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Secular trend of physical fitness indicators related to health in children

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Abstract

Introduction: Health-related physical fitness (HRPF) demonstratesan inverse association with several cardiovascular risk factors in young people; however, few studies have investigated the alterationsin HRPF indicators throughout a determined period.

Objective: To analyze the secular trend of HRPF indicators in children of seven to 10 years of age.

Methods: In total, 1,136 subjects were analyzed, seven to 10 years of age, in three-time periods (2002, 2005, 2010-2011). The HRPF tests were: sit-and-reach (SR), abdominal resistance (AB), 9 min walk/run test (9min), and body adiposity by the skinfold sum (∑SF). Classification of the HRPF indicators was carried out by the Physical Best cut-off point. The ANCOVA test (controlled by BMI, height and ∑SF) was used to compare the differencesin HRPF indicators betweenthe three-time periods.

Results: Boys presented a 6% decrease in flexibility between the 2010 and 2002 periods; no significance was found in the AB test; children of both sexes presented higher values in the 9min test in the 2005 period.

Conclusion: It was concluded that there was a negative secular trend for HRPF, in that the individuals studied in 2010 presented inferior results to their peers (2002-2005) for HRPF, in both sexes, except for abdominal strength and endurance.

Keywords: physical fitness, muscle strength, flexibility, children.

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Authors summary

Why was this study done?
The present study was part of the master dissertation of Prof. Gabriela Blasquez Shigaki in the Associate Postgraduate Program in Physical Education UEM / UEL (Londrina State University). The theme was proposed from scientific evidence indicating increased prevalence of overweight and obesity, low rate of compliance with health criteria in health-related physical fitness (AFRS) indicators, high prevalence of physical inactivity and association of these indicators with factors. of cardiovascular risk.

What did the researchers do and find?
This study verified the secular trend of indicators of health-related physical fitness (AFRS) in 1,136 children aged seven to ten years. To evaluate the AFRS, the sit-and-reach, abdominal resistance, 9min run / walk tests were used and, for body adiposity, the sum of two skinfolds was used. Negative secular tendency for AFRS was observed during the period from 2002 to 2010, mainly in cardiorespiratory fitness and flexibility in these children.

What do these findings mean?
These findings indicate that in a very short period of time (2002-2005-2010) significant declines in AFRS indicators, especially cardiorespiratory fitness, were found in the sample of children aged seven to ten years. These results are worrisome, since the literature shows an inverse association between AFRS components and health risk factors.

INTRODUCTION

Alterations in a society over time, whether in biological, behavioral, or psychosocial patterns, such as family income, maternal body mass index[1], or educational level[2], can lead to changes in physical growth indicators and motor performance, reflecting not only in the pattern of individual development, but also populational, through economic, nutritional, and health indicators.The study of secular trends seeks information on these changes over a given period of time and has contributed to the formulation of hypotheses about alterations in several variables, whether in the social, cultural, or health context of a country[3,4].

In this sense, in recent decades, several changes have been observed in society, such as increased risk factors for cardiovascular diseases, for example high blood pressure, type II diabetes, dyslipidemia, abdominal fat accumulation, and obesity, at an early age, and these factors are inversely associated with the components of health-related physical fitness (HRPF), especially low cardiorespiratory fitness and excess body fat[5]. Some studies show that muscle strength is also inversely associated with several cardiovascular risk factors in young people[6].

Despite this finding, few individuals during childhood and adolescence meet the recommended health criteria of HRPF indicators[7], which may lead to a serious public health problem due to the inverse relationship between HRPF indicators and cardiovascular risk factors, and the fact that these unhealthy behaviors continue until adulthood[8].

Some studies analyzing the secular trend of HRPF indicators in young people point to declines in these indicators over the years, especially in relation to cardiorespiratory fitness (CRF) and muscle fitness[9-13], as a consequence of decreased physical activity levels among young people[14,15]. Despite the efforts and research that seek to verify the secular trend in HRPF indicators, there are still few studies that cover all HRPF components, since the majority of these studies investigated only the CRF indicator. In contrast, few studies have verified alterations in the neuromuscular components, including muscle fitness and flexibility.

