



## Lung function and functional capacity in school age children

### *Função pulmonar e capacidade funcional de escolares*

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#### Abstract

**Introduction:** Six-minute walk test (TC6') and peak expiratory flow (PEF) can be influenced by variables like gender, age and body mass index (BMI). In the school context, these tests can identify losses caused by sedentary habits and/or manifestation of overweight/obesity. Nevertheless, although widely studied in the adult context, they have not been properly clarified in the child public. **Objective:** To assess the PEF and TC6' between students in the public and private network and to correlate them with factors like age, gender and BMI. **Methods:** 39 male and female children between eight and ten years of age were selected for the study. The TC6' was held at a sports court. The child was instructed to walk at maximum speed for six minutes and the PEF test took place in accordance to the recommendations by Pereira et al (1). **Results:** No significant correlation was found between the BMI and the PEF and TC6' scores. No significant correlation was found between sex and PEF, with measures within normal parameters for the entire sample. The EPF measures did not influence the distance walked in the TC6'. A significant correlation was found between sex and distance walked in the TC6' only among male children attending public schools. **Conclusion:** Both sex and BMI did not influence the PEF measures which, in turn, does not seem to have influenced the distance the sample walked in the TC6'. Also concerning the TC6', only the children from public school reached the normal scores proposed in the literature.

**Keywords:** Physical Therapy Modalities. Exercise Test. Pediatric Obesity.

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## Resumo

**Introdução:** Testes de caminhada de seis minutos (TC6') e pico de fluxo expiratório (PFE) podem ser influenciados por variáveis tais como, gênero, idade e índice de massa corporal (IMC). Em âmbito escolar são capazes de identificar prejuízos gerados por hábitos sedentários e/ou manifestação de sobrepeso/obesidade. No entanto, embora amplamente estudados no meio adulto, ainda não estão bem esclarecidos no público infantil. **Objetivo:** Avaliar o PFE e TC6' entre escolares da rede pública e privada, bem como correlacioná-los com fatores tais como idade, gênero e IMC. **Métodos:** Participaram do estudo 39 crianças de ambos os gêneros e idades compreendidas entre 8 e 10 anos. O TC6' ocorreu em quadra poliesportiva, a criança orientada a caminhar em velocidade máxima por seis minutos e o teste de PFE, conforme Pereira et al. (1) **Resultados:** Não houve correlação significativa entre o IMC e os valores obtidos de PFE e TC6'. Não houve correlação significativa entre sexo e PFE, cujas medidas ficaram de acordo com a normalidade para toda a amostra. As medidas de PFE não influenciaram a distância percorrida no TC6'. Houve correlação significativa entre o sexo e distância percorrida no TC6' apenas entre as crianças do sexo masculino, pertencentes às escolas públicas. **Conclusão:** Tanto o sexo quanto o IMC não influenciaram as medidas de PFE, e este por sua vez, não parece ter exercido influência sobre a distância percorrida no TC6' da amostra. Ainda no que tange ao TC6', apenas as crianças oriundas de escolas públicas alcançaram os valores de normalidade propostos pela literatura.

**Palavras-chaves:** Modalidades da Fisioterapia. Teste de Esforço. Obesidade Infantil.

## Introduction

The pulmonary function measures and submaximal exercise tests can help to diagnose and manage countless respiratory conditions and clarify the impact of morbidity and mortality factors on childhood, such as the increase in weight/obesity. It is known, however, that these measures are not taken in clinical practice, a fact that is due, among others: to the lack of standardization of many tests for the pediatric age range, to the small patients' comprehension and cooperation difficulty, to the high equipment cost and, mainly, to the lack of dissemination of these tests among pediatricians and other health professionals as a fundamental part of the physical examination. Nevertheless, their practice is recommended, even among children under six years of age (2, 3, 4).

The peak expiratory flow (PEF) is considered the maximum flow produced during forced expiration at the level of the total pulmonary capacity (TPC). Its value is strongly correlated with the forced expiratory volume in the first second (FEV and forced vital capacity (FVC), measured using conventional spirometry. It can also be considered an indirect pulmonary strength index (5). Its measure is used as a non-invasive method to detect airflow alterations, asthma, exercise-induced bronchoconstriction and chronic obstructive pulmonary disease (COPD) (6).

The six-minute walking test (TC6'), in turn, is described as the submaximal test applied in patients with cardiac and/or pulmonary disease, whose results reflect both aspects of quality of life and of the patient's performance for activities of daily living (ADLs) (7, 8). It is considered an important alternative to replace the maximum effort tests which, although elected as the gold standard to estimate tolerance to efforts, are difficult to execute for the child public because they demand high-cost equipment and the recruitment of specialized staff (9).

