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Is fat free mass or fat mass capable of reflecting sedentary time in individuals with COPD?

A massa magra ou a massa de gordura são capazes de refletir o tempo sedentário em indivíduos com DPOC?

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Abstract

Background: Most individuals with chronic obstructive pulmonary disease (COPD) spend much of their day in sedentary activities, and body composition in this population is still scarcely studied. Analyzing the relationship between fat-free mass, fat mass and sedentary time (ST) can help better understanding disease impacts and optimizing clinical management. **Aim:** To determine if there is correlation between ST and fat-free mass index (FFMI) or fat mass index (FMI) in individuals with COPD. **Methods:** This is a cross-sectional study that included individuals with COPD who underwent assessment of physical activity in daily life over seven consecutive days using an accelerometer to quantify ST (<1.5 METs) per day. Body composition was assessed using bioelectrical impedance analysis. **Results:** 32 individuals with COPD were analyzed (56% males, 70±7 years, FEV_1/FVC 49±11%pred, FFMI 25±5 kg/m^2). ST was 519±136 minutes per day (64±13% of the day). FFMI and FMI showed a weak and negative correlations with ST expressed both in minutes per day (r=-0.30 and -0.31, respectively; p>0.05 for both) as in % of the day (r=-0.31 and -0.21, respectively; p>0.05 for both). Statistically significant correlations of ST with FFMI and FMI were observed only in men, although moderate (r=-0.40 and -0.54, respectively). **Conclusion:** Sedentary time showed a weak correlation with FFMI and FMI, suggesting that body composition is not associated in a relevant way with sedentary behavior in individuals with COPD. However, men showed a moderate correlation, indicating a possible sex-related association in this relationship.

Keywords: Chronic Obstructive Pulmonary Disease; Body Fat Distribution; Sedentary Behavior.

Resumo

Introdução: A maioria dos indivíduos com doença pulmonar obstrutiva crônica (DPOC) passa grande parte do dia em atividades sedentárias, e a composição corporal nessa população ainda é pouco estudada. Analisar a relação entre massa magra, massa de gordura e tempo sedentário (TS) pode ajudar a compreender melhor seus impactos e otimizar o manejo clínico. **Objetivo:** Determinar se há correlação do TS com o índice de massa livre de gordura (IMLG) ou com o índice de massa de gordura (IMG) em indivíduos com DPOC. **Métodos:** Trata-se de um estudo transversal que incluiu pacientes com DPOC submetidos à avaliação da atividade física na vida diária durante sete dias consecutivos por meio do uso de um acelerômetro para quantificar o TS (<1,5 METs) por dia. A composição corporal foi avaliada por meio da bioimpedância elétrica. **Resultados:** 32 indivíduos com DPOC foram analisados (56% homens, 70±7 anos, VEF_1 47±20%pred, IMLG 25±5kg/m^2). O TS foi de 519±136 minutos/dia (64±13% do dia). IMLG e IMG apresentaram correlação fraca com o TS, tanto expresso em minutos/dia (r=-0,30 e -0,31, respectivamente; p>0,05 para ambos) quanto em % do dia (r=-0,31 e -0,21, respectivamente, p>0,05 para ambos). Correlações estatisticamente significantes do TS com IMLG e IMG foram observadas apenas nos homens, embora moderadas (r=-0.40 e -0.54, respectivamente). **Conclusão:** O tempo sedentário apresentou correlação fraca com o IMLG e o IMG, sugerindo que a composição corporal não se relaciona de forma relevante com o comportamento sedentário em indivíduos com DPOC. Contudo, homens demonstraram correlação moderada, sugerindo possível associação do sexo nessa relação.

Palavras-chave: Doença Pulmonar Obstrutiva Crônica; Distribuição da Gordura Corporal; Comportamento Sedentário.

INTRODUCTION

Body composition and nutritional status are important factors in individuals with chronic obstructive pulmonary disease (COPD) for being directly linked to a higher risk of exacerbation, increased mortality, and worsening of the disease[1]. The fat mass index (FMI) and fat-free mass index (FFMI) are accurate measures of adipose tissue and non-adipose mass, respectively, regarding an individual's height[2,3]. A low FFMI is strongly associated with aging, a greater number of disease exacerbations, worse performance on the six-minute walking test (6MWT), increased dyspnea, and reduced maximal inspiratory pressure (PImax) [4], making it a key tool for assessing prognosis and functional health in individuals with COPD[5].

