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ORIGINAL ARTICLE

Correlation between body mass index and joint pain intensity with gait performance in individuals with osteoarthritis

Correlação entre o índice de massa corporal e intensidade da dor articular com o desempenho da marcha em indivíduos com osteoartrite

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ABSTRACT

BACKGROUND AND OBJECTIVES: Individuals with osteoarthritis (OA) often have joint pain and are overweight or obese. Thus, the objective of this study was to observe whether there is correlation between body mass index and joint pain intensity with gait performance in individuals with OA.
METHODS: Cross-sectional study, which evaluated 60 volunteers, being 30 with clinical diagnosis of knee osteoarthritis and 30 without the disease, of both sexes and aged between 50-82 years. Joint pain intensity was assessed using the Visual Analog Scale, gait-related functional tasks using the Dynamic Gait Index, and the functional mobility using the Timed Up and Go test.
RESULTS: There was a correlation between overweight/obesity and high levels of joint pain intensity (p=0.018), with worse performance in gait-related functional tasks (p=0.000) and with worse functional mobility (p=0.034) only for the individuals with OA. High levels of joint pain intensity also correlated with worse performance in the gait-related functional tasks (p=0.000) in the OA group, and also with worse functional mobility in the OA group (p=0.001) and also in the group of individuals without the disease (p=0.032).
CONCLUSION: This study identified a correlation between overweight/obesity and high levels of joint pain intensity and worse gait performance in individuals with osteoarthritis. High levels of pain intensity also correlated with worse gait performance in individuals with OA.
Keywords: Accidental falls, Aging, Arthralgia, Knee Osteoarthritis, Overweight, Walking.

RESUMO

JUSTIFICATIVA E OBJETIVOS: Pacientes com osteoartrite (OA) frequentemente apresentam dor articular e sobrepeso ou obesidade. Assim, o objetivo deste estudo foi observar se existe uma correlação entre o índice de massa corporal e a intensidade da dor articular com o desempenho da marcha em indivíduos com OA.
MÉTODOS: Estudo de corte transversal, que avaliou 60, sendo 30 com diagnóstico clínico de osteoartrite de joelho e 30 sem a doença, de ambos os sexos e com faixa etária entre 50 e 82 anos. A intensidade da dor articular foi avaliada pela Escala Analógica Visual, as tarefas funcionais relacionadas à marcha pelo *Dynamic Gait Index* e a mobilidade funcional pelo teste *Timed Up and Go*.
RESULTADOS: Houve correlação entre o sobrepeso/obesidade e níveis elevados de intensidade da dor articular (p=0,018), com um pior desempenho nas tarefas funcionais relacionadas à marcha (p=0,000) e com menor mobilidade funcional (p=0,034) apenas para os indivíduos com OA. Os níveis elevados de intensidade de dor articular também mostraram correlação com um pior desempenho nas tarefas funcionais relacionadas à marcha (p=0,000) no grupo com OA, e ainda, com uma menor mobilidade funcional no grupo com OA (p=0,001) e também no grupo de indivíduos sem a doença (p=0,032).
CONCLUSÃO: Este estudo identificou correlação entre o sobrepeso/obesidade e níveis elevados de intensidade da dor articular e um pior desempenho na marcha nos indivíduos com OA. Os elevados níveis de intensidade da dor também mostraram correlação com pior desempenho na marcha nos pacientes com OA.
Descritores: Acidentes por quedas, Artralgia, Caminhada, Envelhecimento, Osteoartrite do Joelho, Sobrepeso.

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HIGHLIGHTS
- High body mass index was correlated with the presence of pain and lower gait performance in individuals with osteoarthritis.
- High pain intensity was correlated with lower gait performance in individuals with osteoarthritis.
- Senior individuals and those with osteoarthritis had the highest pain intensity and the worst gait performance in this study.

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INTRODUCTION

Osteoarthritis (OA) is a degenerative disease, usually insidious and slow, which typically affects the joints of the hands, spine, hips, and knees. It can be considered that this condition affects individuals in a multidimensional way, involving everything from the structures of the bone and joint system to social relationships, as it causes various functional limitations. OA is more prevalent from middle age onwards and is equally prevalent between the sexes, although it is more prevalent in women after the menopause[1].

