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Original article

Motor competence and health-related fitness in children: A cross-cultural comparison between Portugal and the United States

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Abstract

Background: Motor competence and health-related fitness are important components for the development and maintenance of a healthy lifestyle in children. This study examined cross-cultural performances on motor competence and health-related fitness between Portuguese and U.S. children.

Methods: Portuguese ($n = 508$; 10.14 ± 2.13 years , mean ± SD) and U.S. ($n = 710$; 9.48 ± 1.62 years) children performed tests of cardiorespiratory fitness (Progressive Aerobic Cardiovascular Endurance Run), upper body strength (handgrip), locomotor skill performance (standing long jump), and object projection skill performance (throwing and kicking). Portuguese and U.S. children were divided into 2 age groups (6–9 and 10–13 years) for data analysis purposes. A two–factor one–way analysis of covariance (ANOVA) was conducted with the Progressive Aerobic Cardiovascular Endurance Run, handgrip, standing long jump scores, kicking, and throwing speed (km/h) as dependent variables.

Results: Results indicated that Portuguese children, irrespective of sex, presented better performances in locomotor and cardiorespiratory performance (standing long jump and Progressive Aerobic Cardiovascular Endurance Run) than U.S. children in both age bands. U.S. children outperformed Portuguese children during throwing and handgrip tests. Kicking tests presented gender differences: Portuguese boys and U.S. girls outperformed their internationally matched counterparts.

Conclusion: Cultural differences in physical education curricula and sports participation may impact differences in motor competence and fitness development in these countries.

Keywords: Children; Cross-cultural comparison; Health-related fitness; Motor competence

1. Introduction

Decreased physical activity (PA) is a major global health issue and the fourth leading underlying cause of mortality.[1,2] In 2013, inadequate PA cost international health care systems USD53.8 billion worldwide, with USD25.7 billion spent in North America and USD11.7 billion spent in European countries.[3] Thus, the development of programs that help to promote and sustain PA levels in both children and adults is a critical worldwide public health initiative.[4] A focus on health-related fitness (HRF) and motor competence (MC) is also important in that they impact child[5] and adolescent[6,7] PA levels.

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HRF can be described as the capacity to perform PA, with cardiorespiratory and musculoskeletal fitness being 2 important aspects of fitness.[8] MC is defined as a person's capability to perform a wide range of motor acts or skills[9] and involves both locomotor (e.g., standing long jump (SLJ)) and object projection (e.g., throwing and kicking) skills.[10,11] Childhood is a critical period for the acquisition of MC and HRF; however, recent research has shown a secular decline in HRF and MC in many countries over recent years.[12–16] Understanding how different environmental and cultural contexts may impact normal development[17] is important, and cross-cultural research that incorporates these factors can play a key role in informing strategies and policy measures that promote child development around the world. Cross-cultural comparisons may provide insight into similar and/or unique mechanisms for MC and HRF promotion that transcend cultural differences, or identify factors that are unique to each country. For example, differences in culture and educational practices (e.g., duration of recess and physical education opportunities) may have a dramatic impact on similarities or differences in MC and HRF development among boys and girls. In addition, differences in youth sport culture can increase the variance in MC and HRF between countries; for example, in the U.S., children (boys and girls) usually enroll in several sports throughout childhood and adolescence, offering an increased opportunity for the development of motor skills. However, the majority of Portuguese boys participate in only 1 sport (soccer), and girls prefer sports without object control (like swimming and gymnastics), deficiencies that may inhibit the throwing skills of Portuguese boys and the object control skills of Portuguese girls. Thus, cross-cultural studies analyzing both MC and HRF may offer researchers and physical education practitioners insight into performance and educational outcomes, but such research has been rare. Therefore, the aim of this study was to compare MC and HRF levels in boys and girls from 2 different countries located on 2 different continents.

2. Methods

2.1. Participants and procedures

The overall study sample was compiled from deidentified data collected in 4 different projects that used similar methodologies and similar standardized protocols. The total sample comprised 1218 children ranging in age from 6 to 13 years old. The 4 data collections were conducted between 2009 and 2015; thus, all data used in our study were collected between those years. In the Portuguese study, 508 children (10.14 ± 2.13 years, mean ± SD) were recruited from different municipalities in the Lisbon district. Data from 3 U.S. studies were combined for our study, yielding data on 710 U.S. children (9.48 ± 1.62 years). The U.S. children were recruited from several moderately sized urban cities (with populations between 200,000 and 500,000 people) located in the Midwest, Southwest, and Southeast regions of the United States. The sample from the Midwest was from a Title I school ($n = 263$), where participants were more than 80% non-Hispanic white. The sample from the Southwest was from 2 Title I schools ($n = 373$), with approximately 60% being Hispanic and most of the remaining sample being non-Hispanic white. The sample from the Southeast was also from Title I school ($n = 74$) and was 46% non-Hispanic white and 44% African American. Thus, this sample provided a relatively large and diverse convenience sample of children in the United States.

