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Original Article

Effects of physical activity on aerobic capacity, pulmonary function and respiratory muscle strength of football athletes and sedentary individuals. Is there a correlation between these variables?

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Abstract
Background: Physical activity allows sport athletes some systemic adjustments that lead to a better performance when compared to sedentary people. However, the real difference that the respiratory system may present between the two populations has yet to be established. This study aimed at evaluating the effects of physical activity on aerobic capacity, pulmonary function and respiratory muscle strength by determining thecorrelation among athletes and sedentary people. **Methods:**The study sample consisted of 20 male individuals aged 18-24 years, divided into two groups: Athlete group-AG (n = 10), and Sedentary group-SG(n = 10).Respiratory evaluation was performed through *spirometry* and manovacuometry.The *Bruce treadmill test* was used for evaluation of cardiac function. **Results:**The comparison between AG and SG showed a significant increase (p (0.05) with regards to the following variables: *maximum volume* (V) of *oxygen* (O_2) (AG = 79.31; SG = 72.40 ml/kg.min); forced vital capacity (AG = 5.76; SG = 4.93L); forced expiratory volume in 1 second (AG = 5.10; SG = 4.41 L); inspiratory muscle strength (AG =-108; SG =-90 cmH_2O); positive correlation between maximum oxygen volume and the other variables. **Conclusion:**The results showed that the football-related physical activities have improved the aerobic capacity, the pulmonary function and the inspiratory muscle strength, demonstrating a positive correlation between these variables.
Keywords: physical activity, spirometry, oxygen consumption, sedentary

Introduction

The regular practice of physical exercises promotes important physiological changes in sports practitioners, whose performance depends on numerous events in the heart, lung and muscle systems. The evidence in the literature shows that athleteshave better lung function compared to sedentary people[1,2].

Adaptations of the maximum aerobic capacity (VO_2Max) play an important role in predicting cardiopulmonary condition and are influential factors on the exercise performance[2]. Different protocols have been used as effective methods in the indirect evaluation of VO_2Max, including the *Bruce treadmill test*[3]. The data obtained in the indirect evaluation of the VO_2Max may be associated with the evaluation of the pulmonary function carried out using the spirometry test, *which provides measurements that facilitate accurate interpretations* of *results*[4]. During this assessment,different and basic measurements are recorded: volumetime, and airflow. Some of the spirometric measures include:forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1) andthe **FEV_1/FVC ratio (FEV_1%),** also known asthe **Tiffeneau-Pinelli index**[5].However, some aspects may change the ventilatory mechanics, such as the reduction of inspiratory and expiratory muscle strength and even resistance,which can modify the respiratory flow[6].

This study aimed at describing how physical activity can be a determining factor for the conditions of the respiratory system, involving aspects, such as respiratory muscle strength and lung capacity of the individual. We also compared the significant differences in lung capacity, maximum volume of oxygen, respiratory muscle strength in AG and SGto determine if there were correlations between the variables.

Materials and methods

This case-control study consisted of 20 maleindividuals,between the ages of 18 and 24 years (20.80 ± 1.54). The sample selection and criteria for exclusion were determined as follows: participants who had developed a cold seven days prior to the assessment;exhibited any changes derived from cardiorespiratory pathology; and the sedentary individuals who were training three times a week. The subjects were divided into two groups: Athlete Group-AG (n = 10) and Sedentary Group-SG(n = 10). All participants performed manovacuometry, spirometry and Bruce treadmill tests.

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The present study was approved by the Research Ethics Committee of the Centro Universitário Unifafibe, Bebedouro – SP, Brazil (protocol N.2.649.194).

The Bruce treadmill test

Subjects performed the Bruce treadmill test on anEmbreex 550 EX-1 treadmill. The test consists of seven stages. Stage 1 is performed at 1.7 mph and at a gradient (or incline) of 10%. At three-minute intervals the incline of the treadmill increases by 2%, and the speed increases up to 6.0 mph[7].

