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Level of physical activity and respiratory muscle force in healthy children

Atividade física e força muscular respiratória em crianças saudáveis

Actividad física y fuerza muscular respiratoria en niños sanos

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ABSTRACT | This study aimed to verify the relationship between the level of physical activity (LPA) and age with respiratory muscle strength (RMS) parameters of healthy children, as well as to compare this data between boys and girls. Healthy schoolchildren (6 to 12 years old) from the metropolitan area of Florianópolis-Santa Catarina/Brazil were the subjects of this study. Health was controlled by questionnaire, health record and spirometric parameters. Manovacuometry was performed to evaluate the RMS parameters and a questionnaire was applied to assess the LPA. In the sequence of the Kolmogorov-Smirnov test, the Spearman's correlation test was applied to verify the relationship between variables, and U-Mann-Whitney test to compare the RMS parameters between genders and LPA (active group-AG and inactive group-IG). The level of significance adopted was 5%. In total, 76 children (10.1±1.7 years) participated in this study, with mean maximum inspiratory pressure (MIP) of −89.7±41.4cmH_2O and maximum expiratory pressure (MEP) 86.6±22.6cmH_2O. The parameters of RMS and LPA level were not related. Values of MIP, MEP and predicted percentage of MEP were significantly related to age. AG showed a higher MIP value compared with IG. There was no difference between genders for LPA, there was only a difference for MEP in boys. RMS parameters and LPA were not related, but both were related to age. Active children had a higher MIP value compared with inactive children. Between genders, there was no difference in the LPA and boys showed higher MEP values.

Keywords | Respiratory Muscles; Physical Activity; Muscle Strength; Child.

RESUMO | Este artigo tem como objetivo verificar a relação entre a idade e o nível de atividade física de crianças não saudáveis (NAF) com parâmetros de força muscular respiratória (FMR) de crianças saudáveis e comparar os dados entre gêneros. Participaram da pesquisa escolares saudáveis de 6 a 12 anos provenientes da Grande Florianópolis (SC), Brasil. A higidez foi controlada com um questionário, um recordatório de saúde e parâmetros espirométricos. Avaliaram-se parâmetros de FMR por manovacuometria e seus valores preditos (%) e foi aplicado um questionário sobre NAF. Aplicou-se também o teste Kolmogorov-Smirnov e, na sequência, foram realizados os testes de correlação de Spearman, T e U-Mann-Whitney para comparação dos dados de FMR entre gêneros e NAF. Denominou-se GA para o grupo ativo e GI para o grupo inativo e se adotou 5% como nível de significância. Participaram da pesquisa 76 crianças (10,1±1,7 anos) com média de pressão inspiratória ($PI_{MÁX}$) de −89,7±41,4 cmH_2O e de pressão expiratória máximas ($PE_{MÁX}$) de 86,6±22,6cmH_2O. Os resultados mostraram que os parâmetros de FMR e NAF não apresentaram relação,

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enquanto os valores de $PI_{MÁX}$, $PE_{MÁX}$ e $\%PE_{MÁX}$ se relacionaram significativamente com a idade. Além disso, o GA apresentou maior valor da $PI_{MÁX}$ em comparação ao GI e não houve diferença entre gêneros para NAF, somente maior $PE_{MÁX}$ nos meninos. Os parâmetros de FMR e NAF não se associaram, mas ambos apresentaram relação com a idade. Na comparação entre os grupos, as crianças ativas apresentaram maiores valores de $PI_{MÁX}$ que as inativas. Não houve diferença no NAF entre gêneros, mas os meninos apresentaram maiores valores absolutos de $PE_{MÁX}$.
Descritores | Músculos Respiratórios; Atividade Física; Força Muscular; Criança.