OA is among the top three diseases among insured people benefiting from the social security program in Brazil, second only to cardiovascular and neurological diseases[2]. For clinical purposes, OA can be classified as primary or secondary. Primary OA has an uncertain cause, usually related to ageing or mechanical overload in the joints, when there is wear and tear of the articular cartilage, whether or not it is associated with genetic factors. Secondary OA is due to the presence of a disease or condition that corroborates osteoarticular conditions, such as intra-articular trauma, joint infections, inflammatory diseases, or the sequelae of these diseases, such as Chikungunya fever, metabolic or hemorrhagic diseases, which trigger the osteoarthritic process[3-5].

In addition to these aspects, obesity contributes greatly to initiating the process of damage to the different anatomical components of the joints. It is already well established in the literature that the synovium, bone, and articular cartilage are the three main tissues affected by the pathophysiological mechanisms of OA[6]. It is worth noting that obesity is the most significant and predictable risk factor for the development of OA, its role in the genesis and worsening of the lesion is based on the fact that increased body weight causes significant mechanical overload on the joints, articular cartilage and subchondral bone, especially in the joints of the lower limbs[7-9].

Osteoarthritis affects the functionality of the joints in the lower limbs, especially the knees and hips, which has a negative impact on the functional performance of individuals affected by this disease, especially when walking. Pain in the affected joint, aggravated by movement and relieved at rest; joint stiffness, especially in the morning; the presence of edema and deformities, as well as generating insecurity when crossing obstacles, also impair the movement of these individuals in activities of daily living, increasing the risk of falls and morbidity and mortality related to falls in individuals with OA[10-13].

Given the functional walking difficulties faced by individuals with OA, especially senior individuals with OA, often measured by the Timed Up and Go (TUG)[14-16], and the scarcity of studies that have assessed the gait of this population using instruments that analyze real conditions and situations in the daily lives of these individuals, such as dual-task gait, this study is justified. Thus, the primary objective of this study was to see if there is a correlation between body mass index (BMI) and the joint pain intensity pain with gait performance in individuals with OA. The secondary objective was to compare the joint pain intensity pain and gait performance between individuals with and without OA, and according to age group.

METHODS

This is a cross-sectional, investigative, and descriptive study, written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for conducting observational studies[17-19].

Initially, a survey was carried out at the health department of the municipality of Serra Talhada, Pernambuco, Brazil, to identify how many individuals with OA were listed in the records of the basic health units (*Unidade Básicas de Saúde* - UBS) that were collaborating in the study, and 73 individuals with OA were reported to be assisted by these UBS. With the help of community health workers, the researchers took the volunteers to their homes to explain the characteristics of the study and invite them to take part, provided they met the eligibility criteria. For the control group, another 30 people were invited, registered in the records of the UBS with no report or complaint of OA, with age and gender matched to the group of patients with OA.

The inclusion criteria were: age between 50 and 85, independent walking without the need for assistive devices, and being assisted by a UBS that collaborated in this study. Those with other illnesses, whether orthopedic, rheumatological or neurological, individuals with a history of Chikungunya fever infection and with any type of diabetes mellitus were also excluded. Those who met the eligibility criteria and agreed to take part in this study signed the Free and Informed Consent Term (FICT).

In order to define the outcome variable: presence/absence of OA, their medical records were consulted at each UBS. Although there were X-rays of the volunteers with OA and the clinical diagnosis provided by the doctor, there was no information on the degree of joint involvement. However, for all the other eligibility criteria, the information was in the medical records, and/or was confirmed by the volunteers, or by the guardian/accompanying person; this last item was used exclusively for senior volunteers.

Data collection

The assessments were carried out in reserved rooms at the UBS. The assessment began with the volunteers' personal data, using the standardized assessment form, which contained the following information: name, age, sex, history of falls in the last six months recorded in the medical records and, exclusively for the OA group, which joint(s) were affected. In addition to this data, each volunteer's height, weight, and BMI were also measured.

Initially, the researchers explained the aim of the study to each volunteer individually and explained how the joint pain intensity would be assessed, after which the volunteers were shown the Visual Analog Scale (VAS). The scale consists of a horizontal line whose ends are defined by the following terms: "no pain" and "disabling pain"[20]. Pain was measured during the gait tests. The intensity of knee and hip joint pain was assessed by the VAS[21], and when the volunteers had no more doubts, the gait assessment guidelines began.