In Brazil, Gonçalves[16] conducted one of the few studies that analyzed the secular trend in all HRPF indicators in children and adolescents aged 7 to 14 years between 1990 and 2000 in the city of Londrina-PR. The results demonstrated a positive secular trend for the body composition indicators, while motor performance presented a negative secular trend. Another work developed by Dórea[17], through a secular trend approach, verified changes in the behavior of anthropometric variables and health-related motor performance tests in students from 7 to 12 years old in the city of Jequié-BA, between the years 1990 and 2001.The results demonstrated increases in anthropometric variables, characterizing a positive secular trend. On the other hand, sitting and reaching and 9-minute running/walking motor tests indicated a negative secular trend.

Given the current scenario, cultural alterations in children and adolescents, particularly caused by the increase in sedentary behavior, have mainly concentrated on increase in overweight and obesity and others indices considered insufficient for the indicators of physical fitness[15,18,19]. Regarding the HRPF indicators and their secular alterations, the majority of studies have been dedicated to verifying the changes in CRF, demonstrating that there is still no consensus on the secular trend of this component in young people[9,10]. Thus, the aim of the current study was to verify the secular trend of indicators of health-related physical fitness in children aged 7 to 10 years of age.

METHODS

Sample

The present study is part of a study entitled: "Secular trend of physical growth and indicators of health-related physical fitness in children of high socioeconomic status" which analyzes secular trend analysis from three data collections carried out in 2002, 2005, and 2010/11, with transversal approaches. The collections followed the same evaluation protocols for all indicators, using the same measurement instruments.

Two private educational institutions in the city of Londrina, Brazil, which met the following requirements: many children enrolled in the specific age group, adequate infrastructure for data collection, and application of motor tests and institutional support.

All students between 7 and 10 years of age enrolled in the selected institutions, were invited to participate, of which approximately 36% accepted the invitation. The following were adopted as exclusion criteria: 1) Refusal to participate or has no authorization from parents or guardians; 2) Individuals who did not belong to the age group and pre-established socioeconomic level; 3) Absence from class on evaluation days.

Thus, the sample consisted of 511 individuals in 2002, 322 in 2005, and 303 in 2010/2011, aged between 7 and 10 years. All participants and their parents were informed about the study proposal and signed a Free and Informed Consent. This study was approved by the Research Ethics Committee of the State University of Londrina (Approval Opinion No. 161/10), according to the rules of Resolution 196/96, 10/10/1996 of the National Health Council on research involving human beings

Anthropometry

Body mass was measured on a digital platform scale, Filizola, accurate to 0.05 kg, and height with a wooden stadiometer, with an accuracy of 0.1 cm, according to the procedures described by Gordon *et al.*[20]. Based on these measurements, BMI was calculated through the ratio of body weight/height^2, expressed in (kg/m^2).

Body fat (BF) was estimated by skinfold measurements in the subscapular (SB) and triceps (TR) regions. A single evaluator performed the measurements, using a scientific Lange skinfold caliper (Cambridge Scientific Instruments, Cambridge, MD), according to the techniques described by Harrison *et al.*[21]

Three measurements were collected at each anatomical point, in rotational sequence, on the right side of the body, and the median value was recorded.For the analyses, the sum of skinfold thickness (∑SF) was used. The test-retest coefficient exceeded 0.95 for each of the anatomical points, with a measurement error less than ± 1.0mm in all measurements.

Socioeconomic level

To classify the socioeconomic level of the families, the Brazil Criteria of Economic Classification questionnaire was applied, developed by the Brazilian Association of Research Companies[22]. The questionnaire was attached to the Free and Informed Consent and those responsible for authorizing the participation of the children in the study were requested to respond to the instrument. From the results it was established that the subjects enrolled in the private schools belonged to families considered of privileged socioeconomic status, since more than 95% of the sample were classified in economic classes A and B, and more than 55% in economic class A (data not shown).