RESUMEN | Este artículo tiene como objetivo comprobar la relación entre la edad y el nivel de actividad física de niños no sanos (NAF) con los parámetros de fuerza muscular respiratoria (FMR) de niños sanos, así como comparar los datos entre los géneros. En el estudio participaron escolares sanos de 6 a 12 años de edad de la gran Florianópolis (Brasil). Para analizar la buena salud se utilizaron cuestionario, recordatorio clínico y parámetros espirométricos. Los parámetros de FMR se evaluaron por manovacuometría y sus valores predichos (%), y se aplicó un cuestionario sobre NAF. También se aplicó la prueba de Kolmogorov-Smirnov y, posteriormente, se realizaron los test de correlación de Spearman, t y U-Mann-Whitney para comparar los datos de FMR entre géneros y NAF. Se denominó GA al grupo activo y GI al grupo inactivo, y el nivel de significación adoptado fue del 5%. En el estudio participaron 76 niños (10,1±1,7 años) con presión inspiratoria media ($PI_{MÁX}$) de –89,7±41,4 cmH_2O y con presión espiratoria máxima ($PE_{MÁX}$) de 86,6±22,6 cmH_2O. Los resultados mostraron que los parámetros de FMR y NAF no estaban relacionados, mientras que los valores de $PI_{MáX}$, $PE_{MÁX}$ y $\%PE_{MÁX}$ se relacionaron significativamente con la edad. Además, el GA tuvo un valor de $PI_{MÁX}$ más alto que el GI y no hubo diferencias entre los géneros para NAF, solo mayor $PE_{MÁX}$ en los niños. Los parámetros de FMR y NAF no estuvieron asociados, pero ambos se relacionaron con la edad. Al comparar los grupos, los niños activos tuvieron valores de $PI_{MÁX}$ más altos que los niños inactivos. No hubo diferencia en NAF entre los géneros, pero los niños tuvieron valores de $PE_{MÁX}$ más altos.
Palabras clave | Músculos Respiratorios; Actividad Física; Fuerza Muscular; Niño.

INTRODUCTION

Physical activity is defined as any body movement produced by skeletal muscles that requires energy expenditure. If practiced regularly and in moderate intensity, it brings health benefits[1] such as: optimization of blood oxygenation, better weight control, and improvement of cardiorespiratory and mental functions. In children, muscle strength, flexibility, and the bone mass peak also increase[2,3]. Thus, if started early in childhood and associated with factors such as genetics, nutrition and environment, physical activity will help the full development of physical fitness and ensure a good health for growth[1].

The practice of physical activity optimizes the action of respiratory muscles even when they are not the focus of exercise, having a conditioning effect on muscles of this group, besides benefiting pulmonary function. This happens because the overload generated during physical activity causes the respiratory musculature to work with greater speed and strength to supply the body demand, which improves its function[1] and conditioning.

In young people, the study by Quirino et al. showed that the practice of physical exercise increases the maximal respiratory pressures in young people aged 18 to 30 years[4]. Dassio and Dimitriou also found an association between aerobic exercise and respiratory muscle strength (RMS) in healthy young people aged 6 to 18 years, with higher RMS in exercise practitioners when compared with non-practitioners[5].

However, it is still necessary to understand the influence of physical activity on the respiratory muscles of healthy schoolchildren, since this is usually studied exclusively in disease conditions[6,7]. This study aimed to evaluate the relationship of RMS parameters with the level of physical activity (LPA) and age of healthy children, and to compare the results, also in terms of gender.

METHODOLOGY

The cross-sectional observational analytical study included healthy students aged from 6 to 12 years old; non-athletes, i.e., not enrolled in sports federations; non-obese and non-malnourished (≥3 percentile and <85kg/m^2); from educational institutions in Florianópolis metropolitan area (Santa Catarina). Parents and guardians filled out an informed consent form and the students also consented to participate.

Students who presented altered spirometry or were unable to perform it were excluded. The values of forced expiratory volume in the first second (FEV_1) and forced vital capacity (FVC) 80% below predicted and FEV_1/FVC ratio lower than 70%, according to Polgar and Weng[8], and Knudson et al.[9], were considered altered. Children on medications with direct influence on the systems, those whose health history indicated respiratory impairment and those whose score in asthma module 1 of the international study of asthma and allergies in childhood (Isaac) questionnaire was ≥5 in the age group from 6 to 9 years and ≥6 for 10 to 12 years[10] were excluded.

