ORIGINAL ARTICLE

Gait speed and functional performance in elderly women with knee osteoarthritis

Velocidade da marcha e desempenho funcional de idosas com osteoartrite de joelho

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Date of first submission: January 27, 2021
Last received: June 4, 2021
Accepted: August 6, 2021
Associate editor: Mariana Asmar Alencar Collares

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Abstract

Introduction: Knee osteoarthritis is a degenerative and inflammatory disease that causes skeletal muscle dysfunction and induces limitation of functional activities, such as gait. **Objective:** To assess the relationship between gait speed and functional performance in elderly women with knee osteoarthritis. **Methods:** 38 elderly women were divided into two groups: knee osteoarthritis group (KOAG) (n = 24, 68 ± 4.42) and control group (CG) (n = 14, 66.35 ± 3.54). Gait speed data was assessed through Qualisys system and functional performance through a checklist of the International Classification of Functioning, Disability and Health (ICF). **Results:** Comparing with CG ($p < 0.05$), KOAG patients had lower gait speed ($p = 0.004$) and worse functional performance in d4500 (walking short distances), d4501 (walking long distances), d4502 (walking on different surfaces), and d4503 (walking around obstacles) ICF categories. By associating gait speed and functional performance in KOAG, significant differences were found in the d4500 ($p = 0.019$) and d4501 ($p = 0.035$) categories, but none for either the d4502 ($p = 0.511$) or d4503 ($p = 0.076$) categories. Gait speed was negatively correlated with d4500 (rho = -0.585, p = 0.003), d4501 (rho= -0.552, p = 0.005), and d4502 (rho = -0,548, p = 0,006). **Conclusion:** Gait speed is related to functional performance in elderly women with knee osteoarthritis for the activities of walking short distances, walking long distances, and walking on different surfaces. However, it seems that gait speed is not related to walking around obstacles.

Keywords: Gait analysis. International Classification of Functioning, Disability and Health. Osteoarthritis.

Resumo

Introdução: *A osteoartrite de joelho (OJ) é uma doença degenerativa e inflamatória que causa incapacidade musculoesquelética, acarretando limitação de atividades funcionais como a marcha.* ***Objetivo:*** *Avaliar a relação entre velocidade da marcha e desempenho funcional em idosas com OJ.* ***Métodos:*** *Trinta e oito idosas foram divididas em grupo com osteoartrite de joelho (GOAJ) (n = 24, 68 ± 4,42) e grupo controle (GC) (n = 14, 66,35 ± 3,54) e avaliadas quanto à velocidade da marcha, utilizando o sistema Qualisys, e quanto ao desempenho funcional através de um checklist da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF).* ***Resultados:*** *GOAJ apresentou menor velocidade da marcha (p = 0,004) e pior desempenho funcional nas categorias da CIF d4500 (andar distâncias curtas), d4501 (andar distâncias longas), d4502 (andar em superfícies diferentes) e d4503 (andar contornando obstáculos) em comparação ao GC (p < 0,05). Ao associar velocidade da marcha e desempenho funcional do GOAJ, encontrou-se diferenças nas categorias d4500 (p = 0,019) e d4501 (p = 0,035), mas não em relação às categorias d4502 (p = 0,511) e d4503 (p = 0,076). Velocidade da marcha correlacionou-se negativamente com d4500 (rho = - 0,585, p = 0,003), d4501 (rho = -0,552, p = 0,005) e d4502 (rho = -0,548, p = 0,006).* ***Conclusão:*** *Existe relação entre velocidade da marcha e desempenho funcional de idosas com OJ quanto às atividades de andar distâncias curtas e longas e sobre superfícies diferentes; no entanto, a velocidade da marcha parece não interferir na atividade de andar contornando obstáculos.*

Palavras-chave: *Análise da marcha. Classificação Internacional de Funcionalidade, Incapacidade e Saúde. Osteoartrite.*

Introduction

Osteoarthritis (OA) is considered the second leading cause of physical dysfunction and the fastest advancing health condition among chronic diseases,[1] reported by the Brazilian Society of Rheumatology[2] as the main reason for disability in the musculoskeletal system.