Motor performance

Motor performance was measured by applying three motor tests that make up the Physical Best[23] battery, following the appropriate guidelines and collection recommendations. The tests were administered on two days. On the first day of motor assessment, the sit and reach (SR) and sit-ups test (endurance test/ modified 1min abdominal strength) - (AB) were carried out, while on the second day of evaluation the nine-minute run/walk (9-min) test was performed.

Classification of HRPF indicator

To classify adiposity indicators (BF), flexibility (SR test), and strength (AB test), the health criteria suggested by the Physical Best[23] were adopted. For the cardiorespiratory fitness rating, the values suggested by the Physical Best[23] battery were adopted, which suggests the use of running tests and/or the six-minute walk as an alternative to the 1mile test. Thus, the values recommended for 1 mile run tests were divided by the test time used, setting speed breakpoints (m/min) for the 9-minute test.

The relative measurement technical error was approximately 5% for the SR test and 9min and 8% for the AB.

Statistical Analysis

The Shapiro-Wilk test was used to verify that the data were not normally distributed. Therefore, to characterize the sample, the median was used as the measure of central tendency and the interquartile range as the dispersion measure (Q3-Q1). To verify the secular trend in the analyzed variables, the Kruskal-Wallis test was used, followed by the Mann-Whitney U test, when $p<0.05$ for comparisons of variables between the three studies, since the Levene's Test showed differences in the variances ($p <0.05$). In addition, Analysis of Covariance (ANCOVA) was used to compare variables between the three studies, controlled for influencing variables (Co-variables) of the dependent variables. The criteria used to select the covariates were: present significant linear correlation with the dependent variable, meet the homogeneity of variances in the Levene's test ($p>0.05$), and present interaction with the dependent variable. To represent the percentage differences in the dependent variables between the three studies, the percentage deltas were used, obtained using the following formula:

$$\Delta\% = [(\mu 2 - \mu 1)*100]/\mu 1$$

Where: Δ%= Percentage delta; μ1= Mean of the variable in the year assumed as line zero; μ2= Mean of the variable from the second study.

The adopted significance level was 5%. Data were processed in the SPSS statistical package, version 20.0.

RESULTS

Descriptive characteristics of the sample are described in Table 1. The girls in 2010 were younger than the girls in 2002 ($P< 0.05$). Boys presented lower values of ∑SF in 2002 and 2010; however, in 2005 they presented higher values in this variable ($P< 0.05$). Girls presented lower values for ∑SFin 2010 compared to 2005 ($P< 0.05$).

For motor performance, only the 9-min test presented a significant difference between the three time points for girls, with better performance in 2010 ($P< 0.05$). The comparisons between HRPE indicators, controlled for covariates, are demonstrated in Table 2, wherein the ∑SF presented significant differences at all time points ($P< 0.05$) when adjusted by BMI in both sexes.

Table 1: Descriptive characteristics according to sex group and time period.

	B 2002G		B2005G		B2010G	
	(n=274)	(n=237)	(n=177)	(n144)	(n=149)	(n=154)
Age (years)	8.6 (1.8)	8.9 (1.8)	8.8 (1.6)	8.7 (1.5)	8.5 (2.0)	8.4 (5.0)[a]
Body Mass (kg)	31.1 (12.0)	29.8 (10.3)	31.7 (11.4)	29.8 (9.8)	29.9 (10.4)	29.7 (9.9)
Height (cm)	133.6 (12.6)	132.3 (11.7)	133.4 (11.6)	132.6 (11.1)	132.0 (13.9)	133.5 (14.0)
BMI (kg/m^2)	17.3 (4.3)	17.0 (3.4)	17.6 (4.2)	16.9 (3.7)	17.0 (3.6)	17.2 (3.9)
∑SF (mm)	19.5 (14.6)	22.5 (13.5)	22.5 (17.3)[a]	24.0 (13.5)	17.0 (10.0)[a, b]	21.0 (12.0)[b]
SR (cm)	25.0 (8.0)	29.0 (8.0)	25.0 (9.0)	29.0 (8.0)	25.0 (8.0)	28.0 (9.0)
AB (repetitions)	32.0 (10.0)	30.0 (10.0)	32.0 (11.0)	29.0 (11.0)	31.0 (12.0)	28.5 (12.0)
9-min (m/min)	146.7 (31.7)	133.3 (25.0)	147.3 (28.1)	135.4 (21.0)	142.6 (31.3)	127.1 (19.0)[a, b]

