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Osteoarthritis grades no affects gait analysis in middle-age and elderly's women. A cross-sectional study

Los grados de osteoartritis no afectan el análisis de la marcha en mujeres de mediana edad y adultas mayores. Un estudio transversal

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Abstract. Aging is habitually related to modifications in the peripheral, central nervous and musculoskeletal systems. These modifications are frequently associated with mobility complications. It is currently considered that the spatiotemporal gait parameters (SGP) may be good functional indicators of the severity of knee osteoarthritis (KOA). Objective: to compare the SGP in middle-age and older women with different radiographic KOA diagnosis. Methods and materials: For this, ninety-nine (99) female participants (age: 61.0±3.0 years; body mass: 72.9±13.4 kg; height: 1.5±0.1 m; BMI: 31.2±5.7 kg/m^2) were enrolled in a cross-sectional design. All participants were classified according to the Kellgren-Lawrence radiological scale (None n=15; Doubtful n=24; Minimal n=22; Moderate n=20 and Severe n=18). All participants performed a 25-m walk test for which the SGP was measured (cadence, duration of monopodal support phase, and stride length). Results: No differences were observed in any SGP measures (cadence, p=0.57; monopodal support phase, p=0.65; and stride length, p=0.22). Conclusion: Our results showed that there is no agreement between the SGP and radiographic KOA diagnosis.
Keywords: gait analysis, knee osteoarthritis, musculoskeletal diseases, early diagnosis.

Resumen. El envejecimiento se relaciona habitualmente con modificaciones en los sistemas periférico, nervioso central y musculoesquelético. Estas modificaciones se asocian frecuentemente con complicaciones de movilidad. Actualmente se considera que los parámetros espaciotemporales de la marcha (SGP) pueden ser buenos indicadores funcionales de la severidad de la osteoartritis de rodilla (KOA). Objetivo: comparar los SGP en mujeres de mediana edad y adultas mayores con diferente diagnóstico radiológico de KOA. Métodos y materiales: Para esto, se inscribieron noventa y nueve (99) participantes femeninas (edad: 61±3.0 años; masa corporal: 72.9±13.4 kg; estatura: 1.5±0.1 m; IMC: 31.2±5.7 kg/m2). un diseño transversal. Todos los participantes fueron clasificados según la escala radiológica de Kellgren-Lawrence (Ninguna n=15; Dudosa n=24; Mínima n=22; Moderada n=20 y Severa n=18). Todos los participantes realizaron una prueba de caminata en 25 m para la cual se midió el SGP (cadencia, duración de la fase de apoyo monopodal y longitud de zancada). Resultados: No se observaron diferencias en ninguna medida del SGP (cadencia, p=0.57; fase de apoyo monopodal, p=0.65; y longitud de zancada, p=0.22). Conclusión: Nuestros resultados mostraron que no existe concordancia entre el SGP y el diagnóstico radiográfico de KOA.
Palabras claves: Análisis de marcha, osteoartrosis de rodilla, enfermedades musculoesqueléticas, diagnóstico precoz.

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Introduction

Osteoarthritis (OA) is a prevalent disease in the musculoskeletal system, with the knee being the most affected joint (Gauffin, Filbay, Andersson, Ardern, & Kvist, 2019). Subjects with knee osteoarthritis (KOA) show frequent pain and progressive joint deterioration, therefore KOA tends to decrease their ability to perform daily activities since walking capacity is compromised (Kopp, Furlough, Goldberg, Ring, & Koenig, 2021). Moreover, it can affect the lower limb movements, also worrying the quality of life (Goh et al., 2019), and increase the risk of falling (di Laura Frattura et al., 2018). Aspects that increase the risk of developing KOA include aging, overweight or obesity, and female gender (Lee et al., 2018), where women aged 55 years or older are more likely to develop KOA, which is mainly because they begin the menopausal period (Heidari, 2011).

