

Flexibility and muscle strength/resistance indicators and screening of low back pain in adolescents

Indicadores de flexibilidade e força/resistência muscular e a triagem de dor lombar em adolescentes

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Abstract – Low back pain is increasing considerably among adolescents, reaching proportions similar to the adult population. Flexibility (Flex) and muscle strength/resistance, components of Health-Related Physical Fitness (HRPF), seem to be associated with presence of low back pain. The aim of this study was to assess the ability of Flex and muscle strength/resistance in the screening of adolescents with low back pain and to propose cutoff points for these HRPF components. The study was conducted with 1.455 students aged 10-17 years randomly selected. Low back pain was estimated using a questionnaire. Flex was measured by the sit and reach test and muscle strength/resistance by the one minute sit up test. The analysis of the receiver operating characteristic (ROC) curve was used to identify the capacity of Flex and muscle strength/resistance for screening low back pain. To propose cutoffs points, the best balance between sensitivity and specificity was analyzed. The frequency of low back pain was 16.1 %, higher ($p < 0.05$) among females (21.6%) than in males (10.5%). The ROC curve analysis indicated that Flex is able to identify girls more likely of having low back pain ($p < 0.05$). Sit and reach test and the proposed cutoff points can be used as screening tool of female adolescents more likely of having low back pain.

Key words: Adolescents; Health; Low back pain; Roc curve.

Resumo – *A dor lombar vem aumentando consideravelmente entre os adolescentes, atingindo proporções semelhantes à da população adulta. A flexibilidade (Flex) e a força/resistência muscular (F/R), componentes da Aptidão Física Relacionada à Saúde (ApFRS), parecem estar associadas à presença de dor lombar. O objetivo do estudo foi verificar a capacidade da Flex e da F/R na triagem de adolescentes com dor lombar e propor pontos de corte para estes componentes da ApFRS. O estudo foi realizado com 1.455 escolares de 10 a 17 anos selecionados aleatoriamente. A dor lombar foi estimada através de questionário. A Flex foi medida através do teste de sentar e alcançar e a F/R pelo teste de abdominais em 1 minuto. A análise da curva Receiver Operating Characteristic (ROC) foi utilizada para a identificação da capacidade da Flex e da F/R para a triagem de dor lombar. Para a proposição dos pontos de corte, foi analisado o melhor ajustamento entre sensibilidade e especificidade. A frequência de dor lombar foi de 16,1%, sendo maior ($p < 0,05$) entre o sexo feminino (21,6%) do que no masculino (10,5%). A análise da curva ROC indicou que a Flex é capaz de identificar meninas com probabilidade aumentada de apresentarem dor lombar ($p < 0,05$). O teste de sentar e alcançar e os pontos de corte propostos podem ser utilizados como instrumento de triagem de adolescentes do sexo feminino com probabilidade aumentada de apresentarem dor lombar.*

Palavras-chave: Adolescente; Curva roc; Dor lombar; Saúde.

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INTRODUCTION

Health-Related Physical Fitness (HRPF) comprises cardiorespiratory fitness (ApC), muscle strength/resistance (F/R), flexibility (Flex) and body composition¹. ApC and body composition seem to be more associated with cardiovascular health maintenance^{2,3}, and F/R and Flex seem to be more associated with prevention of musculoskeletal health problems^{1,4}. Thus, studies on HRPF levels of different population groups should be carried out.

A series of descriptive studies on HRPF of Brazilian children and adolescents have been developed indicating that a large proportion of these individuals does not meet HRPF recommendations⁵⁻⁷. The concern about low HRPF levels during childhood and adolescence is justified because its components remain relatively stable during the years of childhood and adolescence to adulthood⁸. In addition, regular practice of physical activity in this age group results in increased chance of maintaining these habits into adulthood, contributing to maintaining adequate HRPF levels⁹. The appearance of various risk factors for cardiovascular diseases is among the main health problems associated with low HRPF in children and adolescents^{3,10,11}, strongly related to ApC and body composition, complaints of back pain and identification of postural deviations¹² related to Flex and F/R. The presence of low back pain appears to influence the population's quality of life and may even limit the performance of common tasks of the daily living¹³. In this context, low back pain in childhood and adolescence has attracted attention due to its high prevalence, with values similar to those found in adults¹⁴, being therefore a public health problem.