Legend Table 1: B= Boys; G= Girls;∑SF= skinfold sum; BMI= Body mass index; SR= Sit and Reach test; AB= Abdominal test; 9min= 9min walk/run test.a= P<0.05 significantly different from 2002; b= P<0.05 significantly different from 2005. (Kruskall-Wallis test, following Mann-Whitney U test, when P<0.05);

Table 2: Statistical significanceof secular trend for HRPF indicators according to sex and time period.

Variable	Co-variables B	Difference between			ETA	Co-variables G	Difference between			ETA
		2002 - 2005	2002 - 2010	2005 - 2010	n^2		2002 - 2005	2002 - 2010	2005 - 2010	n^2
SA	-	ns	ns	ns	0.03	-	ns	ns	ns	0.03
	HG^I + ∑SF^I	ns	0.036			HG^I	ns	ns	ns	
AB	-	ns	ns				ns	ns	ns	0.10
						AGE^I	ns	ns	ns	
9 min	-	ns	ns	ns	0.25	-	ns	<0.001	<0.001	0.26
	AGE^I + ∑SF^I	ns	0.008	<0.001		AGE^I + ∑SF^I	ns	<0.001	<0.001	

Legend Table 2: B= Boys; G= Girls;∑SF= skinfold sum; BMI= Body mass index; HG= Height; SR= Sit and Reach test; AB= Abdominal test; 9min= 9min walk/run test; BMI= Body Mass Index; % F= Fat percentage; ns= not significant; I= Interaction between co-variable and dependent variable.

In the SR test, only the boys presented a significant difference between 2002 and 2010, when adjusted by height and ∑SF covariate. However, the girls presented an interaction for the SR and AB test with the height and age covariate respectively. No significant difference was found among the three time points. Children in 2010 presented lower results in the 9-min test (P<0.01) compared to 2002 and 2005. Boys presented this difference when the 9-min test result was adjusted by age and ∑SF and for girls the difference occurred independent of the adjustment.

Figure 1 presents the differences in the HRPF indicator by percentage according to sex.

Between 2002 and 2010 a significant decrease of -6% was observed in the results of the SR test for boys. Children in 2010 presented a significant decrease in the 9min test results compared to 2002 (4.2% in boys and 5.2% in girls) and 2005 (-5.8 in boys and 6.5% in girls).