Among the weight-bearing joints affected by the disease, the knee joint has the highest prevalence (37%) as it is located between two large levers (tibia and femur), lacks joint congruence between the femoral condyles and tibial plateau, and by accentuating joint misalignment (valgus/varus).[1,3]

Approximately 25% of individuals with knee osteoarthritis (KOA) cannot perform the main activities of daily living due to pain, muscle weakness, reduced balance, proprioceptive deficits, reduced joint motion range, and joint instability.[4,5] Among the possible limitations caused by KOA, difficulty in walking has great clinical relevance, as it is the most commonly performed functional activity, most often compromising the independence of individuals.[3]

The goal of investigating the lower gait speed[6-10] in individuals with KOA is to reduce the load imposed on the knee and consequently lessen the pain during walking.[6,7] Thus, variation in this spatiotemporal parameter can be a good indicator of functional limitation.[1,11-13]

In this context, the analysis of functionality in elderly people with KOA requires specific instruments to identify the population unable to carry out their activities. In view of this circumstance, in 2001 the World Health Organization (WHO) proposed the International Classification of Functioning, Disability and Health (ICF).[14] Some strategies to facilitate using the ICF have been implemented, such as the use of core sets or checklists, corresponding to a selection of a minimum of domains related to a specific health condition, capable of making the application of the ICF practical and comprehensive.[15]

It is crucially important to understand the relationship between the kinematic and functional gait analysis to provide a global view of gait and facilitate establishing a physiotherapeutic diagnosis consistent with the particular incapacities of the individual with KOA. Therefore, this study aims to assess the relationship between gait speed and functional performance in elderly women with KOA. It is expected that lower gait speed leads to worse functional performance in elderly women with KOA.

Methods

Design of the study

This is a pilot, cross-sectional, analytical, and quantitative study, involving a non-probabilistic sample. The study was designed according to the STROBE (Strengthening the reporting of observational studies in epidemiology) recommendations.[16]

Participants

Twenty-four elderly women (residents of Recife and respective metropolitan region) diagnosed with unilateral or bilateral knee OA, according to the clinical criteria of the American College of Rheumatology[17] (group with knee osteoarthritis - KOAG), and 14 asymptomatic elderly women with no history of alterations related to chronic-degenerative diseases in the lower limbs (control group - CG). Despite being among the criteria of the American College of Rheumatology[17] for diagnosing KOA, radiographic analysis was not applied to all KOAG participants, which hindered to identify whether the knee involvement was unilateral or bilateral.

The following inclusion criteria were considered: female individuals, aged between 60 and 80 years old, able to walk independently (without human assistance or using a mechanical device to aid mobility), and not frequent physical activity practice. In turn, the exclusion criteria ranged: unstable cardiovascular and/or respiratory diseases, cerebrovascular diseases, knee and/or hip arthroplasty, recent lower limb fractures, and lower limb amputations.

The study was approved by the Ethics Committee for Research with Human Beings at the Federal University of Pernambuco (UFPE) (Protocol: 2,224,111) and all participants signed the Informed Consent Form.

Procedures and instrumentation

Data collection was performed in a single day, at the Laboratory of Kinesiology and Functional Assessment (LACAF) of the Department of Physiotherapy at UFPE in Recife/PE, from October 2018 to April 2019.

Identification form

A form for sociodemographic and clinical data was elaborated and applied to obtain the patient's main data (age, weight, height, body mass index – BMI, comorbidities, and clinical criteria of the American College of Rheumatology[17]) to characterize the sample according to the groups.

ICF checklist

To assess the individuals functionality and incapacity, we developed a ICF checklist of codes specifically for the study encompassing the activity and participation components related to the walking domain, distributed into four categories. Both groups received the instrument as a structured questionnaire with the examiner recording the difficulties reported by the volunteers regarding walking short distances – less than 1 km (d4500), walking long distances – more than 1 km (d4501), walking on different surfaces – sloping or uneven (d4502), and walking around obstacles – in order to avoid objects or people (d4503).[14]

The activity and participation components have two qualifiers: performance and capacity. The former describes the activities and participation performed by the individual in their daily environment, influenced by environmental and personal factors, while the latter refers to the individual's ability to perform activities and participation, considering their intrinsic limitations, in a standardized environment. Both are scored from zero to four, according to the following classifications: 0 (no difficulty, 0-4%), 1 (mild difficulty, 5-24%), 2 (moderate difficulty, 25-49%), 3 (severe difficulty, 50-95%) and 4 (total difficulty, 96-100%), with the worst functional performance represented by the highest valuer.[14]

However, as functional performance refers to the tasks performed by the individuals in their daily lives, considering their day-to-day environment, our study analyzed only the performance qualifier proposed in the ICF.[18]

Gait speed analysis

To collect the gait speed data, we used the Qualisys ProReflex MCU motion analysis system (QUALISYS MEDICAL AB, 411 12 Gothenburg, Sweden) containing six cameras, allowing the reconstruction in three dimensions (3D) of passive reflective marks located in specific bony prominences.[19]

Before collecting the studied parameter, we calibrated the Qualisys system to allow generating data that determine the location and orientation of the cameras. The maximum residual error parameter was set at 3 mm.[19] Data were captured at a frequency of 80 Hz.