Although theoretical hypotheses support the importance of F/R and Flex for the prevention of low back pain in children and adolescents^{1,4}, there are few studies that performed these associations and the results are inconsistent^{12,15}. Unlike body composition and ApC, several studies^{3,10,11,16,17} have shown association with risk factors for CVD, providing information for empirically validated cutoff points to be proposed^{11,16,17}, the musculoskeletal HRPF components do not present sufficient evidence of association with low back pain. Thus, international results¹⁸⁻²⁰ based on normative scales for the classification of Flex and F/R have been used⁷, though there are efforts at national level²¹. The aims of this study were: a) verify the ability of Flex and F/R in screening adolescents with low back pain and b) to propose cutoff points for F/R and Flex.

MATERIAL AND METHODS

Population and sample

This cross-sectional school-based observational study was conducted with information of adolescents aged 10-17 years enrolled in the project called "Habitual Physical Activity and Associated Factors in Children and Adolescents at the Western Border of Rio Grande do Sul". The project was

reviewed and approved by the Ethics Research Committee of the Federal University of Pampa (CEP Registration: 001/2011).

Sample size was calculated according to the following criteria: a) population of 15,210 students at this age group from the School Census of Basic Education in the year 2010²²; b) prevalence of 50% because it is a study with multiple outcomes c) 95% confidence interval (CI 95%); d) sampling error of 3 percentage points; and, e) 20% increase to compensate for possible losses and refusals. With the adoption of these criteria, the need to evaluate 1,196 adolescents was estimated.

The sampling criterion used was probabilistic multiphase. For the selection of schools in the urban area, the city was divided into four regions, with regard to the proportion of students enrolled in schools in each region relative to the total number of students. It was necessary to select two schools in three regions and three schools in one region. For the selection of students from rural areas, a simple draw among all schools of this area was carried out, requiring the selection of only one school.

All students of the selected schools enrolled from the fifth grade of elementary school to the twelfth grade of high school were invited to participate. The inclusion criteria were: a) being enrolled in the public school network; and b) providing free and informed consent form signed by parents and express willingness to participate by signing the consent form for underage. Exclusion criteria were: a) carriers of physical or cognitive disability that could compromise the performance of any measurement; and b) being outside the age range proposed.

Data collection procedure

Once the ten schools were selected (nine urban and one rural), contact with directions for presentation of justifications, objectives and procedures was held. After institutional permits, dates were scheduled for data collection. The procedures took place during classes in two or three days as needed. On the first day, classes to be evaluated were visited to explain to students the study reasons, goals and procedures and delivery of the informed consent form and consent term with the following instructions: a) the reasons for receiving the document; b) the document should be handed to a responsible and that after reading it, should sign it authorizing the student's participation and, c) to participate in the study, the document should be returned the next day. On the second day, data collections were held. For students that parents signed the consent form, but forgot to return the document, a third day of visit was scheduled so that these students had the opportunity to participate. All measurements were performed by a team of evaluators (teachers and physical education students), who were properly trained. Data collection took place between May and November 2011.

Variables and data collection instruments

For this study, variables gender (male or female), age (years), and musculoskeletal HRPF (F/R and Flex) were used. Low back pain (dependent

variable) was estimated by applying the adapted instrument proposed by Sjoile et al.¹⁵. Adolescents answered the following question: “Have you ever had lower back pain or discomfort (at the side of the question, there was a figure indicating the lower back location)?” The possible answers were: Never; rarely; often and always. Categories never and rarely were grouped and considered as “no back pain” and categories often and always were grouped and considered as “low back pain”.

Musculoskeletal HRPF was considered through its components (independent variables) F/R and Flex. Measurement procedures were those suggested by *Projeto Esporte Brasil*²¹. Abdominal test in 1 minute for F/R and sit and reach test for Flex.

Data analysis

Descriptive statistics was initially used. The occurrence of low back pain has been described from absolute and relative frequencies and 95% confidence intervals (95%). F/R and Flex were described by average and standard deviation. The description of data was performed by sex and age. To identify possible differences in the frequency of low back pain between sexes and the average F/R and Flex, the Chi-square tests for heterogeneity, the t test for independent samples and one-way Analysis of Variance followed by post hoc Bonferroni test, respectively, were used.