COPD involves not only respiratory impairments but also systemic manifestations, such as muscle dysfunction, inflammation, nutritional changes, and cardiovascular comorbidities[6]. The interaction among these factors contributes to a sedentary lifestyle, reduced daily physical activity and physical deconditioning[7]. Dyspnea, muscle weakness, and functional limitations lead patients to adopt an inactive lifestyle, which further aggravates these symptoms, thus perpetuating a vicious cycle[8-10].

Individuals with COPD typically spend most of the day engaged in sedentary behaviors, characterized by activities performed in positions such as sitting, lying down or reclining, with low energy expenditure (≤1.5 metabolic equivalents [METs]). Common examples include staying in these positions for long periods or performing tasks that require minimal energy[11,12]. Research indicates that individuals with COPD who are sedentary for ≥8.5 hours per day have a four times greater risk of mortality compared to those who are less sedentary[13].

This study aims to provide a better understanding of the mechanisms involved in body composition and sedentary behavior in patients with COPD. We hypothesize that FFMI has a stronger relationship with ST than FMI, given that FFMI and ST are associated with mortality in individuals with COPD. Therefore, this study aimed to determine whether sedentary time (ST) is reflected by FFMI or FMI in individuals with COPD, to investigate the existence of differences in body composition between sexes, and to identify which body composition index best reflects ST in each sex for a deeper understanding of this relationship.

METHODS

This is a cross-sectional study conducted at the Pulmonary Physiotherapy Research Laboratory (LFIP – *Laboratório de Pesquisa em Fisioterapia Pulmonar*) of the State University of Londrina (*Universidade Estadual de Londrina*) and is part of a broader, longitudinal study focused on reducing sedentary behavior after pulmonary rehabilitation through physical training, health education, and a wearable device, structured according to the Behaviour Change Wheel intervention model[14]. The study was approved by the Institutional Ethics Committee for Research with Human Beings (opinion number 5.459.958). All participants read and signed an informed consent form. This research uses only baseline assessment data. Participants were recruited through convenience sampling from the outpatient clinics of Respiratory Medicine and Respiratory Physiotherapy of the University hospitals. The assessment protocol was conducted entirely by trained researchers, using validated methods and divided into two sessions. Participants were assessed for pulmonary function, body composition, and level of sedentary behavior and physical activity in daily life, as detailed below.

The following inclusion criteria were applied: individuals with a clinical diagnosis of COPD, according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria[7]; clinical stability, without infections or exacerbations in the last month; no severe and/or unstable heart disease; no severe osteo-neuromuscular alterations that could influence the assessment of physical activity in daily life (PADL); and not having followed any type of high-intensity physical exercise program in the last three months. The exclusion criteria included non-use of the physical activity (PA) monitor for the time considered minimally acceptable for a valid assessment (more details below), and severe acute exacerbation requiring hospitalization during the evaluation protocol.

Level of sedentary behavior and physical activity in daily life

The assessment was performed using the Actigraph wGT3X-BT® physical activity monitor (Actigraph, United States of America [USA]). It is a small, portable device widely used in research on physical activity and sedentary behavior[15]. Its main variables include the number of steps, energy expenditure, and time spent in sedentary activities (<1.5 MET), light physical activity (between 1.5 and 2.9 METs), moderate (between 3 and 5.9 METs), vigorous (between 6 and 8.9 METs), very vigorous (>9 METs), and moderate to vigorous physical activity (MVPA, >3 METs). Participants wore the device on the waist for seven consecutive days during all waking hours. The device was only removed momentarily during activities involving water (e.g., showering). In order to consider the assessment as valid, individuals had to wear the monitor for at least 4 valid assessment days, and a valid day comprised a minimum time of body use of 480 min (i.e., 8 h) per day[16]. Participants also received a diary to keep track of the use of the monitor, containing information such as time of wakening and periods of non-use (e.g., showering and bedtime).

Pulmonary function

After providing demographic and anthropometric data, the patients underwent pulmonary function testing using spirometry (Vmax®, Carefusion, Germany). The variables of interest were forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and the FEV_1/FVC ratio. The evaluation was performed according to the guidelines of the American Thoracic Society (ATS)/ European Respiratory Society (ERS)[17,18] with reference values from Pereira et al.[19] for the Brazilian population.

