ	**Male** (n=152)	13.32 (3.49)	15.21 (2.41)	13.88 (3.30)	13.90 (3.27)	0.089
	Female (n=202)	9.16 (4.34)	12.50 (2.87)	12.58 (3.14)	11.86 (3.91)	

Results are presented as mean (standard deviation). Bpm: beats per minute (in heart rate) or breaths per minute (in respiratory rate); DBP: diastolic blood pressure; HR: heart rate; RR: respiratory rate; SBP: systolic blood pressure; SpO_2: peripheral oxygen saturation; APALQ: assessment of physical activity levels questionnaire; %pred.: percentage predicted.

† P-values represent the significance of the age*gender interaction.

* p<0.05

Table 2 presents normative data for the HRPF measures. Participants had a normal BMI for their age, being slightly above the 50th percentile. No significant differences were found in the BMI for age or gender (p>0.05). The ISWT distance increased with age and there were significant differences between all age groups (p<0.05) except for the comparison between the 9-11 and 12-14 age groups. The TUG scores tended to decrease from the first to the third age group, and then increase in the older age group. Nevertheless, significant differences were only found between the 6-8 age group and the other age groups (p<0.05). No significant differences were found for muscle strength (HHD) among the age groups (p>0.05).

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Regarding comparisons between genders, there was a significant difference between male and female genders in the ISWT (p<0.001) and the quadriceps muscle strength (p=0.028), with boys performing better than girls. Only the MSRT showed age*gender interaction effects (p=0.036). When the simple effects analysis was carried out, the MSRT results showed that girls had significantly higher results than boys only in the 15-17 age group (p=0.001).

TABLE 2

Normative values for health-related physical fitness tests for male (n=152) and female (n=202) children aged 6-17 years.

Test		6-8 (n=62)	9-11 (n=56)	12-14 (n=102)	15-17 (n=134)	p-value†
BMI (pctl)	**Male** (n=151)	62.4 [52.8-72.0]	61.3 [52.3-70.3]	60.0 [50.3-69.8]	63.8 [55.4-72.2]	0.629
	Female (n=200)	61.6 [52.7-70.6]	58.6 [45.5-71.6]	50.3 [43.2-57.4]	53.4 [48.3-58.5]	
ISWT (m)	**Male** (n=103)	932.2 [817.8-1047.7]	1102.9 [980.9-1225.0]	1334.7 [1266.9- 1402.5]	1453.8 [1329.3-1578.3]	0.562
	Female (n=180)	682.7 [414.7-950.8]	1066.4 [947.7-1185.2]	1152.4 [1072.0-1232.8]	1316.7 [1241.5-1391.9]	
HHD (kgf)	**Male** (n=57)	----††	19.7 [15.2-24.3]	22.7 [19.5-25.9]	24.1 [21.2-27.0]	0.846
	Female (n=64)	----††	----††	18.7 [16.3-21.2]	18.6 [16.2-21.0]	
MSRT (cm)	**Male** (n=101)	35.7 [33.4-37.9]	34.6 [31.7-37.4]	41.5 [36.9-46.2]	28.1 [22.3-34.0]	0.036*
	Female (n=155)	40.1 [35.2-45.0]	39.6 [34.3-44.5]	40.9 [37.4-44.4]	41.6 [39.0-44.1]	
TUG (s)	**Male** (n=101)	5.2 [4.9-5.5]	4.5 [4.3-4.7]	4.2 [3.9-4.4]	4.7 [3.0-6.3]	0.742

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Female	5.3	4.7	4.6	4.8
(n=155)	[5.0-5.6]	[4.3-5.0]	[4.4-4.8]	[4.6-5.0]

Results are presented as mean [lower and upper limits of the 95% Confidence Intervals]. BMI: body mass index for age; HHD: hand-held dynamometry; ISWT: incremental shuttle walk test; MSRT: modified sit and reach test; pctl: percentile; TUG: timed up and go test.

† P-values represent the significance of the age*gender interaction.

††There is no data for this age group due to the reduced sample number.

*p<0.05

There was no age*gender interaction in physical activity levels (p=0.089). However, when exploring each of the groups separately (i.e., age and gender), males presented a higher score than females (p<0.001). There were no significant differences across age groups (p>0.05). When considering the whole sample, 24 children were included in the sedentary group, 70 in the low activity group, 159 in the moderately active group and 101 in the vigorously active group.