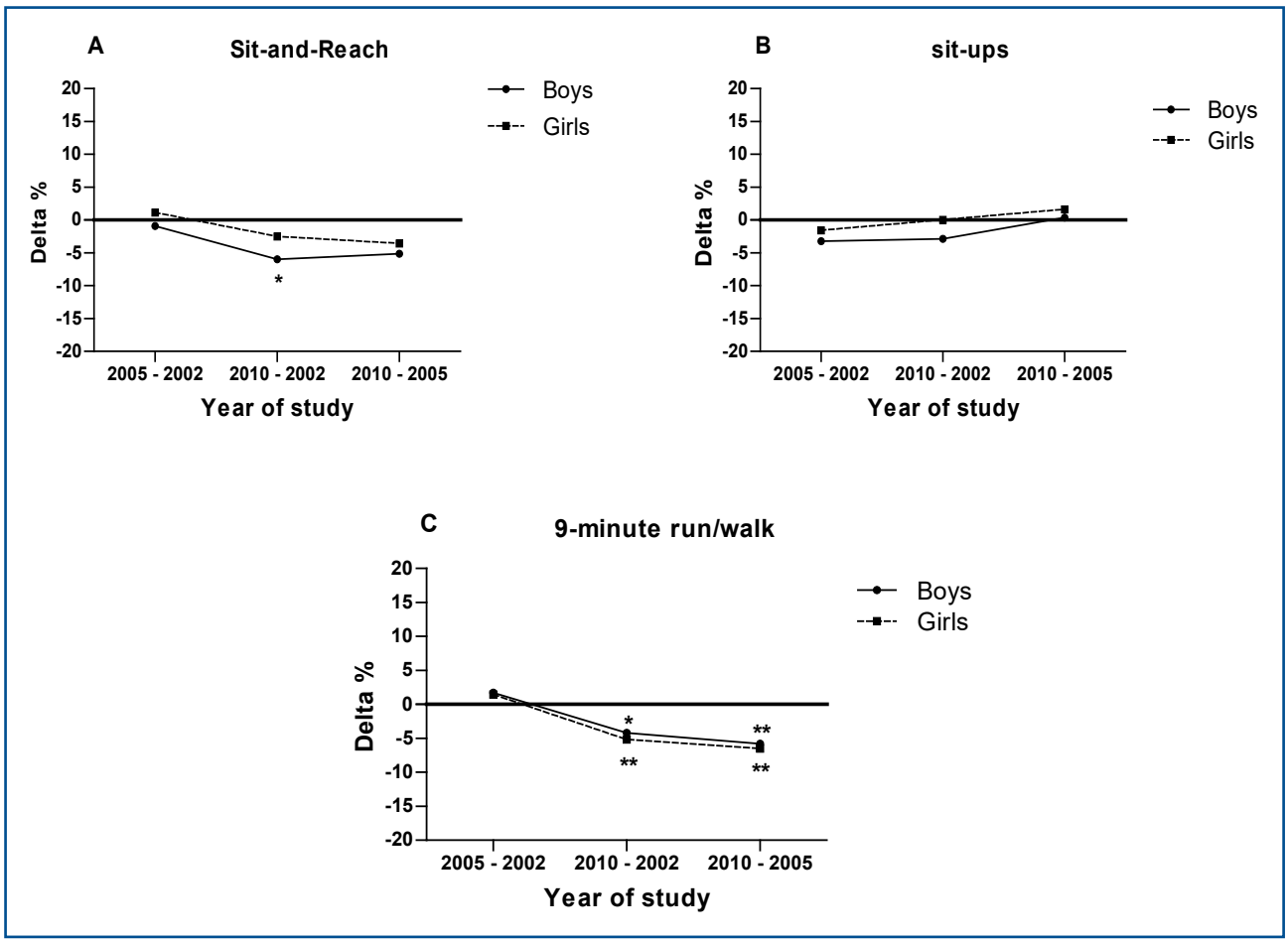

Figure 1: Percentage Difference (Δ%) between 2005 and 2010 compared to 2002 (zero line), and 2010 compared to 2005 (assumes the zero line) for the physical fitness and health indicators.
Note: Statistical comparisons refer to variables adjusted for covariates presented in Table 10. * p <0.05; ** P <0.01.

DISCUSSION

The main results of the present study demonstrated a negative secular trend for CRF, and individuals in 2010 presented inferior results in the 9-min test performance, compared ($p<0.01$) with individuals in 2002 and 2005, in both sexes. However, in boys the difference occurred when adjusted for age and ΣSF, while in girls there were differences ($p<0.001$) independent of statistical adjustment.

A negative secular trend was also observed for flexibility only in males, indicating lower performance in the SR test over the years; the differences were significant only when adjusted for the covariates height and ΣSF.These findings contribute to understanding of the behavior of alterations in HRPF indicators in Brazilian children; over very short period of time (2002-2005-2010) significant declines were observed in HRPF indicators, mainly CRF, in this sample of children aged seven to ten years. These results are concerning, since the literature shows an inverse association between HRPF components and cardiovascular risk factors[5,6].

Despite being a valuable tool for epidemiological studies, when using the secular trend approach, some care should be taken when interpreting the data, such as using coefficients rather than absolute values, since in the case of long periods of time, changes in the size of the population are expected[3]. Other factors should also be considered, such as the development and improvement in diagnostic and measurement techniques; alterations in data classifications, with new adjustments and control of confounding variables; and changes in environmental and social conditions in society[3,24].