In addition to gait dynamics collection, the system requires to perform static collection with the individual in the standing position in order to generate the dynamic model on Visual 3D software (C-Motion Inc., Rockville, MD, USA). Reflective marks were placed over bony prominences located at the proximal and distal ends of the segments (anatomic marks). The constructed segments were pelvis, thigh, leg, and foot. The anatomical references for placing the markers included the sacrum and the following bilateral points: anterosuperior iliac spine, greater trochanter, lateral and medial epicondyle of the femur, tibial tuberosity, fibular diaphysis, lateral and medial malleolus, head of the 2nd and 5th metatarsals, distal phalanx of the hallux, and calcaneal tuberosity.

After receiving the instructions for the gait test, the volunteers were asked, through verbal stimulation, to walk barefoot on the established range at their usual speed. Data collection continued along the time required by the volunteer to walk for approximately five meters. Gait assessment included five trials, and after each collection, the data were verified for quality and stored for further analysis.

We processed the captured data on the Qualisys Track Manager 1.6.0.x (QTM) acquisition software by calculating the position of each mark in three dimensions. A polynomial interpolation was performed if the trajectory of the markers was lost for a maximum of 40 frames (0.5 seconds).[19] Subsequently, the data were transferred to the Visual 3D software for processing. From the anatomical marks, we designed the biomechanical model composed of the pelvis, thigh, leg, and foot (Figure 1).

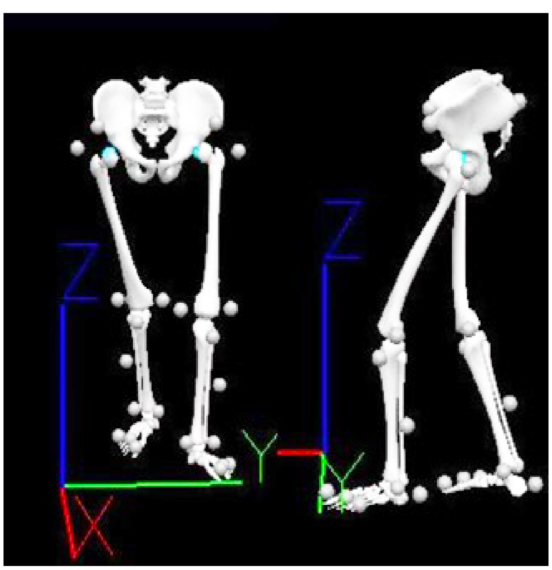

Figure 1 - View of the biomechanical model on 3D Visual software.

In the trajectories of the markers, a fourth-order low-pass digital filter was applied with the cutoff frequency set at 6 Hz to reduce noise resulting from moving the marks.[20] Afterwards, we calculated the step width in meters by identifying the first and second contacts of the same foot. Step width results from the subtraction between the final and initial values. The average gait speed was acquired by dividing the step width and the time interval, in seconds, with the speed established in meters per second.

Statistical analysis

For descriptive data analysis, we used the data of mean, standard deviation and frequency in percentage. The Kolmogorov-Smirnov test was used to verify the normality of the analyzed parameters. In cases of normality, we applied the t test for an independent sample to compare the KOAG and the CG, as well as the performance qualifiers by category regarding the gait speed variable. In cases in which normality was rejected, the Mann-Whitney test was applied. The ICF categories and their qualifiers between the KOAG and CG were compared through chi-square test. The association of gait speed and the ICF categories with KOAG qualifiers was assessed through an ANOVA One Way with *post-hoc*. Spearman's correlation test was applied to correlate gait speed and ICF categories.

We adopted the following classification to interpret the magnitude of the correlations: correlation coefficients (rho) < 0.5 (weak correlation), from 0.51 to 0.70 (moderate correlation) and from 0.71 to 0.9 (strong correlation). Positive correlation coefficients indicate direct correlation between two variables (increasing values of one variable are associated with increasing values of another variable), while negative correlation coefficients indicate inverse correlation between variables (increasing values of one variable are associated with decreasing values of another variable).[21] All data were analyzed with a significance level of $p < 0.05$, considering 95% confidence in all calculations, on the Statistical Package for the Social Sciences (SPSS) software version 20.0.