All children in all 4 studies participated in regular physical education classes (2–3 per week for approximately 45 min each). The physical education curriculum in the 3 U.S. samples primarily focused on sports, games, and fitness-related activities. The physical education curriculum in the Portuguese schools focused primarily on fundamental motor skills and games. Because there are different levels of MC across age, comparisons at the same age level are preferable. Therefore, the sample was divided into 2 age bands (6–9 years and 10–13 years) for the purposes of our study. Approval from the Bowling Green State University, Texas Tech University, University of South Carolina and Faculty of Human Kinetics - University of Lisbon ethics committees in each country was granted for each individual data collection, and written informed consent was obtained from all parents/guardians and participants. All children tested were able to complete all the MC and fitness tests.

Assessments for each child were generally conducted across 2 days, and all assessments were administered by trained researchers with experience in MC and HRF testing. The data collection in both countries was performed in physical education classes in gymnasiums. The Progressive Aerobic Cardiovascular Endurance Run (PACER) test was assessed after all other MC and HRF tests were conducted to minimize acute fatigue that would have potentially influenced performance on the MC and HRF tests. The motor skill and fitness tests were assessed in at different stations with small groups of 3–5 children rotating among stations. Motivational feedback to promote maximum effort was provided to children for all tasks during testing; however, no verbal instructions or instructional feedback on skill performance was provided.

2.2. Measures

2.2.1. HRF

The PACER test was used to evaluate cardiorespiratory fitness because it is appropriate for measuring cardiorespiratory endurance in youth.[18] The PACER test is a progressive shuttle run performed over 20 m and was administered using a standardized protocol.[19] The total number of 20-m laps performed by each participant was recorded for data analysis.

The handgrip test is a widely recognized test for assessing muscular strength.[8] Each participant started from a standing position and, using the dominant hand, squeezed the dynamometer with maximum effort, maintaining the squeeze for about 5 s. The maximal result after 3 attempts was recorded for data analysis purposes.

2.2.2. MC

The SLJ[20,21] is a locomotor skill that also is used as a valid field test of musculoskeletal fitness.[22,23] Participants were instructed to perform the jump with maximal effort starting

with both feet together. The distance travelled was measured as the distance from the starting point to location of the heel of the foot closest to the starting point after the jump. This distance was recorded to the nearest centimeter for each jump. The farthest distance travelled of 3 attempts was used for data analysis.

The kicking speed test required subjects to kick a ball against a wall with maximum effort. In Portugal, a regular youth size (Size 4) soccer ball (circumference: 64.0 cm; mass: 360.0 g) was used, and U.S. participants used playgrounds balls (circumference: 67.8 cm; mass: 362.0 g). Both types of balls used were of similar masses and sizes. Ball speed was measured in meters per second using a radar gun (Pro II STALKER radar gun, Plano, TX, USA). The peak speed of 3 kicks was used for data analysis.

The throwing speed test required subjects to use an overarm action to throw a regular size tennis ball (diameter: 6.5 cm; mass: 57.0 g) against a wall with maximum effort. The speed of each throwing attempt was measured in meters per second using a radar gun (Pro II STALKER radar gun). The peak speed of 3 attempts was used for data analysis.

The MC assessments of this study have been conducted in several other studies[11,23–25] and are representative of locomotor and object projection skill categories.