Then, the children's personal data were recorded and anthropometric measurements of height – Sanny stadiometer in meters – and body mass – digital scale G-Tech Glass 200 in kilograms – were made. Body mass index (BMI) was calculated, and students were classified through the National Telehealth Program of the Brazilian Ministry of Health. The evaluation of pulmonary function was conducted with the previously calibrated Jaeger Master Scope IOS/Germany spirometer and the recommendations of the American Thoracic Society (ATS) were adopted[11]. Spirometric parameters were considered in absolute values (liter-l) and percentages of predicted values (%).

After a maximum interval of three days, the indirect RMS parameters of inspiratory pressure – IP_{MAX} – and expiratory pressure –EP_{MAX} – were evaluated by using a calibrated digital manovacuometer ±300cmH_2O (MVD300/Globalmed®Brasil), respecting the ATS standards[12]. The value obtained was analyzed according to the predictive equations of Rosa et al.[13]. A maximum of five maneuvers were conducted for IP_{MAX} and EP_{MAX}, with an interval of one minute between them and five minutes between the measurements of each of the parameters; the value of the best maneuver was recorded.

The physical activity questionnaire for children (PAQ-C), which was verbally answered by the student, was used to evaluate the LPA and investigate the frequency and performance of moderate and intense physical activity in the seven days prior to application[14,15]. It consists of nine questions about the practice of sports, games and physical activities during leisure time and at school. Each question has a value of 1 to 5 – 1 point: the individual is very sedentary; 2: sedentary; 3: moderately active; 4: active; and 5: very active. The final score was obtained by the mean of the answers. Based on this score, the students were divided into an active group (AG: score ≥3) and inactive group (IG: score <3)[15].

Sample size was initially calculated by the software G*Power 3.1, considering 85% power of the test, 0.65% effect size, and 5% significance level, which estimated 35 students for each group.

For the analysis of the results, the distribution of the data was verified with the Kolmogorov-Smirnov test and then the Spearman correlation coefficient was applied to relate the variables (RMS, LPA and age parameters). The RMS parameters were compared between groups and genders by applying Student's t test (EP_{MAX})and Mann-Whitney. A 5% significance level (statistical package for the social sciences/SPSS, version 20.0) was adopted.

RESULTS

A group of 76 students participated in the analytical study, one of them was very sedentary, 34 sedentary, 29 moderately active and 12 active, according to PAQ-C. AG and IG were equal regarding anthropometry, age, and spirometry (p>0.05) (Table 1).

Table 1. Characteristics of the total sample and the groups

Characteristic	TG N=76/G: 57.9%	IG N=35/G: 60%	AG N=41/G: 56.1%	
	Mean±SD (CI)	Mean±SD (CI)	Mean±SD (CI)	p-value
Age(years)	10.1±1.7 (9.7-10.5)	10.1±1.8 (9.51-10.7)	10.1±1.6 (9.57-10.6)	0.91
Body mass(kg)	40.2±10.9 (37.7-42.7)	40.6±11.4 (36.7-44.5)	39.9±10.6 (36.5-43.2)	0.76
Height(m)	1.48±0.11 (1.45-1.50)	1.48±0.11 (1.44-1.52)	1.48±0.10 (1.44-1.51)	0.91
BMI(Kg/m^2)	18.2±3.03 (17.3-18.7)	18.1±3.13 (17.3-19.2)	17.9±3.01 (16.9-18.8)	0.73
IP_{MAX}(cmH_2O)	−89.7±41.4 (−99.2-80.3)	−79.0±29.5 (−68.8-−89.1)	−98.9±47.8 (−83.8-−114.0)	0.04*

(continues)