The sample size was based on gait speed measurements (primary outcome measure in this study), obtained in a pilot study (n = 14) and calculated on the G Power software, version 3.1.3 for Windows, considering a statistical power (β) of 80% and a two-tailed significance level (α) of 5%. Thus, when comparing the

ICF performance qualifiers, the calculations pointed to (i) no difficulty (1.1 ± 0.17), (ii) mild difficulty (1.04 ± 0.25), (iii) moderate difficulty (0.93 ± 0.1), (iv)) severe difficulty (0.92 ± 0.15), and (v) total difficulty (0.74 ± 0.22). Thus, a sample of 13 volunteers per qualifier would be required.

Results

Initially, 50 individuals were contacted and invited to participate in this study (Figure 2), out of which 12 individuals were excluded for various reasons. In total, 38 individuals showed interest in participating, being classified as KOAG (n = 24) and CG (n = 14).

Table 1 shows the characteristics of the study participants. The groups showed no differences regarding their anthropometric characteristics or age.

The mean value of all KOAG elements (0.88 ± 0.2 m/s) for gait speed showed a significant reduction in relation to the CG mean (1.09 ± 0.17 m/s, p = 0.004). In addition, the KOAG had higher performance qualifiers for the categories of walking short and long distances, walking over different surfaces, and walking around obstacles (p < 0.05), as shown in Table 2.

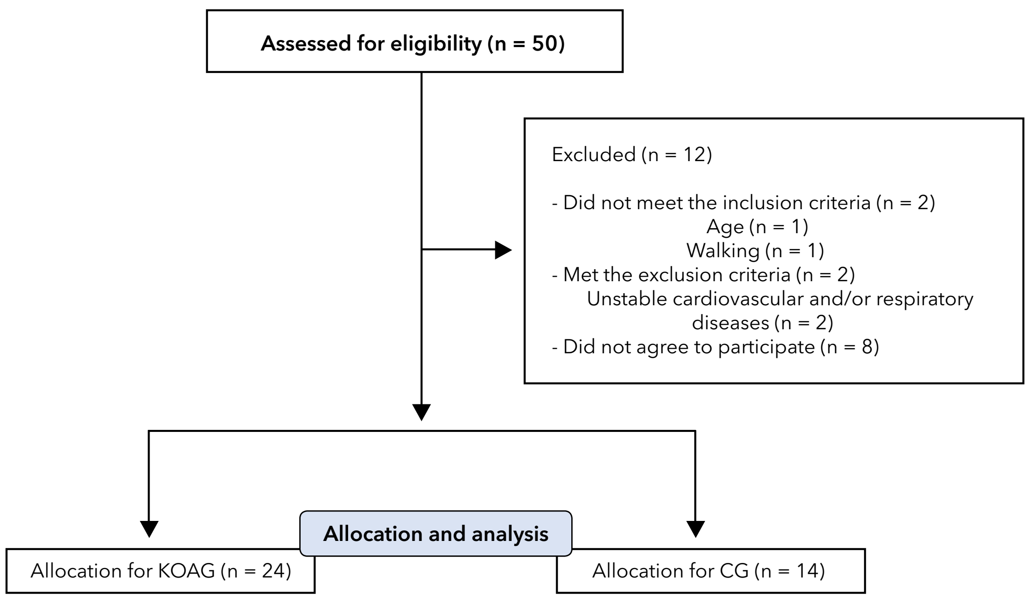

Figure 2 - Selection, exclusion, and inclusion flowchart of elderly women in the group with knee osteoarthritis (KOAG) and control group (CG).

Significant differences in gait speed were found in the KOAG for the performance qualifiers between the categories of walking short and long distances. No difference was found when associating gait speed with the category of walking on different surfaces (p = 0.076) or around obstacles (p = 0.511), as shown in Table 3.

KOAG showed an association between gait speed and the performance qualifiers in the category of walking short distances for the comparisons of: no difficulty and mild difficulty (p = 0.021), none and moderate difficulty (p = 0.038), none and severe difficulty (p = 0.023), none and complete (p = 0.016), and mild and total difficulty (p = 0.039). The qualifiers in the category of walking long distances also showed an association in the comparison of no and total difficulty (p = 0.006), as well as moderate and total difficulty (p = 0.026).