The researchers explained and demonstrated all the procedures and how the two gait assessments would take place to each volunteer individually. When there were no more doubts, the assessments began.

Gait-related functional tasks were assessed using the Dynamic Gait Index (DGI), validated for the Brazilian population[22], and made up of eight tasks which involve assessing gait on a flat surface, changes in gait speed, gait with horizontal and vertical head movements, walking and going over and around obstacles, turning on one's own axis and going up and down stairs. The DGI has 4 response options (normal, mild, moderate, or severe), which must be used in each of the eight tasks, according to the volunteer's performance in the tests, making up a score between 0-24, so that the higher the score obtained by the volunteer, the better their performance in functional tasks related to walking.

Next, the volunteers' functional mobility was assessed using the TUG, recorded by a digital stopwatch. The variable is numeric, continuous, recorded in seconds, for the time taken to perform the test: get up from the initial chair, without armrests, walk towards another chair, located at a distance of three meters, go around this chair, and return and sit in the initial chair, performing this entire route at normal speed and with bare feet[23,24].

This study was assessed and approved by the Research Ethics Committee of the Sertão Integration College, under Opinion Number: 4.900.609 and CAAE number: 39017420.6.0000.8267.

Statistical analysis

The two values given by the volunteer for the intensity of their joint pain in the hip and knee were converted into a single arithmetic mean of the volunteer's pain. In addition, in order to identify the joint pain intensity pain and the performance of the sample according to age group, the groups were divided as follows: up to 59 years old and ≥60 years old.

The data from the evaluations were recorded on the data collection forms and transferred to a Microsoft Excel 2010 spreadsheet. To control typing errors, the transfer was carried out by two independent researchers (double data entry)[25-27].

The data was analyzed using the Statistical Package for the Social Sciences (SPSS), version 20, using a 5% statistical significance level.

The Kolmogorov-Smirnov test was used to test the normality of the quantitative variables. The Mann-Whitney test was used to compare the means between two groups in cases of non-normality of the data and the Student's t-test in cases compatible with normal distribution. For dichotomous variables, Pearson's Chi-squared or Fisher's exact test of independence was used when necessary.

Pearson's linear correlation coefficient was calculated between BMI and the joint pain intensity pain and the volunteers' performance on the DGI and TUG, as well as between the joint pain intensity pain and the volunteers' performance on the DGI and TUG. The interpretation of the size of the correlation coefficient adopted in this study was: 0-0.29 insignificant correlation, between 0.30-0.49 for low correlation, between 0.50-0.69 for moderate correlation, between 0.70-0.89 for strong correlation and between 0.90-1 for very strong correlation[28]. A multiple linear regression model was fitted between BMI, pain intensity and age with gait performance in the TUG and DGI.

RESULTS

The sample for this study was made up of patients of both sexes and aged between 50 and 82, matched by sex and age group, and was a convenience sample. Thirty volunteers had OA and 30 did not.

The sample characterization data is shown in table 1. The OA group in this study had greater joint pain intensity compared

Table 1. Sample Characterization.

	With OA (n= 30)		Without OA (n= 30)		p-value
	Average ± SD	n (%)	Average ± SD	n (%)	
Sexes					
Female		21 (70)		21 (70)	1.000[a]
Male		09 (30)		09 (30)	
Age (years)	59.7±1.54		59.5±1.57		0.912[b]
Weight (kg)	79.5±2.00		73.1±2.20		0.055[b]
Height (m)	1.64±1.90		1.67±1.76		0.123[b]
Body mass index	29.7±0.70		25.8±0.61		0.000[b]
History of falls					
Yes		09 (30)		03 (10)	0.052[c]
No		21 (70)		27 (90)	
Joints with OA					
Knee		28 (93.3)			
Hip and knee		02 (6.7)			

OA = osteoarthritis; BMI = body mass index; SD = standard deviation; [a] = Pearson's chi-square test; [b] = Student's -test; [c] = Fisher's exact test.

to those without OA, with significant differences (p=0.000), as shown in table 2.

Volunteers with OA also showed worse performance in gait-related functional tasks and lower functional mobility when compared to patients without OA, with significant differences ((p= 0.001) and (p= 0.000)), respectively, as shown in table 2.

There was a correlation between overweight/obesity and high levels of joint pain (p=0.018), with worse performance in gait-related functional tasks (p<0.001) and with lower functional mobility (p=0.034) only in the OA group (Table 3).