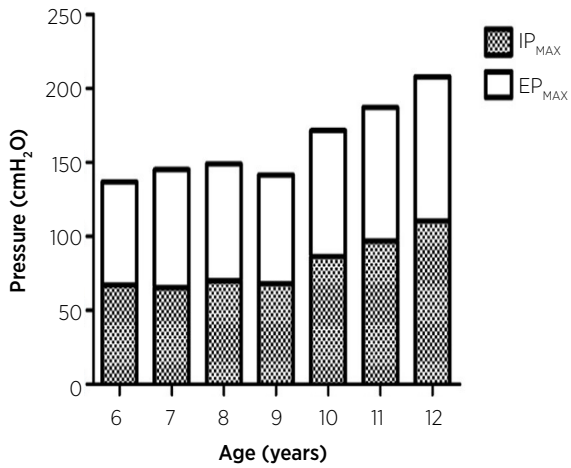
Table 2. Continuation

Characteristic	TG N=76/G: 57.9%	IG N=35/G: 60%	AG N=41/G: 56.1%	
	Mean±SD (CI)	Mean±SD (CI)	Mean±SD (CI)	p-value
$EP_{MÁX}(cmH_2O)$	86.6±22.5 (81.4-91.7)	83.5±25.1 (74.9-92.1)	89.2±20.1 (82.9-95.6)	0.27
FVC(%)	97.9±11.7 (95.2-100.6)	94.6±9.94 (91.2-98.0)	100.7±12.5 (96.7-104.6)	0.10
$FEV_1(\%)$	92.9±10.8 (90.4-95.4)	90.8±10.1 (87.3-94.3)	94.7±11.2 (91.2-98.3)	0.11
$FEV_1/FVC(\%)$	93.7±14.1 (90.4-96.9)	92.7±18.5 (86.3-99.1)	94.5±9.10 (91.6-97.3)	0.59
EFP(%)	84.2±10.0 (81.9-86.5)	85.3±11.5 (81.4-89.3)	83.3±8.58 (80.5-86.0)	0.38

N: Sample. TG: total group. IG: inactive group. AG: active group. G: girls. DP: standard deviation. CI: 95% confidence interval. kg: kilogram. m: meters. BMI: body mass index. kg/m^2: kilogram per square meter. cmH_2O: centimeters of water. IP_{MAX}: maximum inspiratory pressure. EP_{MAX}: maximum expiratory pressure. %: predicted percentage. $FVC_1\%$: forced vital capacity. FEV_1, forced expiratory volume in the first second. $FEV_1/FVC\%$: FEV_1/FVC ratio. EFP%: expiratory flow peak.

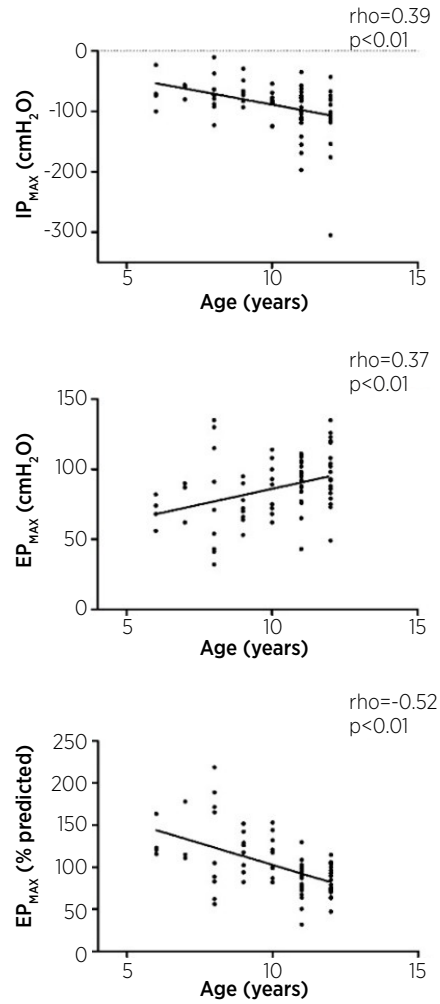
LPA and RMS parameters (IP_{MAX} and EP_{MAX}) did not relate in absolute nor predicted values (p>0.05). IP_{MAX} and EP_{MAX} absolute values increased with age (Graph 1). Only $EP_{MAX\%}$ was negatively correlated with age (Table 2, Graph 2).