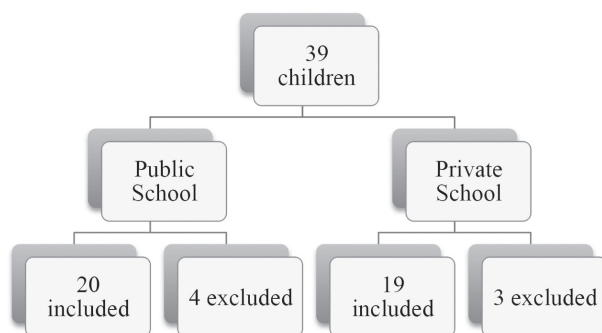
Few studies exist about the theme involving samples of children from the Northeast, whose ethnic and cultural miscegenation can impact the PEF measures and distance run in the TC6', as one of the main motivations for our study. The hypothesis is raised that reduced PEF measures are gender related and that the presence of a high body mass index (BMI) can influence the distances run in the TC6'. Thus, low PEF measures and increased BMI are appointed as predictive factors of bad performance.

Based on the above, the objective in this research was to identify the influence of factors like sex, age and BMI on the pulmonary function (PEF) and functional capacity measures (TC6') in a sample of school-aged children between 8 and 10 years of age.

## Methods

A cross-sectional correlational study was developed with children from two schools, one public and the other private, between August and December 2013, in the city of Itabuna, Bahia. Approval for the research was obtained from the Research Ethics Committee at Universidade Estadual de Santa Cruz (UESC), under CAAE protocol (02878613.5.0000.5526).

The research included the children who presented the Free and Informed Consent Form properly signed by their parents and/or responsible caregivers, between 8 and 10 years of age, who wore appropriate clothing and shoes on the day of the test and who complied with the orientations for a perfect test. Seven children were excluded from the study who presented one or more of the following limitations: presence of cognitive and/or motor function capable of compromising the accomplishment of the test, children with evidence of cough, wheezing, expectoration and dyspnea, according to the recommendations by Matiello et al. (10), as well as children who did not properly complete any of the tests proposed (Figure 1). On the eve of the tests, the volunteers were instructed to avoid the intake of coffee, tea, chocolate and soft drinks, nor engage in vigorous exercises 2h before the test (6). The tests of children who had a cold or history of fever the night before were rescheduled.



**Figure 1** - Flow chart of the sample.

All children were weighted on Filizola electronic scales (Brazil) and measured on a wall stadiometer, wearing as little clothing as possible.

For the PEF measure, the portable device Peak Flow Meter<sup>®</sup> was used. Each child was individually instructed about the test and asked to place the disposable mouthpiece in his/her mouth well adapted to avoid leakages,

and then inspire deeply, followed by a strong and rapid expiration. This maneuver was repeated thrice at one-minute intervals, adopting the highest measure for registration purposes. A maximum of six maneuvers was performed per child, and only if needed. The maneuvers performed were subject to the acceptability and reproducibility criteria standardized by Pereira et al. (1) and Piccioni et al. (3), including: appropriate expiratory flow to verify the PEF measure, non-evidence of coughing or abrupt glottal closing, expiration time less than 0.5s, difference over 200 mL between the measures. The child remained seated during the test, with the head in a neutral position and with the presence of a nasal clip to avoid losses (4).

To perform the TC6', the children were instructed to walk at maximum speed for six minutes along the distance marked between two cones. Before starting to collect the measures, a demonstration was given to each child with an attempt of approximately 25 steps to guarantee proper understanding of the instructions (8). Two experienced evaluators supervised the execution of the tests, who also provided verbal stimuli every one minute.

The PEF measures found were confronted with the normalcy coefficients attributed by Polgar, Promadhat (11), while the TC6' results were compared with the normalcy scores proposed by Iwama, Andrade, Shima (12) according to the age range studied.

The data analysis was developed in the software Bioestat 5.0, in the public domain. The normality of the sample was tested through the Shapiro-Wilk test and the correlation between the ordinal and nominal variables (sex, age, PEF and distance run in the TC6') was analyzed using Spearman's correlation test. The quantitative variables (expected and obtained PEF and TC6') were analyzed using Student's t-test.

## Results

The sample consisted of 39 children, male and female, and between 8 and 10 years, one from a public and another from a private school. All variables presented normal variation when submitted to the Shapiro-Wilk test.

No significant correlation was found between sex and PEF measures for the entire sample. Nevertheless, the male sex showed higher PEF measures when compared to the girls (Table 1).