The KOAG correlation analysis found a moderate negative correlation between gait speed and the categories of walking over short (rho = -0.585, p = 0.003), long (rho = -0.552, p = 0.005) distances, and on different surfaces (rho) = -0.548, p = 0.006), while a non-significant correlation appeared to the category of walking around obstacles (rho = -0.352, p = 0.092).

Table 1 - Sample characterization

Variable	KOAG (n = 24)	CG (n = 14)	p-value
Age (years)	68 ± 4.42	66.35 ± 3.54	0.244[a]
Weight (kg)	74.32 ± 17.15	67.07 ± 14	0.873[a]
Height (m)	1.53 ± 0.05	1.53 ± 0.05	0.173[b]
BMI (kg/m^2)	31.71 ± 7.56	28.63 ± 5.6	0.226[b]

Note: KOAG = knee osteoarthritis group; CG = control group; BMI = body mass index. [a]T-test for independent sample; [b]Mann-Whitney test. Data expressed as mean ± standard deviation.

Table 2 - Distribution of KOAG (n = 24) and CG (n = 14) individuals according to the ICF qualifiers

Qualifiers	Groups	d4500	d4501	d4502	d4503
0	KOAJ	5 (20.8%)	2 (8.3%)	0 (0.0%)	9 (37.5%)
	CG	13 (92.9%)	13 (92.9%)	13 (92.9%)	14 (100.0%)
1	KOAJ	6 (25.0%)	4 (16.7%)	4 (16.7%)	6 (25.0%)
	CG	1 (7.1%)	1 (7.1%)	0 (0.0%)	0 (0.0%)
2	KOAJ	8 (33.3%)	2 (8.3%)	6 (25.0%)	4 (16.7%)
	CG	0 (0.0%)	0 (0.0%)	1 (7.1%)	0 (0.0%)
3	KOAJ	4 (16.7%)	9 (37.5%)	6 (25.0%)	4 (16.7%)
	CG	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
4	KOAJ	1 (4.2%)	7 (29.2%)	8 (33.3%)	1 (7.1%)
	CG	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	p-value	0.001*	<0.001*	<0.001*	0.006*

Note: KOAG = knee osteoarthritis group; CG = control group; ICF = International Classification of Functioning, Disability and Health; d4500 = walking short distances; d4501= walking long distances; d4502 = walking on different surfaces; d4503 = walk around obstacles. Qualifiers: 0 = no difficulty; 1 = mild difficulty; 2 = moderate difficulty; 3 = severe difficulty; 4 = total difficulty. p-value < 0.05 Chi-square test. Data expressed in number of individuals per qualifier (frequency in percentage).

Table 3 - Gait speed (m/s), categories, and ICF qualifiers in KOAG

Qualifiers	d4500	d4501	d4502	d4503
0	1.09 ± 0.13	1.16 ± 0.05	-	0.98 ± 0.19
1	0.87 ± 0.12	0.90 ± 0.19	1.03 ± 0.25	0.92 ± 0.13
2	0.86 ± 0.18	1.00 ± 0.12	0.94 ± 0.10	0.78 ± 0.29
3	0.77 ± 0.20	0.89 ± 0.17	0.91 ± 0.15	0.89 ± 0.17
4	0.49 ± 0.12	0.72 ± 0.18	0.73 ± 0.21	0.72 ± 0.18
p-value	0.019*	0.035*	0.076	0.511

Note: ICF = International Classification of Functioning, Disability and Health; KOAG = knee osteoarthritis group; d4500 = walking short distances; d4501= walking long distances; d4502 = walking on different surfaces; d4503 = walk around obstacles. Qualifiers: 0 = no difficulty; 1 = mild difficulty; 2 = moderate difficulty; 3 = severe difficulty; 4 = total difficulty.*p-value < 0.05 One Way ANOVA. Data expressed as mean ± standard deviation.

Discussion

The results of this pilot study demonstrate that individuals with KOA have impaired gait speed comparing with the group without the disease, in addition to the association of such biomechanical change with lower functional performance.

Even though changes in gait biomechanics occur with aging and are well established in the literature, in elderly people with KOA, these changes are more pronounced and negatively influence their functionality level.[8] Joint pain is the main symptom of the disease, associated with changes in the gait spatiotemporal parameters aimed at minimizing pain and protecting the knee joint.[8]

The elderly women from the KOAG group participating in this study had lower gait speed than those without the disease. According to White et al.,[22] elderly people with KOA are nine times more likely to have a faster decline in gait speed than elderly people without OA, reaching a 2.75% decrease in gait speed per year. According to Kaufman et al.[23] and Kim et al.,[24] individuals with KOA tend to walk at slower speeds to reduce joint stress on the knee joint and facilitate selecting the configuration of joint positions that produce less discomfort during gait. This means that lower gait speed would be a compensatory strategy adopted to minimize the functional demand on this joint. These studies,[22-24] however, do not specify whether the participants had unilateral or bilateral knee impairment or how this factor could interfere with gait speed.