Thus, in order to minimize some bias, statistical analyzes were controlled by covariates; influencing variables of dependent variables. In addition, the evaluation methods and techniques were maintained in all data collections, as well as the selection of the sample with similar characteristics at all study moments, such as sex, age, and socioeconomic level.

These results corroborate the study of Matton *et al.*[12] who verified that boys of 12-18 years, between 1969 and 2005, presented a secular trend for a decline in performance in the SR test over 31 years , whilst in girls, only those of 14 years of age demonstrated a slight decrease in performance between the time periods analyzed.

On the other hand, the results published by Santos *et al.*[25] showed declines in SR test performance in both sexes, however, the largest declines were observed in females in this flexibility indicator. In addition, the results showed that young people in 1992 outperformed those in 2012 in the SR, Shuttle run, and 1-mile walk tests.

In a study performed with Lithuanian adolescents aged 11 to 17 years, mean annual changes of -0.98cm were found for the SR test values, while Estonian adolescents in the same age group demonstrated smaller but significant annual mean changes of approximately -0.25cm for the same motor test[26].

Although flexibility presents a relation with growing of the lower limbs when evaluated through the SR test[27], this factor does not justify the decline found between boys in this test, since no alterations were found among the above studies. However genetic behaviour may be a strong determinant in physical fitness, as well as others environmental factors, such as life style, that influence flexibility. Life style may contribute to restricting movements, reducing the amplitude of daily activity movements, which can generate muscular shortening or injury[27].

Some studies that analyzed the secular trend of HRPF indicators in young people point to declines in these indicators over the years, especially in relation to CRF and muscle fitness[9-12] as a consequence of decreased physical activity levels among young people[14,15].

Given this, it is believed that the reduction in time devoted to physical activity and greater participation in sedentary activities among children and adolescents, such as watching television, playing video games, and using the computer may have contributed to these alterations[28].On the other hand, the AB test results did not demonstrate any alteration in the analyzed period, indicating a null secular trend for abdominal strength/resistance in children of both sexes.

Although the majority of secular trend studies with resistance/strength indicators have investigated adolescents, our results corroborate the results of the study of Jürimae *et al.*[26],since no significant alterations were found in the 30s abdominal test in Lithuanian and Estonian adolescents during the 1992-2002 decade. However, other studies indicate a negative secular trend in this indicator among the young population[29].

The null secular trend may be explained, in part, by the BMI and body mass maintenance in the current study, since the dimensions of the body and body mass are negatively correlated with the sustention and projection of the body against gravity, for instance the motor task in the AB test and walk/run test[29].

Regarding the CRF, there were sharp declines in 2010 compared to other years, regardless of sex. Some meta-analyses show declines in youth performance since the 1970s in all regions of the world, in different types of tests that estimate CRF, and this condition increases with each decade, generating a mean annual drop of - 0.36%, and 75% of the groups analyzed demonstrated a reduction in performance. Thus, the authors indicate that there was a negative secular trend in CRF in the pediatric population during the latter half of the last century[9,30].

According to Andersen *et al.*[11], it is difficult to analyze CRF secular trend studies when direct VO_2max measurement is not available, since comparison with other studies may be impaired by the use of different VO_2max estimation equations, variation in protocol choice, ergometers, and motor tests. However, direct measurements may also present biases related to the test protocol, choice of ergometer, and type of procedure for analysis of VO_2max. In this sense, we chose to represent and compare the results of the 9min test in mean running speed (m/min), not using mathematical equations to estimate the VO_2max.

In contrast to studies that sought to explain the decrease in CRF and the increase in static strength of the adolescents studied through the increase in body mass and BMI[25,29], the present study did not find similar results, since the body mass and BMI of the present sample did not demonstrate significant alterations, whereas a decrease in CRF was observed. Thus, it is believed that the negative secular trend observed in the CRF in the present study is justified to some extent by the reduction in the practice of systematic physical activities and involvement with the practice of sports[9] verifiedamong children and adolescents in recent decades, while the hours devoted to sedentary activities such as watching television greatly increased [15, 28, 31].