For the assessment of *subjective perceived exertion*, each participant received instructions on the use of the Borg CR-10 scale. The *incremental progressive* maximal *exercise* was interrupted when the subject reachedthe highest mark in *the Borg CR10 scale*.The results were calculated by the formula for SG: VO_2Max (ml/kg/min) = (3.288 x time) + 4.07; and for AG: VO_2Max (ml/kg/min) = (3.778 x time) + 0.19[8].

Spirometry

Participants underwent spirometry test with a MIRspirometer (Spirobank II, USA), following the recommendations of the American Thoracic Society / European Respiratory Society. Room temperature was kept between 22 and 24ºC[9]. At least three forced expiratory curves were obtained for the measures of FVC, FEC_1, PEF (peak expiratory flow) and Tiffeneau index.

Manovacuometry

A ComercialMédica®analog manovacuometer with an operational interval of ± 120 cmH_2O was used to assess respiratory muscle strength via exercises to measure maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). Subjects were informed about the test procedures. In order to avoid air escape, all measurements were performed with the participants seating with their feet resting on the ground, using a nose clip properly adjusted to the lips[10]. A minimum of three and a maximum of six measures were taken, with an interval of 1 minute each, computing the highest value obtained.

Statistical analysis

The data were tabulated and submitted to statistical analysisusing SPSS version 22.0 for Windows (SPSS Inc.;Chicago Il, USA).The values obtained in all three tests were compared by an independent t-test ($p \leq 0.0$). The *correlation between* the quantitative *variables* was analyzed usingthe *Pearson's correlation coefficient*, with a significance level of $p \leq 0.05$.

Results

The population distribution of the sample was *matched by pairs* (subject/subject)and the differences were calculated betweenAG and SG, with mean age of 20.80 ± 1.54 years and BMI of 22.04 ± 1.77 and mean age of 20.10 ± 1.79 years and BMI of 22.91 ± 3.01, respectively.The results showed that AG had greater inspiratory muscle strength, increased forced vital capacity and increased forced expiratory volume in 1 s, with higher level of VO_2max during exercises when compared to SG, as displayed in Table 1.

Table 1. Comparison between the variables of respiratory muscle strength, *spirometry*and Bruce test for AG and SG.

Variables	Individuals (N=20)	p	Mean	Standard deviation
MIP (cmH_2O)	Athletes	0.04*	108	±8.95
	Sedentary		90	±5.68
MEP (cmH_2O)	Athletes	0.12^{ns}	102	±1.48
	Sedentary		92	±5.90
FVC (L)	Athletes	0.04*	5.76	±1.13
	Sedentary		4.93	±0.59
FEV_1 (L)	Athletes	0.03*	5.10	±0.81
	Sedentary		4.41	±0.51
FVC/FEV_1 %	Athletes	0.86^{ns}	89	±5.80
	Sedentary		89	±6.94
PFE (L/s)	Athletes	0.49^{ns}	10.83	±1.59
	Sedentary		10.39	±1.15
VO_{2Max} (ml/kg/min)	Athletes	0.00*	79.31	±0.27
	Sedentary		72.40	±1.71

*=Significant ($p \leq 0.05$); NS= non significant.

Table 2 shows moderate correlation between the VO_2max valuesand the variables tested. Values are represented graphically with dispersion curves in Figures 1-5.

Table 2. Correlation between the variables of respiratory muscle strength,spirometry and Bruce test for AG and SG.

Variables	VO_2max MIP	VO_2max MEP	VO_2max FVC	VO_2max FEV_1	MIP MEP
Correlation	0.553*	0.489*	0.455*	0.483*	0.783*
p≤0.05	0.01	0.02	0.04	0.03	0.00

*=Significant (p≤0.05); NS=non significant.

Figure 1. Correlation between the VO_2max and MIP values for AG and SG.