In addition, there was also a correlation between high levels of joint pain and poorer performance in gait-related functional tasks (p<0.001), only in the OA group. There was also a correlation between high levels of joint pain and lower functional mobility in the groups with OA: (p=0.001) and without OA: (p=0.032), according to table 4.

When the groups were divided by age: (up to 59 years old and 60 years old or more), significant differences were observed in all the outcomes analyzed, and always with the OA group showing the greatest intensity of joint pain and the worst gait performances, regardless of the age group. However, individuals with OA and aged 60 or over had the highest joint pain intensity and the worst gait performance in this study, as shown in table 5.

Considering the results of the correlation between BMI, pain intensity and age with gait performance using the TUG and DGI, multiple linear regression models were adjusted, the results of which are shown in table 6.

Table 2. Mean and standard deviation values for joint pain intensity, gait-related functional tasks and functional mobility in individuals with and without osteoarthritis.

	With OA (n= 30)	Without OA (n= 30)	p-value
	Average ± SD	Average ± SD	
Joint pain intensity	5.67 ± 0.35	2.52 ± 0.21	0.000[a]
Gait-related functional tasks	17.6 ± 0.99	22.3 ± 0.53	0.001[a]
Functional mobility	28.6 ± 3.15	16.8 ± 0.83	0.000[a]

OA = osteoarthritis; SD = standard deviation; [a] = Mann-Whitney test.

Table 3. Correlation between body mass index and joint pain intensity, gait-related functional tasks and functional mobility in individuals with and without osteoarthritis.

	With OA		Without OA	
	Correlation	p-value	Correlation	p-value
Joint pain intensity	0.429	0.018[a]	0.081	0.672[a]
Gait-related functional tasks	-0.677	0.000[a]	-0.079	0.679[a]
Functional mobility	0.389	0.034[a]	0.089	0.641[a]

OA = osteoarthritis; [a] = Pearson's linear correlation test.

Table 4. Correlation between joint pain intensity and gait-related functional tasks and functional mobility in individuals with and without osteoarthritis.

	With OA		Without OA	
	Correlation	p-value	Correlation	p-value
Gait-related functional tasks	-0.646	0.000[a]	-0.296	0.112[a]
Functional mobility	0.589	0.001[a]	0.392	0.032[a]

OA = osteoarthritis; [a]: Pearson's correlation test.

Table 5. Mean and standard deviation values for joint pain intensity, gait-related functional tasks (DGI) and functional mobility (TUG) in individuals with and without osteoarthritis with or without a history of falls.

	50-59 years (n=36)		p-value	≥60 years (n= 24)		p-value
	With OA (n=18)	Without OA (n=18)		With OA (n=12)	Without OA (n=12)	
	Average ± SD	Average ± SD		Average ± SD	Average ± SD	
Age	54.3±0.64	54.0±0.51	0.710[a]	67.6±2.26	67.8±2.83	0.959[a]
Body mass index	28.4±0.81	25.8±0.89	0.042[a]	31.7±1.06	25.9±0.80	0.000[a]
Joint pain intensity	4.67±0.39	2.03±1.80	0.000[b]	6.67±1.72	2.49±1.41	0.000[b]
Gait-related functional tasks	20.6±4.36	23.6±1.13	0.000[b]	13.1±3.48	19.9±3.39	0.000[b]
Functional Mobility	20.1±4.79	15.0±2.08	0.022[b]	41.2±1.25	19.6±5.82	0.005[b]

OA = osteoarthritis; SD = standard deviation; [a] = Student's -test; [b] = Mann-Whitney test.

Table 6. Results of the adjustment of the multiple linear regression model between BMI, pain intensity and age with gait performance in the TUG and DGI.

Groups	Variables	Model of TUG		Model of DGI	
		Coefficient	p-value	Coefficient	p-value
With OA	Intercept	-55.435	0.001	50.528	0.000
	Age	1.088	0.000	-0.170	0.046
	BMI	-------	------	-0.578	0.003
	Pain	3.489	0.006	-1.016	0.009
Without OA	Intercept	-0.185	0.969	----	----
	Age	0.279	0.001	----	----
	BMI	---	---	----	----
	Pain	1.245	0.036	----	----

OA = osteoarthritis; TUG = Timed Up and Go; DGI = Dynamic Gait Index.