To identify the screening capacity of musculoskeletal HRPF regarding the identification of adolescents more likely to report low back pain and to propose cutoff points for F/R and Flex, the Receiver Operating Characteristic curve (ROC) was used. This procedure requires a “reference” variable (dichotomous variable - in the case of this study low back pain - yes / no) and a “Test” variable (continuous variable - in the case of this study F/R and Flex). As comparative analyses indicated gender differences ($p < 0.05$) for the frequency of low back pain and the average F/R and Flex values ($p < 0.05$), the ROC curve analyses were stratified by sex. Comparing the analysis of average F/R and Flex values among ages, some differences ($p < 0.05$) were identified. Therefore, variables of musculoskeletal HRPF (test variables) were standardized (Z score) for age and separated by sex for the ROC curve analysis.

With low back pain as reference (yes / no) and test variables defined, the areas under the ROC curve have been identified for each analysis. Those with lower limit of CI95% of the area under the curve higher than 50% were considered for the identification of the cut points. For this procedure, the specific Z score values of F/R and Flex in both sexes that presented the best fit between sensitivity and specificity were considered as the cut-off point. These values were used to identify the percentile value in each age group and sex corresponding to cutoff point found. All analyses were performed using SPSS software for Windows version 20.0.

RESULTS

Overall, 1,554 adolescents were selected to participate. Of these, 41 did

not return the free and informed consent form signed by parents, were not present on the day of data collection and 50 refused to participate. Among those evaluated (1,463), eight were excluded because they are outside the age group of interest. Information on low back pain was reported by 1,377 adolescents, corresponding to 94.6% of the total sample (1,455). The frequency of low back pain was 16.1% (CI 95%: 14.2-18.0). In the analysis stratified by sex, the frequency was statistically higher ($p < 0.05$) among girls (21.6%; CI 95%: 18.5-24.6) than among boys (10.5%; CI 95%: 7.8-12.4) (Figure 1).

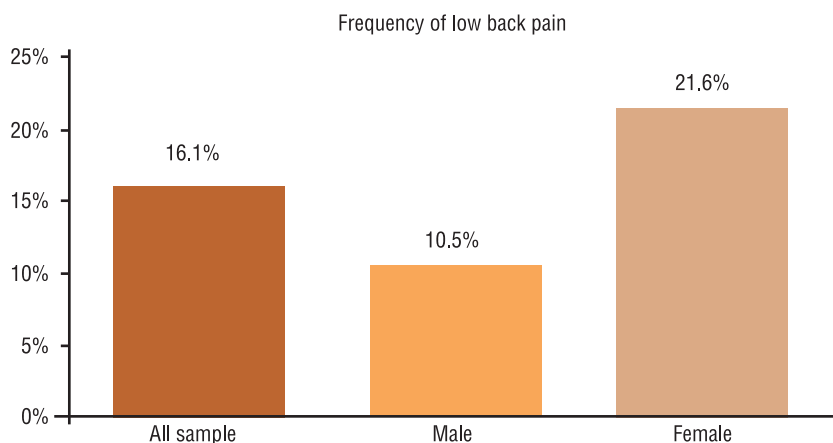


Figure 1. Prevalence of low back pain among adolescents

Table 1 presents the descriptive results of F/R and Flex throughout ages and separated by sex. F/R is higher in males at all ages ($p < 0.05$). Although showing higher mean values at all ages for females, Flex showed statistically significant difference ($p < 0.05$) only after the age of 11 years. Regarding the mean differences among ages, F/R is increasing in males ($p < 0.05$), but these increases were not significant in subsequent ages. F/R for female and Flex for both sexes showed small variations of increase and decrease in mean values and there is no statistically significant difference among ages ($p > 0.05$).

The analyses of the ROC curve were stratified by gender only. Table 02 presents the results of the area under the ROC curve between standard scores (Z scores) of F/R and Flex and low back pain. Among the tested combinations, the results indicated that only Flex in girls was able to predict low back pain ($p < 0.05$).