The habitual practice of physical activity was not evaluated in the present study; however the literature shows that children and adolescents with a high socioeconomic level are more engaged in sports activities[31] compared with children and adolescents with medium and lower socioeconomic levels. The volume and intensity of physical activity practiced, most of the time, does not reach the guidelines of 60min daily of moderate and vigorous intensity[9,31,32] and may be insufficient to promote modifications in the CRF component.

This fact was also observed in a study that sought to investigate the association between CRF and regular sports or systematic exercise practice in adolescents aged 11 to 13 years in the city of Londrina, Brazil. The authors demonstrated that only three out of ten adolescents reported participating in sports or exercise regularly, and this participation was only positively associated with CRF in girls. In addition, it should be noted that there was a high proportion of adolescents with low levels of CRF, indicating that this component of HRPF still deserves to be further investigated[33].

The strengths of the present study include the sample size, and maintenance of the measurement instruments, evaluation protocols, and procedures adopted in the three cross-sectional studies. On the other hand, we highlight as the main limitation the lack of information about the physical activity of the subjects, so that a causal condition could be established. Although the present study is not nationally representative, there is little production of knowledge on the subject, mainly in the Brazilian population, due to the difficulties and criteria necessary for the analysis of secular trends.

Thus, it can be concluded that for the children analyzed, of high socioeconomic level and during the period from 2002 to 2010, there was a negative secular trend for CRF. Additionally, it should be noted that boys presented a negative secular trend in the flexibility indicator.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Authors' contributions

Each author contributed individually and significantly to the development of the manuscript. GBS (http://orcid.org/0000-0002-0241-240X)* participated in the initial study design, literature review, and participated in and coordinated data collection, data analysis, and writing of the manuscript. MBB (http://orcid.org/0000-0002-2513-9354)* participated in data collection, data analysis, literature review, and writing of the manuscript. ACP (http://orcid.org/0000-0001-8771-4580)* and LFZV (http://orcid.org/0000-0002-2743-8315)* participated in data collection, literature review, and data tabulation, and collaborated in the writing of the manuscript. HSJ (http://orcid.org/0000-0002-1156-4237)* collaborated in the analysis and interpretation of the data and in the critical revision of the manuscript. ERVR (http://orcid.org/0000-0003-3430-3993)* was responsible for the project design, and collaborated in the analysis and interpretation of data and critical review of the manuscript at all stages. All authors approved the final version of the manuscript and contributed to the intellectual concept of the study.*ORCID number (Open Researcher and Contributor ID).

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Resumo

Introdução: A aptidão física relacionada à saúde (AFRS) apresenta associação inversa com diversos fatores de risco cardiovascular em jovens, no entanto, poucos estudos têm investigado as alterações ocorridas ao longo de um determinado período nesses indicadores em crianças.

Objetivo: Analisar a tendência secular de indicadores da AFRS em crianças de sete a 10 anos de idade.

Método: A amostra foi composta de 1.136 sujeitos com idade de sete a 10 anos avaliados em três períodos do tempo (2002, 2005, 2010-11). Os testes de AFRS incluíram o teste de sentar-e-alcançar (SA), resistência abdominal (ABDO), corrida/caminhada de 9 min (9min) e para a adiposidade corporal utilizou-se o somatório de dobras cutâneas (∑DC). A classificação desses indicadores foi realizada através dos pontos de corte da Physical Best. O teste de ANCOVA (controlado pelo índice de massa corporal (IMC), estatura e ∑DC) comparou a diferença nos indicadores de AFRS entre os três períodos do tempo.

Resultados: Meninos apresentaram um declínio da flexibilidade de 6% entre os anos de 2010 e 2002; não ocorreram alterações significativas para teste de ABDO; crianças de ambos os sexos apresentaram maiores valores para o teste de 9 min no ano de 2005.

Conclusão: Ocorreu tendência secular negativa para a AFRS, sendo que os indivíduos estudados em 2010 apresentaram resultados inferiores comparados aos seus pares (2002-2005) para a AFRS, em ambos os sexos, com exceção para força e resistência abdominal.

Palavras-chave: aptidão física, força muscular, flexibilidade, criança.