2.2.3. Anthropometry

Height and mass were collected before testing. The height of the Portuguese children was measured using a portable stadiometer (Seca 213, Seca GmbH & Co. KG., Hamburg, Germany) to the nearest 0.1 cm, and mass was measured using a Tanita digital balance scale (BF-350 Total Body Composition Analyzer, Amsterdam, the Netherlands) according to standardized anthropometric measurement protocols.[26] The height of the U.S. children was measured to the nearest 0.1 cm using a portable stadiometer (ShorrBoard Portable Height-Length Measuring Boards, Olney, MD, USA) and mass was measured with an electronic scale (TANITA, SC-331S, Itabashi-ku, Tokyo, Japan). Body mass index (BMI) was calculated using height and mass.

$$\mathrm{BMI} = \mathrm{mass(kg)}/\mathrm{height}\left(\mathrm{m}^2\right)$$

2.3. Data analysis

Descriptive statistics (means and standard deviations) were calculated to characterize BMI, MC, and HRF by age band and sex. Normality of variables was assured before each analysis. To examine differences by country (Portugal and the United States) and age group (6−9 years and 10−13 years) in both boys and girls, 2 Age group × 2 Country one-way analysis of covariance (ANOVA) were conducted to examine potential differences in PACER, handgrip, SLJ, kicking speed, and throwing speed. When significant differences occurred, Bonferroni *post hoc* pairwise comparisons were used to examine interaction effects. All statistical analyses were conducted in SPSS Version 25.0 (IBM Corp., Armonk, NY, USA), and a 0.05 level of significance was considered statistically significant.

3. Results

Descriptive statistics for BMI, MC, and HRF variables according to age group, country, and sex are presented in Table 1. For both sexes, ANOVA revealed significant increases in performance across age groups ($p < 0.001$) and by country groups ($p < 0.001$) for all fitness and MC variables, with the exception of SLJ for girls and kicking for boys (Table 2).

Portuguese boys and girls performed better in the PACER tests than U.S. children in both age bands (Fig. 1A). Portuguese boys outperformed U.S. children in SLJ tests in both age bands (Fig. 1B). U.S. children, however, outperformed Portuguese children in handgrip and throwing speed (Figs. 1C and 1D). The throwing speeds of U.S. boys increased from the younger to older age band at a greater rate than that of their peers from Portugal (Fig. 1D). Additionally, there were differences in kicking speed performance by country and sex. There were no significant differences in Portuguese and U.S. boys' kicking speeds; however, U.S. girls outperformed their Portuguese counterparts with significant differences in the younger age group (Table 2 and Fig. 1E). Finally, the results showed small to medium effects sizes (0.02−0.24) for country in both

Table 1
Age group and sex for motor competence components and health-related fitness variables (mean ± SD).

Variable	6−9 years				10−13 years			
	Boys		Girls		Boys		Girls	
	PT	U.S.	PT	U.S.	PT	U.S.	PT	U.S.
Height (cm)	129.3 ± 7.9	129.8 ± 7.5	128.7 ± 7.8	131.8 ± 7.7	151.1 ± 10.5	150.1 ± 11.8	151.5 ± 10.2	147.7 ± 10.1
Weight (kg)	29.6 ± 7.3	32.2 ± 9.7	29.4 ± 6.9	32.3 ± 8.4	46.0 ± 11.7	43.0 ± 15.1	47.2 ± 10.0	44.11 ± 13.2
BMI (kg/m^2)	17.4 ± 2.4	18.6 ± 4.0	17.6 ± 2.6	18.2 ± 3.6	19.9 ± 3.6	21.2 ± 5.1	20.3 ± 4.4	20.7 ± 5.3
PACER (laps)	33.3 ± 13.3	22.6 ± 12.5	25.3 ± 10.4	19.0 ± 9.6	41.2 ± 18.6	29.7 ± 13.9	31.0 ± 13.5	24.1 ± 13.0
Handgrip (kgf)	11.3 ± 3.3	16.2 ± 3.9	10.5 ± 2.8	14.6 ± 3.5	20.0 ± 6.7	23.5 ± 5.7	18.6 ± 5.1	21.9 ± 5.5
SLJ (cm)	132.8 ± 22.5	125.2 ± 21.0	118.9 ± 25.0	116.3 ± 18.9	148.6 ± 27.2	141.9 ± 26.7	133.7 ± 21.3	131.6 ± 24.6
Kick (km/h)	47.0 ± 7.6	45.3 ± 8.6	36.5 ± 7.6	39.8 ± 10.4	62.0 ± 9.9	61.5 ± 10.0	50.1 ± 7.5	52.0 ± 9.6
Throw (km/h)	44.6 ± 7.8	56.6 ± 14.6	35.6 ± 5.5	43.7 ± 10.9	57.2 ± 10.7	75.1 ± 15.9	43.7 ± 7.0	52.4 ± 13.0

Abbreviations: BMI = body mass index; PACER = Progressive Aerobic Cardiovascular Endurance Run; PT = Portugal; SLJ = standing long jump; U.S. = United States.