Body composition

Body composition was assessed using electrical bioimpedance (Biodynamics, USA). Lean body mass values from bioimpedance were obtained directly from the device (according to age and sex). These values were also used in a formula proposed by Kyle et al.[20], which is specific for patients with chronic respiratory failure. The formula for calculating fat-free mass (FFM) is: FFM = –6.06 + (0.283 × height) + (0.207 × weight) – (0.024 × resistance) + (4.036 × sex). The FFM allowed calculating the FFMI by dividing the lean mass by the square of the height in meters. To determine fat mass (FM), FFM was subtracted from the total weight, and the FMI was calculated by dividing the fat mass by the square of the height.

The values obtained by applying the formula were used as a reference[20]. A low FFMI was considered as ≤16 kg/m² in men and ≤15 kg/m² in women; the expected FMI was 1.8 to 5.2 kg/m² in men and 3.9 to 8.2 kg/m² in women, while the normal values for body fat mass (BFM) used were 13.4% to 21.7% for men and 24.6% to 33.2% for women[3].

Statistical analysis

Data tabulation and statistical analysis were conducted on the Microsoft Excel 365 (Microsoft, USA) and SPSS version 27.0 (IBM, USA) software. Normality of data distribution was assessed by the Shapiro-Wilk test. Data with a normal distribution were described using mean ± standard deviation, while data with a non-normal distribution were described using median [interquartile range 25-75%]. Associations between time and body composition indices (FM, FFMI, and FMI) were examined by calculating Pearson or Spearman correlation coefficients. The strength of the correlations was interpreted as weak ($r < 0.40$), moderate ($r = 0.40–0.69$), or strong ($r \geq 0.70$). The Mann-Whitney test was used to compare differences between sexes. Statistical significance was set at a p-value of < 0.05.

RESULTS

Our sample included 38 individuals diagnosed with COPD. However, five of them were excluded due to missing body composition data, and one individual due to a lack of physical activity data. Hence, the final sample consisted of 32 individuals with COPD (18 men and 14 women), with a mean age of 70±7 years. Table 1 describes their general characteristics.

Comparison of body composition between sexes revealed that men had higher FFMI, lower FMI, and lower FM ($p<0.001$ for all). In contrast, no significant difference was observed in ST between the groups ($p>0.05$) (Table 2).

Table 1. Characterization of the study participants.

Variables	Total (n = 32)
Age, years	70±7
BMI, kg/m²	25±5
FFMI, kg/m²	14±3
FMI, kg/m²	9±4
FM, %	38 (29-52)
FEV_1, % predicted	47±20
FEV_1/FVC, %	49±11
Smoking status	
Current smoker, n (%)	8 (25%)
Former smoker, n (%)	21 (66%)
Never smoked, n (%)	3 (9%)
GOLD	
I/II/III/IV, n (%)	2 / 14 / 9 / 7
6MWT, % predicted	83±19
6MWT, meters	432±105
Retired, n (%)	29 (91%)
Living alone, n (%)	7 (22%)
Wear time, minutes/days	804±95
Steps count, steps/day	4305 (2121-6669)
Time/day in sedentary time, minutes/days	519±136
Time/day in sedentary time, % of the day	64±13
Time/day in MVPA, minutes/day	8±9
Time, day in MVPA, % of the day	1±1

Data are described as mean ± standard deviation, median (interquartile range), or absolute value (percentage). BMI: Body mass index; FFMI: Fat-free mass index; FMI: Fat mass index; FM: Fat mass; FEV_1: Forced expiratory volume in the first second; FVC: Forced vital capacity; GOLD: Global Initiative for Obstructive Lung Disease; 6MWT: six-minute walking test; MVPA: Moderate to vigorous physical activity.

Source: elaborated by the authors based on the research data.

Table 2. Comparison of participant characteristics between genders.