**Table 1** - Profile of the sample concerning PEF, anthropometric measures and TC6', according to the school of origin

	GIRLS	BOYS
<b>Mean PEF (L/min)</b>	244.0	254.2
<b>Mean distance run (m)</b>	696.7	790.8
<b>Mean BMI (Kg/m<sub>2</sub>)</b>	17.49	19.24
<b>Public School</b>		
N = 20	10	10
Mean PEF (L/min)	239	268
Mean distance run (m)	748.1	923.3
Mean weight (Kg)	35.9	38.2
Mean height (cm)	136.5	135.9
<b>Private School</b>		
N = 19	10	9
Mean PEF (L/min)	258	238
Mean distance run (m)	641.1	638.7
Mean weight (Kg)	31.0	33.7
Mean height (cm)	136.7	137.3

A strong statistical correlation was found between sex ( $p < 0.0001$ ) and age ( $p = 0.005$ ) in relation to the distance run on the TC6' (Table 2). And male children scored higher on the distances run when compared to the female sex.

**Table 2** - Correlation coefficients between the study variables

<b>Private School</b>						
	Sex vs. PEF	Sex vs. TC6'	Age vs. PEF	Age vs. TC6'	BMI vs. PEF	BMI vs. TC6'
<b>r</b>	0.1591	0.0233	0.2893	-0.1722	0.1796	-0.1713
<b>p</b>	0.5282	0.9269	0.2441	0.4945	0.4757	0.4968
<b>Public School</b>						
	Sex vs. PEF	Sex vs. TC6'	Age vs. PEF	Age vs. TC6'	BMI vs. PEF	BMI vs. TC6'
<b>r</b>	-0.401	-0.7766	0.0248	-0.6113	-0.0642	0.201
<b>p</b>	0.0888	< 0.0001	0.9199	0.0054	0.7941	0.4092

No significant correlation was found between the BMI and the PEF and TC6' coefficients among the children from both schools.

When comparing the sample's PEF scores with the scores proposed in Polgar's formula (11), all children were able to obtain the expected scores and were considered normal for this measure. On the other hand, when comparing the expected distances with the actual distances run on the TC6', using the formula by Iwama, Andrade, Shima a highly significant relation was only observed among public-school students, independently of gender (Table 3).

**Table 3** - Mean, standard deviation, p-value and confidence interval (CI) of the expected and obtained PEF and TC6' coefficients according to the school origin

<b>PEF</b>				
	<b>Public School</b>		<b>Private School</b>	
	Obtained	Expected	Obtained	Expected
<b>Mean</b>	251.05 ± 46.05	290.10 ± 37.59	246.66 ± 50.29	293.5 ± 41.80
<b>P</b>	0.0035		0.0023	
<b>95% CI</b>	-66.7160 till -11.3893		-78.1647 till 15.5020	
<b>TC6'</b>				
	<b>Public School</b>		<b>Private School</b>	
	Obtained	Expected	Obtained	Expected
<b>Mean</b>	830.10 ± 119.92	634.10 ± 32.01	639.89 ± 53.99	637.21 ± 31.65
<b>P</b>	< 0.0001		0.4287	
<b>95% CI</b>	135.9132 till a 256.0862		-28.6008 till 33.9509	

## Discussion

The assessment of the pulmonary function through the PEF measure in children and adolescents is employed as a non-invasive method to detect airflow alterations, asthma and exercise-induced bronchoconstriction. The PEF measure corresponds to a maximal expiration based on the total pulmonary capacity. Its easy management and low cost facilitate the population's greater access, demonstrating its importance as part of an educational program in the early diagnosis of large-caliber airway obstruction.

The PEF coefficients can be measured using flow meters, which are simple, economical, portable devices that are easy to interpret, like the Peak Flow Meter<sup>®</sup> (12). In addition, its coefficients are strongly correlated with the FEV and FVC (13).

The patients are seated only for the sake of greater comfort, considering that the pulmonary function has been assessed among three to six-year-old children in the standing position, wearing a nasal clip, without any negative effect on the test (3).

It is known that increased age, weight, BMI and waist circumference, as well as exaggerated fat and lean mass percentages, are inversely associated with cardiorespiratory aptitude (14, 15). According to Cibella et al. (16), high BMI coefficients in children can be considered risk factors for the occurrence of severe conditions like asthma.

Heavier children can also present motor difficulties that limit their participation in physical exercise. Thus, these children prefer sedentariness to engaging in exercise programs. In addition, countless authors suggest that the progression of BMI is a factor of loss for the development of motor skills (17).