The literature establishes an ideal value for gait speed as 1.2 to 1.4 m/s to perform functional tasks.[25] The gait speed of the elderly women in both our groups was below the safe threshold value; in addition, even lower in the KOAG, corroborating the findings by Gill et al.,[26] pointing to such lower speed as a risk factor for functional gait decline.

Studies have shown that the functional performance of individuals progressively declines after the third decade of life due to the physiological changes in aging, bringing significant functional limitations, especially regarding walking.[27,28] In contrast, Moraes[29] reports that the presence of functional decline cannot be attributed to normal aging but to the most frequent disabling diseases in elderly people.

In this sense, another relevant aspect of this study is that elderly women with KOA have higher performance qualifiers in the analyzed categories of the ICF than the elderly women without the disease, demonstrating even greater functional walking limitations for the group. Such result can be related to the presence of joint pain in individuals with OAJ mobility impairs, leading to disability and worsening of social integration.[28]

The association found in the KOAG between gait speed and the performance qualifiers in the categories of walking short and long distances demonstrates that lower gait speed leads to greater performance qualifiers, that is, stronger difficulty in walking short and long distances.

According to Camara et al.,[30] for every 0.10 m/s of gait speed reduction, the potential to perform daily instrumental activities, including walking, decreases by 10%. Therefore, the lower the gait speed the greater the functional limitation to walking, which may result in less independence.

Apparently, no significant differences were identified when associating gait speed with the category of walking on different surfaces or around obstacles in the KOAG. However, a larger statistical difference was found when comparing the qualifiers of mild and total difficulty for the category of walking on different surfaces.

Therefore, a moderate negative correlation can be assumed to occur between gait speed in the KOAG regarding the categories of walking short distances, long distances and on different surfaces. Gait speed seems to have little influence on the category of walking around obstacles based on the non-significant correlation found. However, our limited sample size possibly interfered with such result.

This study includes some limitations, as follows: a) use of a questionnaire for the data to classify the ICF performance qualifier instead of a direct analysis of activities related to gait, which may have either underestimated or overestimated some of the information found; b) neither the elderly women in the KOAG or those without KOA participating in the CG were subjected to radiographic assessment; in addition, it is possible that some of the individuals in the group were not aware of any mild structural deterioration associated with KOA; c) the degree of commitment in the KOAG was not assessed; d) participation restricted to female individuals, which prevents the results from reproducing in samples involving male individuals; e) inclusion of individuals with uni-and bilateral involvement in the KOAG and limited sample size, which could lead to result misinterpretations.

However, it is worth highlighting the innovative nature of this study for associating gait speed and functional performance in elderly women with KOA using the ICF "walking" activity categories. The association found suggests that gait speed can be used as a parameter to establish performance qualifiers in the assessed categories. Therefore, further studies addressing more expressive samples, perhaps associating functional performance with other kinematic variables, should be carried out to better understand such relationship.

Conclusion

We found an inverse relationship between gait speed and functional performance of elderly women with KOA regarding the activities of walking over short and long distances, as well as on different surfaces. However, gait speed does not seem to interfere with the activity of bypassing walking obstacles. Furthermore, we observed a decrease in speed and functional performance in elderly women with KOA in relation to elderly women without KOA. As KOA is a chronic-degenerative disease involving progressive gait changes, limiting functional performance, this study aims to contribute to direct physiotherapeutic interventions to treat the disease by identifying the relationships between gait speed and functional performance. Thus, physiotherapy can develop strategies aimed at gait training with greater emphasis on compromised functional categories.

Authors´ contributions

RCSO: substantial contributions to the design of the work; acquisition, analysis and interpretation of data for work; elaboration of the work. AVMI: Substantial contributions to data acquisition and analysis for the work; elaboration of the work. LS: Substantial contributions to the statistical analysis of data for work. MABR and CRV: contributions to the critical review of intellectual content. MACP: substantial contributions to the design of the work; supervision of data acquisition and interpretation; elaboration of the work; responsible for all aspects of the engagement, ensuring that issues relating to the accuracy or completeness of any part of the engagement are properly investigated and resolved. All authors approved the final version published here.

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