Table 2
Interaction and main effects on motor competence components and health-related fitness variables according to country and age group.

Variable	$F_{Country \times Age}$	η^2_p	$F_{Country}$	η^2_p	F_{Age}	η^2_p
Boys						
PACER (laps)	0.71	0.000	90.65**	0.126	41.02**	0.061
Handgrip (kgf)	2.77	0.004	111.41**	0.150	398,61**	0.387
SLJ (cm)	0.04	0.000	13.25**	0.021	69.09**	0.099
Kick (km/h)	0.66	0.001	1.99	0.003	449.45**	0.416
Throw (km/h)	7.68*	0.027	200.02**	0.240	216.09**	0.255
Girls						
PACER (laps)	0.76	0.000	45.53**	0.075	29.94**	0.051
Handgrip (kgf)	1.32	0.002	101.61**	0.150	444.98**	0.453
SLJ (cm)	0.16	0.000	1.54	0.003	64.04**	0.100
Kick (km/h)	0.81	0.001	11.25**	0.019	275.07**	0.322
Throw (km/h)	0.13	0.000	100.04**	0.148	100.20**	0.148

* $p < 0.01$, ** $p < 0.001$.
Abbreviations: BMI = body mass index; PACER = Progressive Aerobic Cardiovascular Endurance Run; SLJ = standing long jump.