Significant correlations were found between the APALQ scores and ISWT (r=0.312, p<0.001), TUG (r=-0.243, p<0.001), BMI (r=0.123, p=0.02) and HHD (r=0.183, p=0.05) scores (Table 3). As APALQ scores increased, ISWT, BMI and HHD scores also increased. However, all correlations were weak. These results were also observed when comparing the HRPF tests to the different physical activity groups. Significant differences were only observed in the ISWT and the TUG test. Specifically, in the ISWT, the vigorously active group walked 380.1±43.2 more meters than the sedentary group (p=0.003), 250.2±4.7 more meters than the low activity group (p=0.001) and 164±13.9 more meters than the moderately active group (p=0.013). In the TUG test, the vigorously active group was 0.6±0.02 seconds faster than the low activity group (p=0.002) and 0.4±0.001 seconds faster than the moderately active group (p=0.018).

TABLE 3

Pearson's correlations between the HRPF tests and physical activity scores in healthy children (n=354).

Variable \ Test	BMI	ISWT	HHD	MSRT	TUG
APALQ	0.123*	0.312†	0.183*	0.109	-0.243†

BMI: body mass index; HHD: hand-held dynamometry; ISWT: incremental shuttle walk test; MSRT: modified sit and reach test; APALQ: assessment of physical activity levels questionnaire; TUG: timed up and go test.

* Correlation is significant at the 0.05 level.

† Correlation is significant at the 0.001 level.

4. DISCUSSION

HRPF measures commonly used in physical therapy clinical practice were administered to a sample of Portuguese children to obtain normative values in this population. The main findings of this study were: a) children were within a normal percentile of body composition; b) boys showed higher performance in cardiorespiratory fitness and muscle strength tests than girls; c) girls in the age group 15-17 years old had higher levels of flexibility than boys; and d) children with higher levels of physical activity had better body composition, cardiorespiratory fitness, quadriceps muscle strength and neuromuscular performance although relationships were weak.

Body composition was within a normal percentile range in all age groups. Since BMI levels higher than the normal range are associated with a worse performance in other HRPF tests,(W. Chen et al., 2002; Fogelholm et al., 2008) it is possible to infer that, in this study, the results obtained in the performance tests (i.e., ISWT, HHD, MSRT and TUG) were not influenced by an altered body composition.

In cardiorespiratory assessment with the ISWT, male children walked a significantly longer

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distance than female children, corroborating the findings of recent studies with similar age ranges.(Lanza et al., 2015; Vardhan, Palekar, Dhuke, & Baxi, 2017) Furthermore, the distance walked in the ISWT increased significantly with age in the present and previous studies.(Lanza et al., 2015; Vardhan et al., 2017) Although the reason for these findings is still not clear, they may be attributed to the differences in the growth and maturation of boys and girls (e.g., differences in muscle mass and fat mass), as well as differences in height. Since boys are usually taller than girls (also found in the present study), the distance covered by boys may be increased because of a longer stride length and step length, which makes walking more efficient.(Vardhan et al., 2017) Although several studies on normative values of the shuttle test (alone or as one of the HRPF test batteries) exist, it was not possible to compare their data with the data from the present study, as they used a 20-m course to perform the test(Olds et al., 2006; Santos et al., 2014) and we used a 10-m course. However, studies conducted in children with clinical conditions have used the 10-m course shuttle test,(Cox et al., 2006; Gomes et al., 2013; Reimberg et al., 2018) which supports our choice for clinical practice. Furthermore, having a 20-m course to perform the test in clinical practice is, most of the times, not feasible.