Analyzing the LPA according to age, there was a peak of inactivity in 8-year-olds and increase of this inactivity with age, as occurred with IP_{MAX} and EP_{MAX}. There was a higher value of IP_{MAX} in AG, in absolute value and percentage, compared with IG – p=0.04; p=0.02, respectively. Comparing RMS parameters between genders, boys presented higher EP_{MAX} absolute values (p=0.02), and LPA was equal between genders (p=0.42) (Graph 3).



Graph 1. Absolute values of IP_{MAX} and EP_{MAX} according to the age of the total sample

IP_{MAX}: maximum inspiratory pressure. EP_{MAX}: maximum expiratory pressure. cmH_2O: centimeters of water.



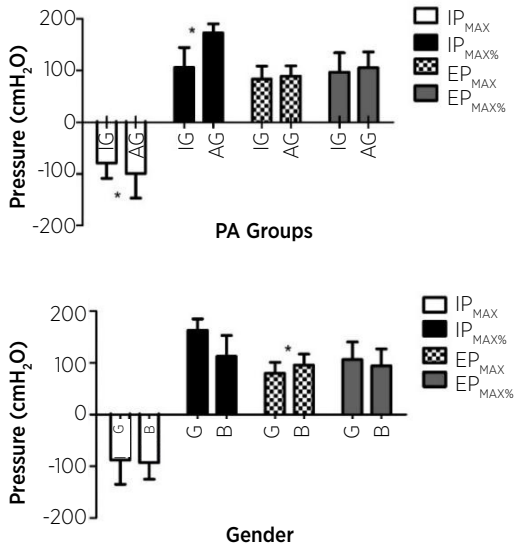
Graph 2. Linear correlation graphs between age and IP_{MAX} and EP_{MAX} values of the sample

IP_{MAX}: maximum inspiratory pressure. EP_{MAX}: maximum expiratory pressure. cmH_2O: centimeters of water. % predicted: maximum pressure in predicted percentage. rho: Spearman correlation coefficient. p: significance level.

Table 2. Result of the relationship between RMS parameters with LPA and age in the total sample

Variables	$IP_{MÁX}$		$EP_{MÁX}$		$IP_{MÁX\%}$		$EP_{MÁX\%}$	
	rho	p	rho	p	rho	p	Rho	p
PAQ-C	−0.20	0.07	0.08	0.48	0.18	0.10	0.08	0.45
Age	0.39	<0.01*	0.37	<0.01*	−0.16	0.14	−0.52	<0.01*

rho: correlation coefficient. p: significance level. IP_{MAX}: maximum inspiratory pressure in centimeters of water. EP_{MAX}: maximum expiratory pressure in centimeters of water. MAX%: maximum pressure in predicted percentage. PAQ-C: physical activity questionnaire for children. *: p<0.05 in Spearman test.



Graph 3. Result of the comparisons of the parameters of IP_{MAX} and EP_{MAX}, in absolute and predicted values, between the IG and AG groups and regarding the gender of the sample

IP_{MAX}: maximum inspiratory pressure. EP_{MAX}: maximum expiratory pressure. cmH_2O: centimeters of water. $IP_{MAX\%}$: maximum inspiratory pressure in predicted percentage. $EP_{MAX\%}$: maximum expiratory pressure in predicted percentage. IG: inactive group. AG: active group. PA: physical activity. G: Girls B: Boys. *: Significant results on the Mann-Whitney test or Student's t test for independent samples

DISCUSSION

This study did not identify a relationship between LPA and indirect RMS parameters in the sample evaluated. On the other hand, comparing inactive and physically active schoolchildren, we observed a statistical higher IP_{MAX} in those with better LPA. The age range from 6 to 12 years was related to IP_{MAX} and EP_{MAX} and without difference in LPA between genders.