DISCUSSION

As observed in the results, pain is an outcome frequently found in individuals with OA and showed a higher correlation with poorer gait performance in this population. The literature mentions that pain worsens with movement and at the end of the day, but in more advanced stages of OA, individuals can develop pain at rest. The chronic inflammation of OA can play a crucial role in the onset of pain and the progression of the disease, compromising the mobility and functionality of individuals with OA[29-31]. The volunteers with OA assessed in this study had a worse performance in gait-related functional tasks, and lower functional mobility compared to those without OA. These findings corroborate those of other studies which assessed the biomechanical characteristics of the gait of individuals with OA and concluded that these patients had alterations in the kinetic and kinematic patterns of gait and that these alterations can compromise the gait performance of these individuals[32-34], which could justify the worse gait performance of the volunteers with OA in this study.

OA is one of the main global causes of disability, with the knee being the most frequently affected joint[35]. There is a proven association between obesity and knee OA, obesity has also been suggested as the main risk factor for OA[35-37] and, as shown, overweight/obesity was correlated with high levels of joint pain only in volunteers with OA.

Overweight/obesity has been associated with greater absolute tibio-femoral compression and shear forces during walking, regardless of the presence or absence of osteoarthritis[38]. Increased joint compression can compress nerve endings, triggering the pain process in these individuals, as identified in this study and contributing to increased pain and accelerated joint damage with obesity[38-41]. It is also worth pointing out that the individuals without OA were also overweight, with an average BMI of 25.8±0.61, but the group with OA was closer to obesity, with an average BMI of 29.7±0.70, which may have contributed to the results found.

Overweight/obesity was also correlated with worse performance in gait-related functional tasks and lower functional mobility only for individuals with OA.

This finding corroborates that of other studies which found that obese individuals with OA performed worse on the TUG[42-44]. Study[45] observed that high BMI seems to be a determining factor for worse performance in the TUG in individuals with knee OA. Obesity is associated with biomechanical changes in gait in individuals with OA, such as prolonged activation of the quadriceps and gastrocnemius muscles, which can result in prolonged contact load on the knee joint. In addition, obese individuals with OA have increased hindfoot movements, leading to forefoot abduction during gait, when compared to those of normal weight[46-48].

These factors (isolated or combined) may help to understand the correlation found between overweight/obesity and poorer gait performance in the OA group, demonstrating how OA associated with obesity can negatively influence the gait of these individuals.

In addition to overweight/obesity, which other factors are associated with poor gait performance in individuals with OA? The literature suggests some factors, such as: biomechanical compensations of the hip and knee during gait, excessive knee flexion movement during the mid-support phase of gait and pain, as negative influencers of gait performance in these individuals[48-55].

Corroborating this data, high levels of joint pain also showed a correlation with worse gait performance in individuals with OA, for both tests used. The study[56] assessed 43 patients with OA and also concluded that there was a correlation between high levels of joint pain and poorer performance on the TUG. Other studies have found similar results using different instruments[57,58] and suggest that high levels of joint pain intensity in individuals with OA can determine poorer gait performance in these patients[41], as identified in this study.

Despite these results, the present group of authors did not find published studies in the literature that have observed the relationship between joint pain intensity and gait performance in individuals with OA assessed by the DGI. The DGI is an instrument that assesses gait-related functional tasks under dual-task conditions and is validated for the Brazilian population, which is the main contribution of this study.

A correlation between high levels of joint pain and lower functional mobility in patients without OA was also identified. This finding corroborates with results of the study[59], which compared the gait of 195 volunteers, 34 healthy individuals and 161 with OA, and concluded that in healthy individuals pain is associated with reductions in knee joint moments during gait, in a similar way to individuals with less severe knee OA, which could justify the observed correlation.

In addition, it should be noted that the volunteers in both groups assessed in this study had pain in the knee or hip at the time of the evaluation, however, the intensity of the pain was greater in the OA group, which could justify the moderate correlation found between high levels of joint pain and poorer gait performance in the OA group, and the low correlation found in the group without the disease.

This study found that patients with OA had higher joint pain intensity and worse gait performance when compared to those without the disease, and also a correlation between overweight/obesity and high levels of pain intensity with worse gait performance in volunteers with a mean age of 59 years. However, evidence suggests that obese senior individuals with OA may have even greater repercussions on gait, due to osteo-myoarticular changes specific to ageing, and that the natural course of knee function may be associated with the subject's characteristics, such as BMI and age[60,61].