Boys presented higher values than girls in quadriceps muscle strength as shown previously in the literature.(Beenakker, Van der Hoeven, Fock, & Maurits, 2001; Daloia et al., 2018; Ervin et al., 2014; McKay et al., 2017) When comparing different age groups, no significant differences were found for quadriceps muscle strength, contrasting with previous literature.(Beenakker, Van der Hoeven, & Fock, 2001; Hébert, Maltais, Lepage, Saulnier, & Crête, 2015) This result may be attributed to the small sample included in each age group and the absence of data in the 6-8 age group (for both male and female children in this sample) and the 9-11 age group (for female children). This absence of data was due to the fact that not all participants completed the whole assessment, since it lasted 1hour and 30 minutes and the investigators did not want to disturb the normal daily routine of the children or school organization. Normative values of quadriceps muscle strength are available in some studies,(Daloia et al., 2018; Eek & Beckung, 2008; McKay et al., 2017) but with different age groups and methodology which hinders comparison with our study. Further research on normative values of the quadriceps muscle strength for Portuguese children and adolescents is needed.

To the best of the authors' knowledge, there are two studies that established normative values for the MSRT in a Nigerian(Adegoke et al., 2012) and a Norwegian sample of children.(Haugen et al., 2014) However, in the Nigerian study age ranges were wider than the ones used in the present study (5-9 years, 10-14 years, 15-19 years), and in the Norwegian were shorter and only included adolescents from 13-15 years, hindering comparisons between studies. Nevertheless, it appears that the Portuguese sample scored more in the MSRT than both samples, which means they were more flexible than Nigerian and Norwegian children and adolescents, confirming the need to collect country-specific normative data. Similarly to other studies,(Fogelholm et al., 2008; Haugen et al., 2014; Toriola & Minyeki, 2012) in this sample there were also significant differences between male and female children aged 15-17 years, with girls achieving higher values than boys, which means they were more flexible than boys. Although all age groups presented significant differences, they were higher in the 15-17 age group. This could be explained by previous literature which has shown that flexibility decreases with age and is significantly lower in adulthood(McKay et al., 2017) and this age group had a small sample size, with almost adult adolescents, which could have influenced the results.

Normative data for the neuromuscular component, assessed with the TUG test, have been previously reported in children of Pakistan,(Habib et al., 1999) U.S.A.(Marchese et al., 2012) and Brazil.(Nicolini-Panisson & Donadio, 2014) Participants' age groups in previous research were not exactly the same as the ones used in this study, which limits comparisons between studies. These differences emphasize the need to establish normative values to specific populations, with large samples from different countries and diverse age ranges, so values can

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be used with greater confidence in studies using the same population and in clinical practice.

Female children in this sample were less physically active than male children, as reported previously.(Aires et al., 2010; Casterad et al., 2012; Mota & Esculcas, 2002) Significant correlations were found between the APALQ scores and the BMI, ISWT, HHD and TUG, suggesting that participants who presented higher physical activity levels were those who performed better in the HRPF tests. These findings are in line with previous studies which have shown that physical activity is related to the results of HRPF tests, i.e., higher physical activity levels are associated with better HRPF test results.(Aires et al., 2010; Gutin, Yin, Humphries, & Barbeau, 2005; Morrow et al., 2013; Ortega et al., 2008) These studies showed weak to moderate correlations between HRPF measures and PA. The weak correlations found in the present study could be explained by the heterogeneity of the sample since children were recruited from different cultural, economic, educational and environmental settings. In addition, the fact that children did not perform moderate to vigorous activity for long periods has also been reported by Malina & Katzmarzyk (2006),(Malina & Katzmarzyk, 2006) and it is known that the improvement of HRPF is related to this intensity of physical activity. (Martínez-Vizcaíno & Sánchez-López, 2008). It is also possible that children had more difficulties when they were asked to recall and report on participation in physical activity in different contexts.(Hardy, Booth, & Okely, 2007) As HRPF is not only the result of genetic factors but also of individual and social determinants,(Martínez-Vizcaíno & Sánchez-López, 2008) further research is needed to explore potential cofactors that may explain this weak relationship. Nonetheless, as it is not possible to modify the genetic factors of HRPF, the focus should be on modifying individual and social determinants of physical activity to potentially improve individuals' HRPF.(Martínez-Vizcaíno & Sánchez-López, 2008) Even if achieving the recommended physical activity levels does not result in significant improvements in children's/adolescents' HRPF, physical activity can still lead to improvements in self-esteem,

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academic performance, or bone density.(Martínez-Vizcaíno & Sánchez-López, 2008) Furthermore, low physical activity levels are associated with several chronic diseases and premature mortality worldwide, therefore, promoting physical activity in children is a global target in terms of public health.(Aubert et al., 2018) The assessment of children's physical activity levels should be conducted and the adoption of active lifestyles during childhood should be promoted.