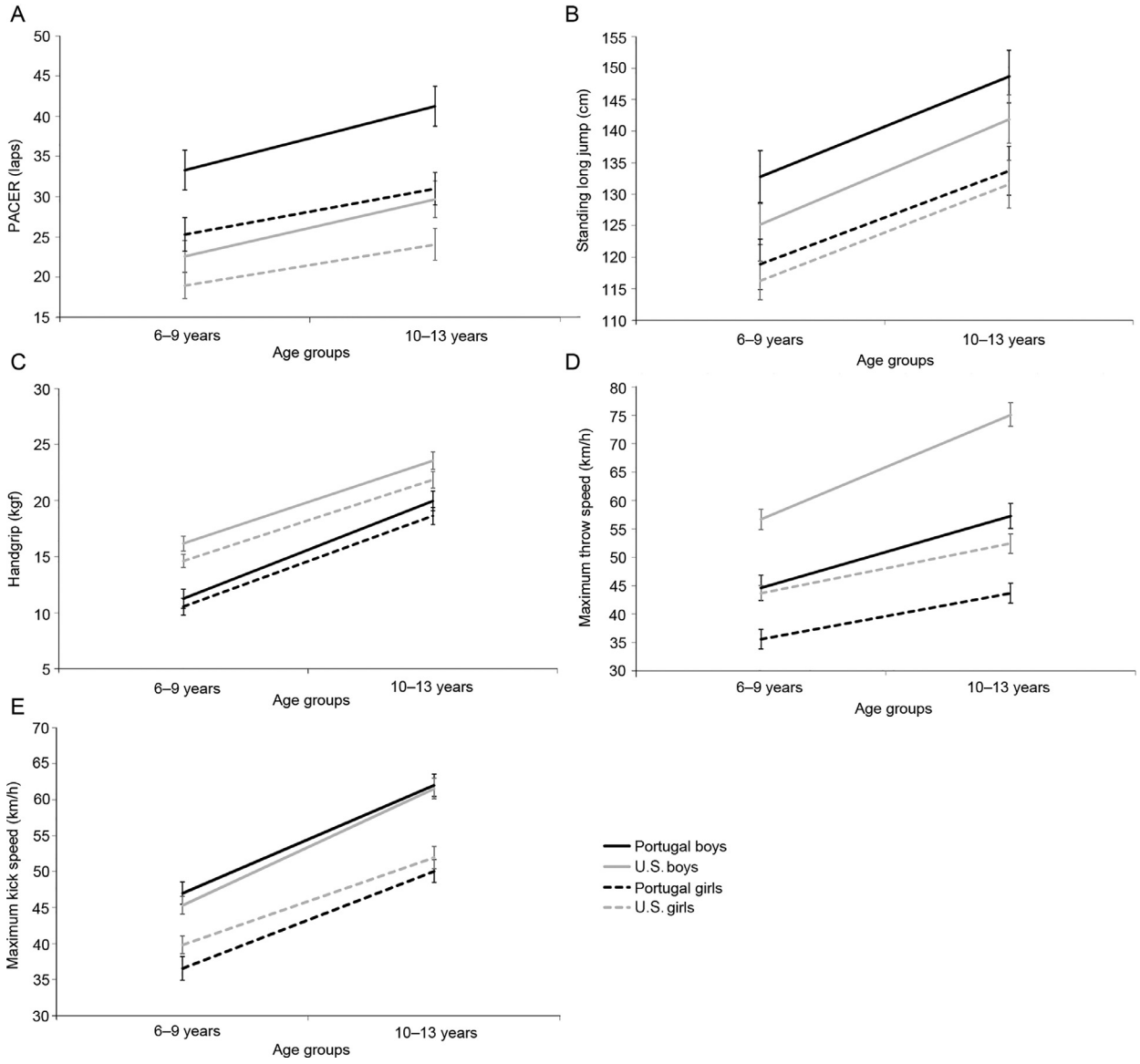

Fig. 1. Performance values for American and Portuguese girls and boys, of the 2 age groups (6−9 years and 10−13 years), in the following tests: (A) PACER, (B) standing long jump, (C) handgrip, (D) maximum throw speed, and (E) maximum kick speed. Error bars represent 95%CI. CI = confidence interval; PACER = Progressive Aerobic Cardiovascular Endurance Run.

sexes. Thus, the cultural effect was most noticeable in throwing for boys ($\eta_p^2 = 0.240$) and handgrip for girls ($\eta_p^2 = 0.150$). In contrast, SLJ and kicking speed displayed the smallest cultural effects in boys and girls, ($\eta_p^2 = 0.021$ and 0.019 for boys and girls, respectively).

Although U.S. children have been noted to have some of the highest BMI levels in the world,[27] there was no significant difference in BMI between boys ($p = 0.068$) and girls ($p = 0.896$) for the 2 countries.

4. Discussion

The purpose of this study was to compare MC and HRF levels in boys and girls from 2 different countries (Portugal and the United States) on 2 different continents (Europe and North America). The results of this study showed that youth from Portugal and the United States demonstrated differences in MC and HRF. In general, Portuguese children demonstrated better performance on the SLJ and PACER tests, whereas U.S. children exhibited higher handgrip strength and overarm throwing speeds.

An interrelationship between PACER and SLJ has been suggested by Luz and colleagues,[24] who noted that cardiorespiratory fitness is also linked to locomotor skill and lower extremity musculoskeletal fitness. Thus, this finding provides a rationale for why both PACER and SLJ present the same kind of results when compared between these 2 countries. It also is important to note that the development of locomotor skills begins in early childhood.[10] To explore possible explanations for these developmental differences, the authors looked first to cultural differences in physical education curricula. Because the time spent in physical education was similar in the 2 samples (i.e., 90−135 min/week), the authors then looked to the onset (age of enrollment) of organized education in young children to identify possible differences. According to a recent Organization for Economic Co-operation and Development report,[28] Portuguese children generally are enrolled in preschool earlier and at a higher frequency than their U.S. peers. Specifically, in Portugal, 79% of 3-year-olds, 90% of 4-year-olds, and 96% of 5-year-olds are enrolled in preschools, whereas their U.S. peers of the same age have lower enrollment percentages of 42%, 65%, and 90%, respectively. Additionally, Portuguese curricular orientations place a specific emphasis on the development of physical and motor activities in early childhood. In the United States, a primary emphasis on free play is more often promoted, and there is almost no formal instruction for the development of gross motor skills in preschools. Thus, differences in the onset of education and organized physical education in early childhood (i.e., preschool) may explain the differences in cardiorespiratory fitness (PACER) and SLJ found in the present study.

Children from the United States outperformed Portuguese children in handgrip strength. An increased emphasis in object control skills for different sports (e.g., baseball, softball, American football, tennis, basketball, and golf) in U.S. culture as compared with Portuguese culture may contribute to the higher handgrip strength of U.S. children. Higher handgrip strength is associated with higher weight status;[29] however, U.S. and Portuguese children in this study did not exhibit significant differences in body weight, body height, or BMI. This result is a surprising, considering the BMI trend among U.S. children. These data may represent a trend of increasing BMI scores in the youth population of Portugal[30] rather than a decrease in BMI scores among U.S. children.

There were no differences in U.S. and Portuguese boys' kicking speeds. Given the known cultural influence of soccer in Portuguese society, this result is somewhat surprising. Boys were sampled from the Midwest, Southwest, and Southeast regions of the United States; thus, it may be possible that the popularity of youth soccer from these regions in the United States is increasing and impacting children's development of kicking skills in the United States. Although the influence of external motivational confounders was not evaluated for the purposes of this study, a plausible explanation for the increase of U.S. boys' kicking speed may be soccer's growing popularity in the United States.