Thus, when both groups (with and without OA) were divided into: (up to 59 years old and 60 years old or more), significant differences in the three outcomes analyzed were observed: pain, TUG and DGI, always with the individuals with OA showing greater joint pain intensity and worse gait performance. The group with OA and 60 years or older had the highest joint pain intensity and the worst gait performance in this study.

These findings corroborate the results from study[62], which observed that BMI levels (>27kg/m2) were associated with a greater likelihood of pain, more so among the older adults with OA, as also was identified in the present study, although the mean BMI of the older adults with OA in this study was higher (31.7kg/m2). The same was true for gait; senior individuals with OA have shown worse gait performance, as assessed by the TUG and other instruments[63-65]. Older adults with symptomatic knee OA seem to adapt to an ankle kinematic gait pattern in order to avoid knee pain, thus increasing forward propulsion to minimize the load on the knee joint[66].

It is also worth noting that pain in the group with OA and 60 years or older had a mean intensity of 6.67±1.72, and the intensity of pain in the older adults is related to kinesiophobia[67]. This fact could explain the low score of older adults with OA in this study in gait-related functional tasks and lower functional mobility, probably due to the discomfort of their pain, or fear of this pain increasing during gait, the presence of kinesiophobia, fear of falling, or a combination of these aspects. However, no such analysis was carried out in this study, and these hypotheses could be investigated, proven or disproven by future studies on the subject.

Patients with and without OA in this study reported episodes of falls, and the prevention of falls is a very important measure to achieve when it comes to older adults[68], and through the results of the sample's gait performance, it is possible to identify the risk of falls for older adults in both groups. According to the study[69], the cut-off point for risk of falls on the TUG for Brazilian community-dwelling older adults is ≤12.47 seconds, and the present study observed that older adults without OA were at risk of falls, as the average performance on the TUG for this group was (19.6±5.82) seconds.

However, when observing the mean TUG score of the group of senior with OA, it is possible to notice that the risk of falls in these individuals is much higher. The cut-off point for falls in older adults with OA is ≤13.5 seconds[65] and the performance of the group of older adults with OA in this study on the TUG was 41.2±1.25, demonstrating how older adults with OA are a risk group for falls. These data support the volunteers' previous history of falls, reported during the assessments in this study, as shown in table 1.

Studies in the literature that assessed the risk of falls in older adults with or without OA using the DGI were not found. However, the TUG can be used as an indicator of functional capacity and a predictor of falls in senior individuals[70].

Overweight/obesity and high levels of joint pain intensity were predictors of poorer gait performance in individuals with OA. These outcomes should be considered by physiotherapists when rehabilitating the gait of individuals with OA. Regular physical exercise can significantly reduce the joint pain intensity and improve functional mobility in patients with OA[71,72]. It is advisable to practice physical exercises that include cognitive tasks, with moderate to high levels of instability and two to three hours of practice per week[73].

The main contribution of the present study was to provide gait assessment data for patients with OA using the DGI, since this data couldn't be found in the literature. The DGI is an instrument used worldwide to assess gait-related functional tasks, validated for the Brazilian population, and demonstrates gait performance in real everyday situations for these individuals, justifying the importance of publishing this data.

Limitations of this study include the fact that it was not possible to correlate gait with degrees of joint impairment, since this data was not available in the volunteers' medical records. This study assessed individuals assisted at UBS, limiting the results to this population only.

CONCLUSION

The OA individuals in this study had greater joint pain intensity and worse gait performance compared to those without the disease.

There was a correlation between overweight/obesity and high levels of joint pain intensity and poorer gait performance in OA volunteers, as well as a correlation between high levels of joint pain intensity and poorer gait performance in individuals with OA.

Volunteers with OA and aged 60 or over had the highest joint pain intensity and the worst gait performance in this study.

Pain intensity showed the highest correlation with the worst gait performance in the OA subjects in this study.

AUTHORS' CONTRIBUTIONS

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Data Collection, Writing - Preparation of the Original, Writing - Review and Editing
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Statistical Analysis, Project Management, Research, Writing - Preparation of the Original, Writing - Review and Editing, Supervision
Renato de Souza Melo
Statistical Analysis, Conceptualization, Methodology, Writing - Preparation of the Original, Writing - Review and editing, Supervision

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