Variables	Men (n = 18)	Women (n = 14)
Age, years	70±6	69±7
BMI, kg/m^2	25±5	25±4
FFMI, kg/m^2	17±2*	12±2
FMI, kg/m^2	8±3*	13±3
FM, %	29 (24-33)*	53 (51-55)
FEV_1, % predicted	46±16	53±23
FEV_1/FVC, %	48±10	53±12
Smoking		
Current smoker, n (%)	5 (28%)	3 (21%)
Former smoker, n (%)	11 (61%)	10 (72%)
Never smoked, n (%)	2 (11%)	1 (7%)
GOLD		
I/II/III/IV, n (%)	0 / 8 / 5 / 5	2 / 6 / 4 / 2
6MWT, % predicted	84±21	81±18
6MWT, meters	471±108*	404±79
Retired, n (%)	17 (94%)	12 (86%)
Living alone, n (%)	2 (11%)	5 (36%)
Wear time, minutes/days	810±94	798±100
Steps count, steps/day	4512 (3512-7294)	3274 (1878-5614)
Time/day in sedentary time, minutes/days	508±125	532±138
Time/day in sedentary time, % of the day	62±13	67±15
Time/day in MVPA, minutes/day	12±16	7±6
Time, day in MVPA, % of the day	2±2	1±1

Data are described as mean ± standard deviation, median (interquartile range), or absolute value (percentage). BMI: Body mass index; FFMI: Fat-free mass index; FMI: Fat mass index; FM: Fat mass; FEV_1: Forced expiratory volume in the first second; FVC: Forced vital capacity; GOLD: Global Initiative for Obstructive Lung Disease; 6MWT: six-minute walking test; MVPA: Moderate to vigorous physical activity. *p<0.05 compared to the women's group.

Source: elaborated by the authors based on research data.

The ST expressed in minutes/day showed a weak negative correlation with FFMI and FMI (r=-0.30 and -0.31, respectively, p>0.05 for both) (Figures 1). The same outcome was found for ST expressed as a percentage/day, which also showed a weak negative correlation with FFMI and FMI (r=-0.31 and -0.21, respectively, p>0.05 for both) (Figures 2). Regarding FM, a very weak correlation was found with ST expressed in minutes/day and percentage/day (r=-0.12 and -0.05, respectively, p>0.05 for both).

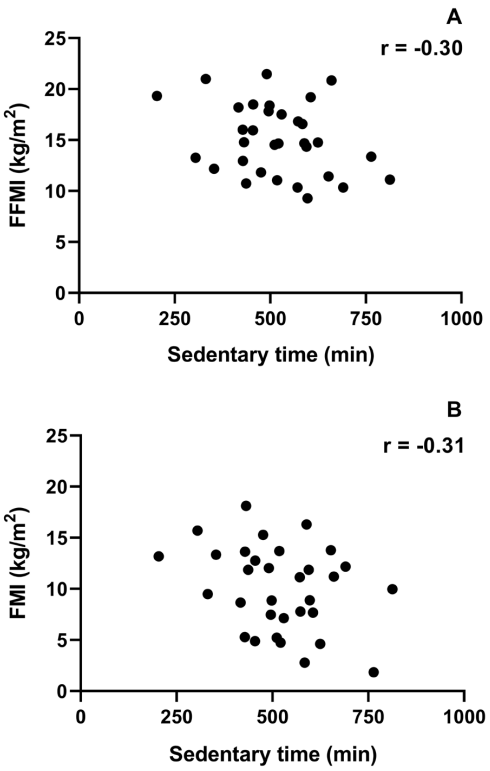

Figure 1. Correlation between sedentary time (ST) in minutes per day with Fat-free mass indices (FFMI) **(Figure A)** and Fat mass index (FMI) **(Figure B)**.

Source: elaborated by the authors based on research data.

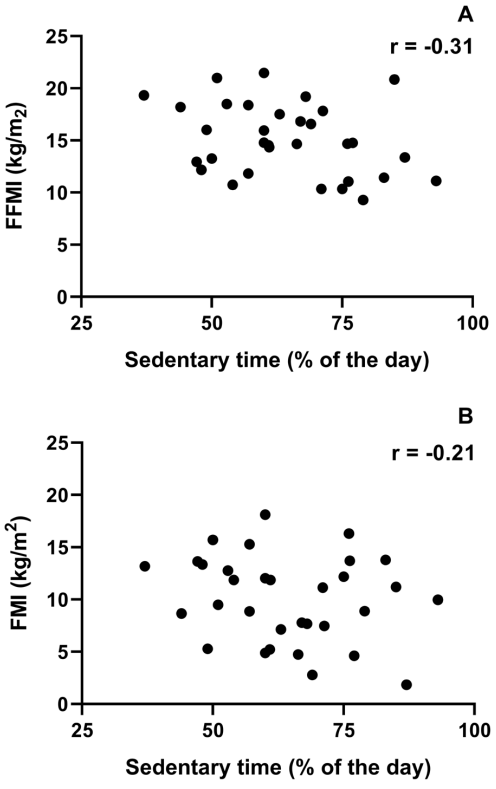

Figure 2. Correlation between sedentary time (TS) as a percentage (%) of the day with the Fat-free mass index (FFMI) **(Figure A)** and Fat mass index (FMI) **(Figure B)**.