The adjustment analysis between Flex sensitivity and specificity and back pain among girls indicated the value of 0.97 (standard score) as the best balance. This value corresponded to the 51st percentile of the standard score distribution. Identifying the value corresponding to this percentile in every age group, the cutoff values ranged from 22 to 24 centimeters (Table 3). The sensitivity and specificity values were 0.535 and 0.620, respectively (Figure 2).

Table 1. Means and standard deviations of muscle strength / resistance and flexibility of adolescents stratified by sex and age

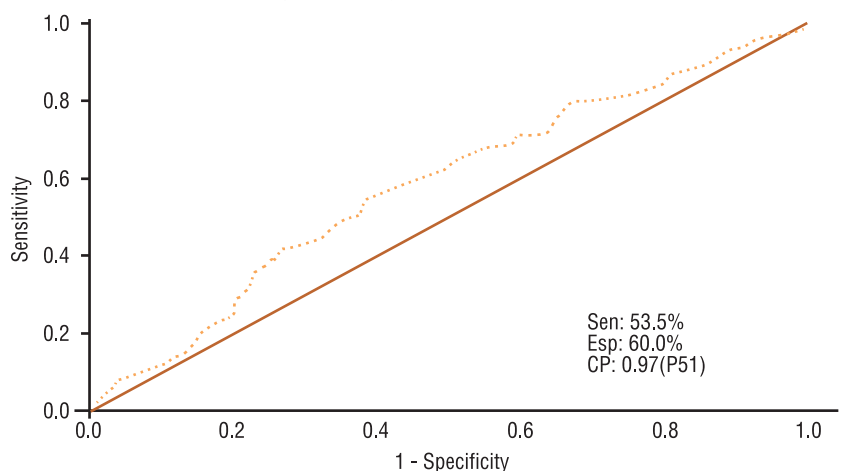
Age (years)	Male		Female		p	Male		Female		p		
	Muscle strength / resistance					Flexibility						
	M	SD	M	SD		M	SD	M	SD			
10	32.04	12.45	26.80	8.57	0.033	21.84	7.32	23.27	6.48	0.368		
11	33.51	8.97	27.50	9.69	<0.001	19.29	7.27	21.54	8.47	0.043		
12	34.89	9.92	26.47	8.34	<0.001	19.02	8.50	20.90	7.84	0.104		
13	38.61	8.32	28.32	9.04	<0.001	20.77	8.62	21.62	7.20	0.420		
14	39.53	7.92	24.81	8.13	<0.001	22.56	7.80	23.08	7.95	0.641		
15	39.49	9.57	24.55	8.61	<0.001	22.77	7.80	23.56	8.49	0.509		
16	41.21	8.22	24.71	8.86	<0.001	25.42	8.03	24.38	7.47	0.404		
17	39.71	11.83	23.37	7.85	<0.001	20.71	8.84	23.43	8.24	0.099		

F/R: muscle strength / resistance; Flex: flexibility; M: mean; SD: standard deviation; p: p-value.

Table 2. Area under the ROC curve between muscle strength / resistance, flexibility and frequency of back pain

	Male				Female			
	n	AURC	CI95%	p	n	AURC	CI95%	p
F/R	684	0.527	0.457-0.596	0.480	671	0.517	0.462-0.572	0.545
Flex	680	0.491	0.422-0.560	0.811	684	0.577	0.523-0.631	0.006

F/R: muscle strength / resistance; Flex: flexibility; n: number; AURC: area under the ROC curve; CI 95%: 95% confidence interval; p: level of significance.

**Figure 2.** Area under the ROC curve between flexibility and low back pain in girls**Table 3.** Cutoff points for flexibility measured by the sit and reach test for females according to age

Age (years)	CP (cm)
10	23
11	23
12	22
13	23
14	24
15	24
16	24
17	24

CP: cutoff point for flexibility measured by the sit and reach test.

DISCUSSION

This study is the first held in Brazil aimed at proposing cutoff points for F/R and Flex from the association of these variables with a health outcome using a representative sample of adolescents. The outcome used, low back pain, was chosen because theoretical assumptions indicate that low levels of both components of the musculoskeletal HRPF analyzed were associated with increased likelihood of low back pain complaints in adolescents^{1,4}. The results of the ROC curve analysis indicated that Flex for girls was able to predict low back pain ($p < 0.05$), confirming in part the hypothesis that adequate levels of this component are important for maintenance of musculoskeletal health in adolescence.