RMS is reflected by the pressure generated by respiratory muscles, whose pressure difference ensures pulmonary ventilation. Thus, the clinical significance of the evaluation of RMS parameters. Such musculature seems to have an influence on the practice and level of physical activity, as it stimulates the maintenance of its integrity[16]. Comparing the students according to the LPA, the AG had higher IP_{MAX} values, which may be related to the fact that physical activity increases the work of respiratory muscles to supply the oxygen demand generated by peripheral muscles[17]. In athletes, IP_{MAX} has already been related to performance[18]. Thus, performing activities based on physical training may be a way to increase the function of this musculature, since the practice of sports promotes ventilatory overload[19].

The absence of a relationship between LPA and indirect parameters of RMS in the total sample analyzed was against the previously established hypothesis, which supposed that the LPA would be directly linked to the greater stimulus and input of the respiratory muscles, resulting in the improvement of respiratory muscle resistance and strength[17,19]. This finding may have resulted from the children misunderstanding the questionnaire used for the evaluation. PAQ-C is a subjective instrument that depends on a good interpretation and memory of the responder[20], which may not be an easy task, especially in the younger age group. This may also explain the discrepant peak of physical inactivity observed at the age of eight, because the students themselves answered about their physical activity practices, that is, age can be indicated as a limitation in this study.

Although the reproducibility and validity of the PAQ-C are considered satisfactory, studies with double labeled water and calorimetry are suggested[20], because its use tends to overestimate values measured directly by accelerometry, which is a worrisome factor when establishing a relationship with children's health data[21]. Therefore, studies with direct methods of LPA evaluation in schoolchildren should be encouraged.

The evaluation of RMS through manovacuometry also requires collaboration and understanding to be performed. Increasing age can positively influence its performance, but it also increases the measure[22]. The same could be seen in the investigation that showed a direct relationship between age and IP_{MAX} and EP_{MAX} values. In a recent review, Verma et al. also observed that RMS parameters increase with age, due to the maturation of the child's respiratory system. Growth involves the development of the lung until adulthood, in addition to muscle and hormonal changes[23]. LPA also increased with age progression, which seems to suggest an improvement in inactive behavior observed with technological advances[24].

In Brazil, the percentage of active schoolchildren was 20.3% in the last national school health survey (PeNSE), and was higher among boys (28.1%) than in girls (12.9%)[24], which may justify boy's higher values of EP_{MAX}. Since during activities ventilation tends to increase, requiring greater respiratory work and predisposition to forced expiration[17], EP_{MAX} consequently increases. Added to this, boys have higher production of muscle mass starting in puberty due to hormonal aspects[25]. However, there was still no difference in LPA between genders in this study.

Regarding the negative correlation between $EP_{MAX\%}$ and age, the literature has no previous studies about this relationship in healthy children. In most studies, absolute values of RMS are used in comparative analyses of groups[19]. A possible hypothesis for the result of our study is that the negative correlation may have resulted from the difference in mass and age frequency between our sample and the sample of the study that generated the equation we used[13]. Although reference values and equations are developed and validated for certain populations[14], their use in different samples may cause underestimation or overestimation of results, since these calculations are intimately related to age, mass, and height of the original samples[13].

Knowing that children who create the habit of practicing physical activities since childhood are more susceptible to keeping the habit until adulthood[17], promoting this practice is essential to decrease the high rates of sedentary lifestyle and benefit the respiratory musculature. Thus, the relationship between LPA and RMS should be further investigated within the therapeutic scope, because this knowledge enables strategies to prevent cases, to identify possible early diagnoses of disease and weakness of the respiratory muscles, besides stimulating the prescription of exercise in every circumstance.

CONCLUSION

LPA and indirect RMS parameters in the healthy schoolchildren studied were unrelated to each other, but there was a relationship between age and IP_{max}, EP_{MAX} and $EP_{MAX\%}$ values. Active children had a higher IP_{MAX} compared with inactive children. Boys had a higher EP_{MAX} value compared with girls and LPA was equal in both genders.

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