Source: elaborated by the authors based on research data.

Table 3. Correlations between measures of sedentary time and body composition in men and women.

Variables	Men (n = 18)		Women (n = 14)	
	r	*p-value*	r	*p-value*
Sedentary time per day, min				
FMI	-0.54	0.02	-0.59	0.05
FM	-0.58	0.01	-0.42	0.13
FFMI	-0.40	0.09	-0.34	0.22
Sedentary time per day, %				
FMI	-0.47	0.04	-0.41	0.14
FM	-0.53	0.02	-0.22	0.45
FFMI	-0.30	0.21	-0.39	0.16

FMI: Fat mass index; FM: Fat mass; FFMI: Fat-free mass index.
Source: elaborated by the authors based on research data.

When separating the sample by sex, in women, ST (minutes/day) showed a weak negative correlation with FFMI and a moderate negative correlation with FMI and FM, while ST (percentage/day) showed a weak negative correlation with FFMI and FM, and a moderate negative correlation with FMI. In men, ST (minutes/day) showed a moderate negative correlation with FFMI, FMI, and FM. In contrast, when expressed as a percentage/day, the correlation was moderately negative with FMI and FM, and weakly negative with FFMI (Table 3).

DISCUSSION

This study shows that ST has a weak, negative correlation with FFMI and FMI, indicating that at the time of the study, none of these variables were strongly related to ST in individuals with COPD.

ST has been shown to have negative impacts on exercise capacity, muscle function, dyspnea, and lung function[21,22]. Furlanetto et al.[13] found that individuals with COPD who spend ≥ 8.5 hours or over 70% of their waking time in sedentary behavior have a four times greater risk of mortality. Webster et al.[21] found that BMI and airflow obstruction are associated with long periods of ST.

A low FFMI in this population has been previously associated with an increased risk of mortality[23], as well as with reduced exercise capacity, worsening airflow limitation, and disease progression[24]. Gologanu et al.[25] found no significant correlation between FFMI and disease severity. However, our study could not detect a significant correlation between ST and body fat indices, including specifically FFMI. It is worth noting, however, that none of the cited studies investigated the relationship with ST.

Machado et al.[26] observed that regardless of body mass index (BMI), low FFMI in individuals with COPD is associated with worse performance on 6MWT and higher scores on the Saint George's Respiratory Questionnaire (SGRQ). Meanwhile, individuals with normal weight and high FFMI showed less airflow limitation, higher PA levels, and better exercise capacity. While FMI showed a strong association with exercise capacity in underweight individuals, FM did not influence this parameter. In contrast, in our study, no association was observed between functional performance, ST, and BMI, possibly because the sample was composed mainly of individuals with good clinical control and relatively preserved pulmonary function, which may have attenuated the impact of these variables on performance at the time of evaluation.

In pre-obese and obese individuals, the benefits of a high FFMI were impaired by excess body fat, resulting in worse exercise capacity and health-related quality of life (HRQoL) in the obese group[24]. Vestbo et al.[27] found that FFMI decreased with disease severity and that approximately 50% of individuals in stages three and four with normal BMI had reduced FFMI.

Xavier et al.[28] reported that PA, sedentary behavior, and body composition should be considered when determining phenotypes in individuals with COPD and are involved in the disease prognosis. Thus, there is a relationship between lean body mass depletion and sedentary behavior. The reduction in FFMI[29] was associated with physical inactivity in this population, with phenotype 3 characterized by the worst body composition, greater physical inactivity, and worse health status[28].

Guo et al.[30] previously described that reduced BMI in older individuals can improve with increased PA. These findings highlight the importance of BMI as one of the most relevant extrapulmonary characteristics in COPD[31], emphasizing the need to include it in the routine assessment of these individuals. Meanwhile, the literature has mainly focused on the association between body composition and inactivity, and further studies should address its relationship with ST.