The frequency of low back pain among adolescents from Uruguaiiana (16.1%) was lower than that of other studies^{15,23-26}. However, the ways these investigations were conducted should be taken into account. Methodological aspects, such as the instruments used to estimate low back pain limited comparisons among results obtained. However, when the analysis is separated by gender, frequency of back pain is higher among girls in all studies, regardless of the instrument used. Culturally, women seem to show algescic conditions more frequently²⁷; pain sensitivity is higher in women²⁸; anatomically, women have a more fragile musculoskeletal condition²⁹; and postural changes in the lumbar region are more frequent among female adolescents¹². These features can help in understanding the higher frequency of low back pain in women.

The cutoff points found in this study for Flex among girls over the ages suggest that adolescents with levels below proposed values have increased likelihood of being affected by low back pain. These cutoff points were three to six centimeters above the health criteria proposed by Proesp-BR²¹, one and two centimeters below the health criteria proposed by the Physical Best¹⁸, and up to 5 centimeters below criteria proposed by the Fitnessgram¹⁹. It is noteworthy that currently Fitnessgram²⁰ adopts Back-Saver Sit and Reach test as one of the flexibility indicators of its battery of tests. This test presents some differences in implementation in relation to the sit and reach test. This impairs the comparison of the cutoffs values proposed for this test with those proposed for the sit and reach test.

The results of the analysis between Flex and low back pain in this study are in line with those reported by Lemos et al.¹² and Sjolie et al.¹⁵. In these studies, the authors found an association between lower Flex levels and hyperlordosis¹² and low back pain¹⁵ in adolescents. Together, these findings reinforce the importance of Flex as a health indicator of the column early in childhood and adolescence.

Although studies cited above have indicated association between lower Flex levels and presence of hyperlordosis and low back pain in adolescents, this study was the first to identify specific values for the screening of female adolescents with increased likelihood to show low back pain, which is the main contribution of this study. The proposition of cutoff points for field

tests of musculoskeletal HRPF for this purpose is timely because laboratory methods for assessing Flex and F/R, when considering high population levels of measure, become unfeasible. Considering the ease of application, reduced time for measurement and low cost, the results of the sit and reach test as a way of measuring Flex enable this test and these cutoffs to be used as tools to identify adolescents more exposed to low back pain complaints.

Although it was possible to propose cutoff points for Flex from its association with low back pain among girls, this result was not observed for boys and for F/R in both sexes. The explanation for these results is impaired because other studies analyzing musculoskeletal HRPF and health outcomes from the ROC curve are not available. However, it is noteworthy that the study by Lemos et al.¹² found association between lower F/R and Flex levels and increased likelihood of adolescents of both genders to show low back pain. Although the outcome used and statistical analyses have been different, the results indicate a possible association between musculoskeletal HRPF and spinal health of adolescents. In practical terms, an alternative for the evaluation of Flex in males and F/R in both sexes would be the use of cutoff points suggested by Proesp-BR²¹, which proposes these values from the results of an association study between components of musculoskeletal HRPF and postural changes in adolescents¹². However, for this issue to be better understood, further studies are needed.

In addition to the features already presented that strengthen the present study, the sample size and the selection process of adolescents should be highlighted. These characteristics give accuracy and representativeness to the sample, increasing the power of analyses and the internal validity of the study. Despite the contributions provided by this study, some limitations and their possible repercussions must be discussed. The study design makes establishing cause and effect relationships impossible. The use of recall for the measurement of low back pain is a weakness, in which exhibiting symptoms and pain conditions can be a barrier found by young people. Another aspect concerns tests used for the measurement of musculoskeletal HRPF. Even with encouragement for adolescents to reach their best performance, the motivational aspect can influence the results.

CONCLUSIONS

Flex in females can be used as a tool for screening girls with increased likelihood to show low back pain complain. The cutoff points proposed in this study are important to approach and minimize the heterogeneity of literature results and an important support tool for the early identification of low back pain in adolescents and may help reverse the increasing incidence of its prevalence in this age group.

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