Some limitations of this study need to be acknowledged. This was a cross-sectional study. Longitudinal studies assessing the HRPF in children should be performed to assess natural changes in individuals' growth and development. Another limitation of this study concerns the potential influence of seasonal changes on children's physical activity and physical fitness.(Atkin, Sharp, Harrison, Brage, & Van Sluijs, 2016; Augste & Künzell, 2014) The assessment was made in different seasons in almost three years and, although it was performed in controlled conditions (at the university laboratory or the school's gym), physical activity in the winter was probably different than in the summer. Hence, in the future, researchers should consider this seasonal influence. Not all participants completed the whole assessment, since the investigators did not want to disturb the daily routine of the children leading to missing data in the muscular strength test. In the present study, muscle strength was assessed with quadriceps muscle strength measured with hand-held dynamometry. Previous studies on HRPF have assessed upper extremity muscle strength with handgrip strength, hindering comparisons among studies. In future studies similar measures for assessing muscle strength in the same group of muscle are recommended. The MSRT was used to assess hamstring flexibility; however, caution should be taken when interpreting the results since the test has shown moderate criterion-related validity results, similarly to the Classical sit-and-reach test.(Mayorga-Vega et al., 2014) Nevertheless, studies assessing the criterion validity of hamstring flexibility tests in children are still limited and the existing studies have shown

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heterogeneous results.(Mayorga-Vega et al., 2014) Since children go through puberty between these ages, it would have been very interesting to have calculated the pubertal stage however it was not evaluated in the current study. Furthermore, results were presented in 3 year-range age groups instead of presenting them by age group. Nevertheless, previous studies have also used age groups to present data on the HRPF of children. (Adegoke et al., 2012; McKay et al., 2017; Nicolini-Panisson & Donadio, 2014) Another limitation is related to the fact that, in this study, a self-report physical activity instrument was used to assess children's physical activity levels, and there is a possibility that children in this sample had under/overestimated their PA. The questionnaire has 5 questions about to the frequency of physical activity, but only one question is related to the intensity of physical activity (question 4, "Outside school, how many hours a week do you usually take part in physical activity to the extent that you get out of breath or sweat?"). Since moderate to vigorous activity is related to HRPF,(Aubert et al., 2018; Júdice et al., 2017) it would be important to have more information of the intensity of physical activity and assess its relationship with children's physical fitness. Furthermore, the fact that the questionnaire relies on children's memory to assess physical activity in five different contexts may have introduced some bias. Future studies should include objective measures (e.g., accelerometers) to assess children's physical activity levels.(Baquet, Stratton, Van Praagh, & Berthoin, 2007; Nilsson, Ekelund, Yngve, & Sjöstrom, 2002; Riddoch et al., 2004) However, it is important to note that a questionnaire is more feasible in clinical practice given its simple and inexpensive application. The ideal approach would be to have an assessment with objective and subjective measures to have a more comprehensive view of physical activity.

5. CONCLUSION

This study established the normative values of commonly used measures to assess HRPF, i.e., body composition, cardiorespiratory fitness, muscular strength, flexibility and neuromuscular component, in Portuguese children from 6 to 17 years old (male and female). It was also found that higher levels of physical activity are associated with better HRPF results, although this relationship was weak.

In physical therapy clinical practice, knowing the normal values of children HRPF's condition is fundamental to prescribe adequate exercise in healthy children and children with health-related conditions as well as to assess the effects of a specific intervention. Yet, few studies have been conducted in this area and therefore, further investigation is required. Active lifestyles should also be encouraged in this population as better physical activity levels are related to better HRFP.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Highlights

- Health-related physical fitness was assessed considering children's gender and age
- Normative values for physical fitness measures were provided for children
- Normative values are essential to identify children at risk of poor health outcomes
- There is a weak relationship between physical fitness and physical activity

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Author Contributions

Alda Marques: conceptualization, methodology, writing-reviewing and editing. Joana Pinto: Data curation, investigation, Writing-Original draft preparation. Joana Cruz: methodology, writing-reviewing and editing. Tania Pinho: investigation.

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