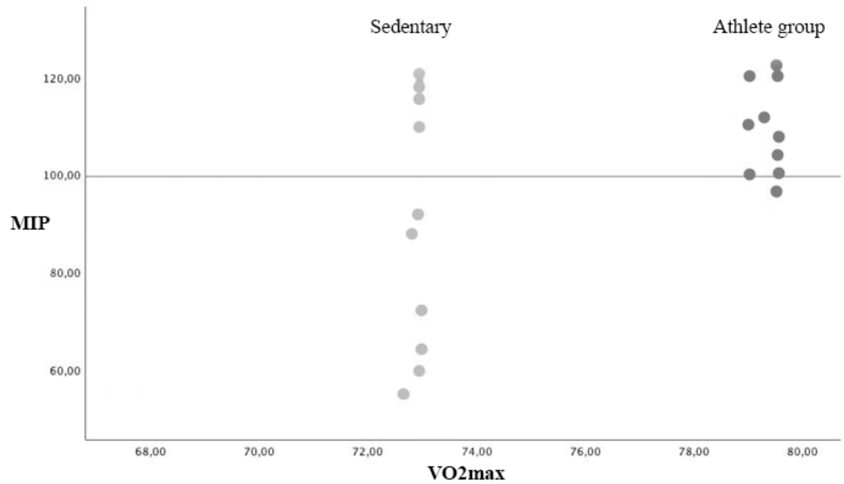

Figure 1 shows a positive correlation between the MIP and VO_2Max values, with AG near or above the baseline. Therefore, the higher the VO_2Max values,the higher the MIP levels.

Figure 2. Correlation betweenthe VO_2Maxand MEP values for AG and SG.

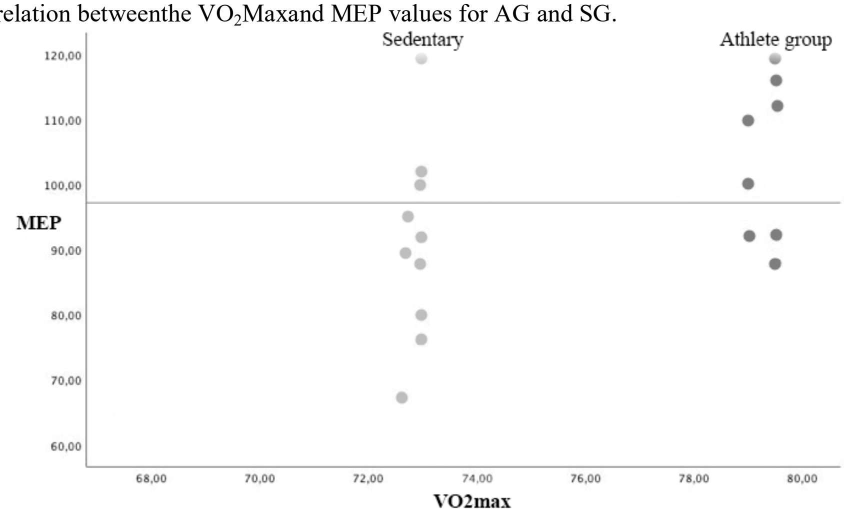

Figure 2 shows a positive correlation between the MEP and VO_2Max values, with AG near or above the baseline. Therefore, the higher the VO_2Max values,the higher the MEP values.

Figure 3. Correlation between the VO_2Max and FVC values for AG and SG.