Ischaki et al.[32] highlighted that individuals with COPD who had a higher BMI showed better performance in exercise capacity, such as in the 6MWT, corroborating Machado et al.[26], who found an association between a high FFMI and greater exercise capacity. However, those with low FFMI and low BMI showed worse pulmonary function and lower exercise capacity. Muscle mass loss in advanced stages of the disease was strongly associated with a poorer quality of life and greater difficulties in performing PA[32], which was reported by Vestbo et al., who found a reduction in FFMI according to the severity of the disease[27].

Shimada et al.[33] identified the differences between FFMI and FMI in individuals with COPD, highlighting that both affect the clinical manifestations of the disease distinctly. The authors observed that a low FFMI is associated with a worse health-related quality of life in this population, while both FMI and FFMI contribute to the development of severe emphysema. Wang et al.[34] found that excess body fat can lead to metabolic abnormalities and intensify the inflammatory state in these patients. Alterations in lipid metabolism may also contribute to reduced immunity, influencing airway repair and impacting remodeling[34].

Yang et al.[35] observed that FMI exerts a protective effect, reducing the risk of acute exacerbations in individuals with COPD and a BMI below 25 kg/m^2. This partially corroborates the results of Chittal et al.[36], who associated a low percentage of body fat with higher mortality in this population[36].

Bredella et al.[37] detected differences in body composition between men and women, finding that males have greater lean body mass (LBM), while females have a greater amount of body fat compared to men. Our findings corroborate these results by also showing that men have a higher FFMI index and lower values of FMI and FM compared to women, reinforcing the distinctions between the sexes in body composition profile. Albrecht et al.[38] highlighted that differences in body composition begin in puberty due to the release of hormones, resulting in greater accumulation of body fat in women and an increase in FFM in men. It is worth noting that BMI, FM, muscle mass, and body composition have been associated with pulmonary function in both sexes[39-41].

Despite the significant differences in body composition between men and women with COPD observed in our study, when men show higher FFMI and lower FMI and FM, there was no significant difference in ST between the sexes. Although sex influences body mass distribution from puberty onwards[37,38], sedentary behavior seems to be more related to ventilatory limitation, dyspnea, functional capacity, and disease stage[21,32,41] than to body composition alone. Factors such as muscle strength, systemic inflammation, and dyspnea also contribute to physical inactivity, as pointed out by Xavier et al.[28].

Our findings suggest that although men and women with COPD have distinct body profiles, these differences are not necessarily reflected in daily ST. This may be attributed to both genders facing similar challenges in engaging in PA, primarily due to respiratory symptoms and functional limitations of the disease[21,22,32]. A limitation of this study must be highlighted: individuals with mild disease were not proportionally well represented in the sample, which may not reflect the full spectrum of the COPD population. The reduced sample size further limits the ability to reflect the clinical heterogeneity of the COPD population. This occurs because the profile of individuals referred to and enrolled in rehabilitation programs mainly consists of those in more advanced stages of the disease.

CONCLUSION

The findings of this study reinforce the complex relationship between body composition and sedentary behavior in individuals with COPD. While men showed a higher FFMI and a lower FMI than women, there was no significant difference in sedentary time between genders, suggesting that differences in body composition do not necessarily lead to variations in sedentary behavior. Despite statistically significant, the correlations found in men had moderate magnitude, suggesting that several additional factors may influence sedentary time in this population. These findings highlight the complex relationship between body composition and sedentary time in individuals with COPD, indicating the need for further research to better understand these factors, especially regarding possible gender differences.

FUNDING SOURCE

Nothing to declare.

CONFLICT OF INTEREST

Nothing to declare.

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RESEARCH DATA AVAILABILITY

Research data are available only upon request.

ARTIFICIAL INTELLIGENCE USE STATEMENT

Does not apply.

AUTHOR CONTRIBUTIONS

Franciele Del Nobile: Writing – original draft, Study design, Methodology, and Investigation. Thais Moçatto Tofoli: Study design, Methodology, Supervision, Writing – Review. Laís Santin: Investigation, Writing – Review. Letícia Medeiros: Investigation. Heloisa Krokoch: Investigation. Fabio Pitta: Study design, Methodology, Writing – Review and Editing, Project administration.

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