Interestingly, U.S. girls demonstrated higher kicking speeds than Portuguese girls in both age groups. This finding may be representative of cultural differences in the United States, where a large population of girls participate in soccer at a young age. U.S. youth soccer (ages 5−19 years) has grown from 100,000 participants in 1974 to more than 3 million in 2017 (www.usyouthsoccer.org), with one-half of the participants being girls. Furthermore, Portuguese boys participate at 3 times the rate that Portuguese girls participate (IPDJ (http://www.ipdj.pt), PORDATA (https://www.pordata.pt)). In the United States, soccer now has the second highest rate of youth participation in a sport, ranking only behind basketball. However, in Portugal, the same does not apply; boys' soccer represents the most popular youth sport in that country, with girls' soccer lagging surprisingly behind as the seventh most popular sport (IPDJ, PORDATA).

Given that sedentary behavior among children is increasing,[31] sports participation can help to decrease this trend because it is associated with a decrease in sedentary time and an increase in health-enhancing moderate to vigorous PA.[32,33] Also, recent data demonstrate that the practice of object projection skills (e.g., kicking, striking, and throwing) can provide an avenue for the achievement of recommended levels of moderate to vigorous PA that are health enhancing from a metabolic expenditure perspective.[34] Participation in organized sports also provides important opportunities for motor skill development. The practice of organized sports has been suggested as a strategy to increase PA in children by the World Health Organization.[27] However, the most effective learning occurs through deliberate play and involvement in structured activities that are generally regulated by rules adapted from standardized sports and designed to maximize enjoyment.[35] Thus, all forms of practice and play should be included in recommendations aimed at increasing PA and reducing sedentary time.

This study is not without limitations. First, although very similar, the balls used for kicking in each country were made

of different materials and had slightly different in diameters and masses. The balls were chosen because they were the ones available in physical education classes in their respective countries and because the participants were more comfortable using the balls to which they were most accustomed. The authors of this study are unaware of any performance differences that may be present between these 2 types of balls; nonetheless, it remains a limitation. A second limitation is the absence of maturational information. Maturational characteristics were not collected for the purposes of this study. Biological maturation influences all aspects of growth and development and may have influenced our results. Skeletal maturation is associated with higher scores during motor performance tests (e.g., balance, SLJ, shuttle run, kicking, and overhand throw) among children ages 3−6,[36] 7−10,[37] and 11−14 years old.[38] A final limitation relates to the limited generalizability of the results, which is based on specific samples from only 3 different regions in the United States and only 1 region of Portugal.

5. Conclusion

The results of the MC and HRF tests conducted in the present study may be attributed to cultural differences in physical education curricula and sports participation between Portugal and the United States. In both age bands, Portuguese children, irrespective of sex, presented better performances in locomotor and cardiorespiratory performance (SLJ and PACER) compared with U.S. children. U. S. children outperformed Portuguese children in the throwing speed and handgrip tests. Kicking speed tests presented gender differences; Portuguese boys and U.S. girls outperformed U.S. boys and Portuguese girls, respectively. The popularity of specific sports in each country (American football, baseball/softball, and basketball in the United States; soccer in Portugal) may have contributed to the differing performance levels in the MC skills tested (throwing and kicking). The physical education curricula may also have contributed to the differences. Differences in the 2 countries' onset of formal education in early childhood, including opportunities for physical education and PA, also may have influenced the early development of HRF. Future research is warranted to explore and identify curricular, socioeconomic, and cultural differences that may impact levels of MC and HRF development in these and other countries. Understanding the mechanisms responsible for improving the performance of MC and HRF may offer information that can be used to increase the prevalence of children and adults who engage in healthy lifestyles in the future.

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Authors' contributions

DFS participated in the conceptualization of the study, the design and coordination of all U.S. data collections, and drafting of the manuscript; JDG, ZG, and DRN participated in the coordination and completion of individual U.S. data collections and drafting of the manuscript; RCF, RSS, and LKT participated in the completion of U.S. data collections and drafting of the manuscript; CL participated in the conceptualization of the study, the design, coordination and completion of all Portuguese data collections, and drafting of the manuscript; RC and LPR participated in the conceptualization and design of the study and drafting of the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

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