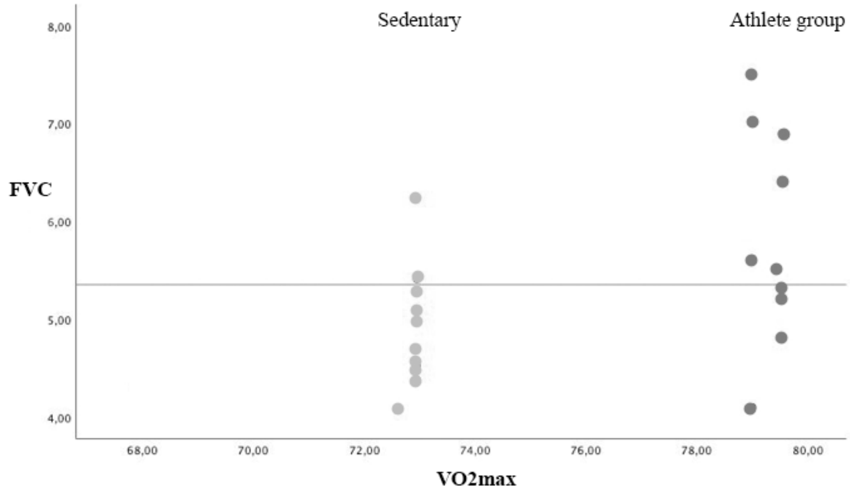

Figure 3 shows a positive correlation between the FVC and VO_2Max values, with AG near or above the baseline. Therefore, the higher the VO_2Max values, the greater the FVC.

Figure 4 – Correlation between the VO_2max and FEV_1 values for AG and SG.

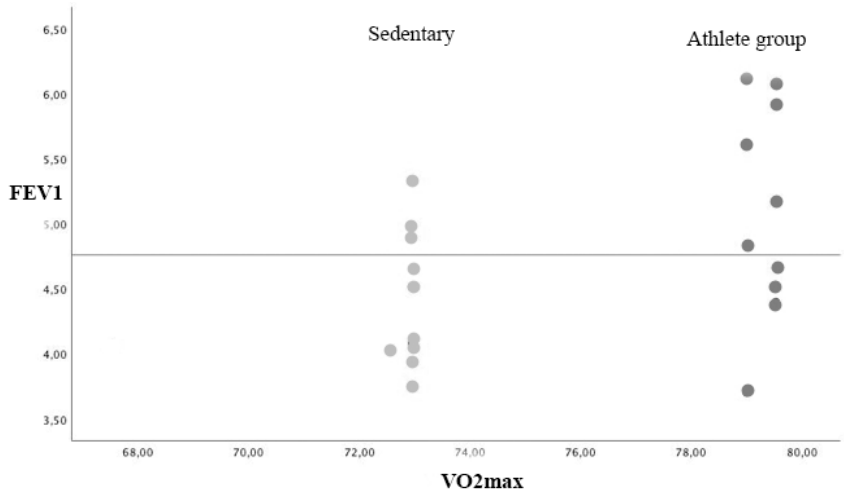

Figure 4 shows a positive correlation between the FEV_1 and VO_2max values, with AG near or above the baseline. Therefore, the higher the VO_2Max values, the greater the FEV_1values.

Figure 5. Correlation between the MIP and MEP values for AG and SG

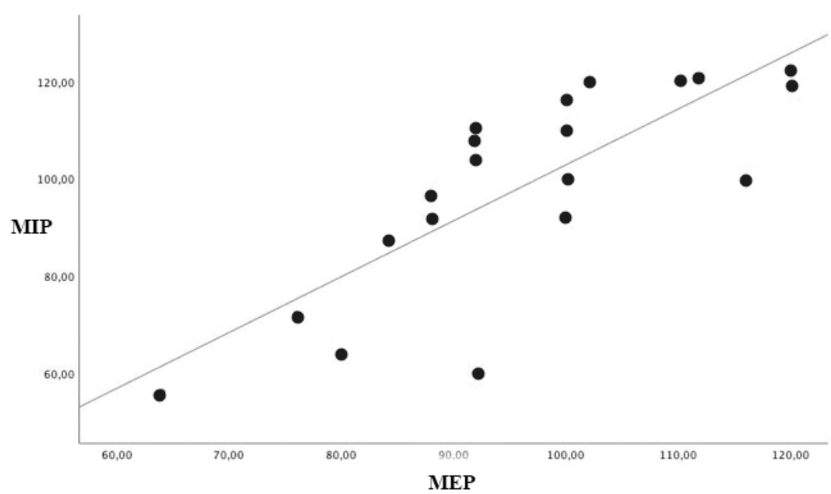

Figure 5 shows a positive correlation between the MIP and MEP values, whether for athletes or sedentary individuals so that an increase in MIPprovides a significant *increase in respiratory muscle strength*.