Surprisingly, in our research, the BMI did not influence the PEF and TC6' measures (Table 2). Drumond et al. (18) did not observe any statistically significant difference either for PEF and FVC measures when compared to different BMI coefficient. The literature in general differs from our findings, as appointed in Gundogdu; Eryilmaz (15), who assessed the PEF measures of 1,439 obese and non-obese children, and observed that the former were associated with low PEF coefficients, indicating obesity as a risk factor for good cardiopulmonary performance. Torun et al. (19) reached similar results for the PEF, FVC and FEV measures, affirming that the increased BMI was directly associated with PEF coefficient below normalcy among children

between 9 and 17 years of age. As documented by Silva et al. (13), the mechanical load of fat deposit in the thoracic and abdominal regions of children can affect the pulmonary growth, promoting losses in the ventilator function and consequently reducing the volumes and capacities.

In this research, no statistically significant difference was found between the PEF measures according to gender. It should be highlighted, however, that higher mean PEF measures were associated with the male sex (Table 1). This is in line with the findings by Boaventura et al. (12), who assessed the PEF of adolescents between 12 and 18 years of age, and observed that the PEF scores varied linearly with age and height. More expressive results were found in male patients. Pérez-Padilla et al. (20), in turn, examined children between eight and 12 years of age for two consecutive years and variations in spirometry tests were more frequent in girls, as well as among younger and taller subjects. In adults, the sex can influence the PEF measures (1).

The schools elected through this research are located in geographically distinct areas, but no statistically significant difference was found between the PEF measures of children from a school near the urban center (private) and a more distant school (public). According to Linares et al. (21), whose study assessed public-school students between six and 14 years of age, students from schools closer to polluted areas presented lower PEF scores, as mentioned by Epton et al. (22). In our research, the children from both schools achieved the PEF scores established in the literature through Polgar's formula (11).

The TC6' can assess the individual performance through the submaximal effort and has been widely used as a success marker for the objective measure of physical capacity and cardiac and ventilator performance among normal children and, more recently, among children with musculoskeletal, neurological and metabolic disorders (7, 10, 23, 24).

In this research, it was observed that boys walked longer mean distances when compared to girls (Table 1), in accordance with Li et al. (7), who assessed 78 adolescents between 12 and 16 years of age, and the studies by Fonseca et al. (5), who attributed the fact, among others, to the greater presence of muscle mass in boys. We also observed that only the children from public schools presented a strong positive correlation for the distances walked and expected for the TC6' (Table 3). The authors attribute this fact to public



school children's habit to walk to school, while private school children mentioned using motor vehicles to get to school. No statistically significant difference was found for the obtained and expected distances when related to age (Graph 2).

Hallal et al. (24) reached similar results and concluded that the active movement to school was associated with the low socioeconomic level. According to them, the active movement of the childhood population to the school was much more due to the lack of another alternative means of transport than to the population's true awareness of the benefits of this type of movement. It is also known that children encouraged to perform daily walks of moderate intensity can perceive increased insulin and reduced glucose levels, as well as lower fat concentrations than children exposed to sedentary habits (25, 26). In that sense, behaviors that are considered sedentary, such as watching television and playing videogames for more than two hours, talking on the phone and using the computer are associated with higher BMI and lower exercise levels (27).

Although the BMI was not statistically significant in relation to the TC6' in our study, it can be affirmed that the distances run can be strongly influenced by the amount of body fat, as presented in the study by Burgos et al. (28).

It was also observed that, during the TC6', the children's speed dropped around the third minute when compared to the final test minute. This result was also observed in the study by Goemans et al. (29). Finally, it is widely acknowledged that certain factors can influence the TC6' results and, consequently, the distance walked, such as the child-juvenile growth and development period (puberty and growth spurt), which can interfere in the child's pace and speed (9, 30).

The contribution to the assessment of Northeastern school-aged children was characterized as a strong point in this research, in view of the lack of studies published involving this public. Nevertheless, the authors appoint the following study limitations: enormous difficulty to get the test accepted concerning the signing of the Informed Consent Form by the responsible caregivers of the private-school children. This fact exuberantly implied the limitation of the sample size and prevented the assessment of other age groups and greater BMI variations to reaffirm the results proposed here.

## Conclusion

In this study, it is concluded that neither sex nor BMI could influence the PEF scores obtained in relation to the scores expected in the literature for the investigated age range. Nevertheless, we know that the increased BMI is considered a risk factor for sedentary habits in the study population and contributes to the occurrence of adverse effects on motor activities, as well as functional capacity and respiratory dynamics measures. Only the children from public schools ranked within normalcy parameters for the expected distances walked according to the TC6' test, a fact attributed to the daily habit of walking to school, which the researchers exhaustively advised and encouraged among the children from the private school, who tend to use other than active transportation media to get to school.

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