Discussion

The study evaluated the effects of physical activity on aerobic capacity, pulmonary function and respiratory muscle strengthin football athletes and sedentary people. It also verified if there was a positive correlation between these variables. The results suggest that the physical activity had an impact on the respiratory patterns of these individuals.

Some articles have reportedalterations in VO_2Max in response to duration or frequency of training. However, other authors have observed that these variables exerted little effect onVO_2max when compared to the intensity of the exercises proposed[11].Perez et al.[12]in their reports, analyzed the cardiopulmonary profile of street runners using a maximum effort test. The runners were divided into three homogeneous groups: elite, amateur, and non-athlete. The results showed that the elite group obtained the highest performance level with respect to VO_2Max compared to the non-athlete group.The present study corroborates this finding, considering that the football athletes showed better performance when compared to sedentary people. This may be explained by the fact that elite athletes have a higherlevelof cardiorespiratory capacity due to the different demands of sports and theexercise intensity, which requirephysiological adaptation of the respiratory system[13].

ORTIZ et al.[14] in their experimental study, observed that regular participation in small-sided soccer games increased aerobic performance, promoted health benefits related to similar aerobic training, and showed improvements in VO_2max comparedto pre and post football practice. These findings are in accordance with those of our study, whichreported that football practice has increased VO_2max when compared to non-athletes.Current evidence indicates that training exercise can be a determining factor for the alterations in spirometric parameters, with statistically higher values for FEV_1 and FVC, particularly in longerduration training exercises[15].SHIN et al.[16]measured the respiratory function of both elite judo athletes and non-athletes, using a spirometer. The authors found that FVC was significantly increased in judo athletes compared to non-athletes. These results support those found in the present study since the positive correlation observed confirmed that higher VO_2max levels can increase FVC.

Some studies have shown that resistance training increasesthe respiratory muscle strength[17,18]. SILVA et al.[19] analyzed the performance of the inspiratory muscle strength in football players pre and post specific muscle training and found that these players exhibited a higher inspiratory strength prior to engaging in muscle training compared to the other group. These findings corroborate those reported in our study where AG had greater inspiratory muscle force compared toSG due to specific demands of football practice. Moreover, muscle training can bring benefits to these athletes and their respiratorysystem,andconsequently, improve these values.

To our knowledge, no study has investigated the correlation of the variables analyzed in the present study. However, we verified that VO_2max had a moderate positive correlation with the other determinants. This occurred because VO_2max is the maximum integrated capacity of the pulmonary, cardiovascular and muscular systems to uptake, transport and utilize O_2, respectively, and is essential for the respiratory muscles during any physical activity. Therefore, increased supply of oxygen has a direct effect on the capacity of the expiratory and inspiratory muscle strength.

The analysis of the correlation between the MIP and MEP values showed that these measures were directly proportional i.e. an increase in inspiratory muscle strengthsuggests an increase in expiratory muscle strength. This occurred because the demand of the diaphragm muscle strength in inspiration is greater, and may helpgenerate force during expiration.

VO_2max can have a direct influence on lung capacity, as evidenced in our study.The FVC and FEV_1values increased with the increase of VO_2max, due to greater adaptation and performance, which suggests a direct effect on the expiratory capacity and inspiratory muscle strength.

Conclusion

Based on the results obtained, it can be suggestthat the football-related physical activities have improved the aerobic capacity, the pulmonary function and the inspiratory muscle strength, showing a positive correlation between these variables.AG exhibited a significant increase of these variables when compared to SG.

The present study is intended to help generate guidance for *further* research in order to correlate the real effects of different physical training exercises on respiratory function.

We declare that there are no conflicts of interest.

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