An earlier and more accurate diagnosis increases the treatment efficiency, thus preventing disease progression (Almhdie-Imjabbar, Toumi, & Lespessailles, 2023; Lee et al., 2018). The diagnosis can be made through radiographic imaging, magnetic resonance imaging, and serum biomarkers (Iolascon et al., 2017). Of these methods, Kellgren-Lawrence radiographic imaging scale proposed by Kellgren and Lawrence (1957) can be applied to establish the degree of disease progression (grade 1 – doubtful; grade 2 – minimal; grade 3 – moderate; grade 4 – severe); where grade 2 is considered the onset of the disease (Kellgren & Lawrence, 1957; Kohn, Sassoon, & Fernando, 2016b). However, imaging diagnosis is static and therefore may fail to detect functional aspects of disease progression (Zeng et al., 2017). Furthermore, the mobility is one of the factors most affected by KOA (Goh et al., 2019; Kaufman, Hughes, Morrey, Morrey, & An, 2001), the existence of tests which measure physical capacity are essential to verify disease progression and treatment success (Dobson et al., 2013). However, Jordan et al. (2009) state that there is no gold standard test to measure physical function in patients with OA, and this fact makes it difficult to compare clinical findings.

In order to address the lack of standards for physical testing, the Osteoarthritis Research Society International proposes the 30-s chair-stand, 40-m fast-paced walk, and stair climb as the minimal core set to determine the hip or knee progression of the disease. In fact, KOA does affect biomechanical parameters of the knee joint (Astephen, Deluzio, Caldwell, & Dunbar, 2008), but to the best of our knowledge, few studies analyze knee gait patterns classified into levels 1 to 4 on the Kellgren-Lawrence scale. Zeng et al. (2017) observed that the severe KOA patients had higher medial translation when compared to the asymptomatic. However, it is possible that this analysis is biased since gender is a confounding variable regarding the deteriorating of the knee joint due to OA (Thati, 2021), where some studies have indicated that osteoarthritis is more frequent in women (Debi et al., 2009; Zhang et al., 2001), which is corroborated by Kiss (2011) where he demonstrated greater variability of SGP in women with OA versus men with OA where compared with Kellgren-Lawrance radiological scale in level 3 and 4. However, the data acquisition for this study was on a treadmill without incline and not in normal floor walking, where some studies that compared walking on a treadmill vs. floor walking showed differences in joint displacement, greater electromyography activity of quadriceps (Murray et al., 1985), and tendency to use a faster cadence (Vickery-Howe, Bonanno & Middleton, 2023) and shorter stride length (Vickery-Howe, Bonanno & Middleton, 2023) than during floor walking. Therefore, the purpose of the present study is to determine if there are differences between the biomechanical parameters of the knee SGP (cadence, single-leg stance phase and stride length) in middle-aged and older women with different radiological diagnoses of KOA (score scale 1, 2, 3 and 4). Kellgren-Lawrence). We hypothesized that women with a lower degree of disease by radiography would perform better on biomechanical measures.

Methods and materials

Experimental approach and participants' selection

This is a cross-sectional observational study designed to investigate whether there is linearity between the diagnosis of KOA by radiographic imaging and SGP analyzed in a 25 meters test. This study followed the STROBE checklist (https://www.strobe-statement.org/checklists/). For this, we included in analysis participants belonging to four cohorts of Family Health Medical Centers (CESFAM) in the metropolitan region of Santiago (Chile). The procedures followed in this study were approved by the ethics committees of the four CESFAM attended by the participants (*Vitacura* protocol 21062016, *Bicentenario* protocol 2886/11082016, *La Bandera* protocol 038/18082016 and *José Alvo* protocol 16012017). Lectures and information campaigns were initially held at the four CESFAM.

Based on the available literature (Kaufman et al., 2001; Zeng et al., 2017), we performed a representative analysis to determine the appropriate sample size based on the cadence, which was the main variable of SGP. To achieve 80% statistical power, a minimum sample size of 56 participants (14 in each group) would be necessary to detect a difference of 10 steps/min among groups (Granmo 5.2; IMIM, Barcelona, Spain). A total of 141 subjects who met the following inclusion criteria volunteered for the study: a) women 55-65 years old; b) submitted to diagnostic analysis for OA; c) who were beginning treatment for OA, or who had undergone treatment between 1-6 months (except the 'None' group) and; d) no help needed to perform the gait test. After applying the exclusion criteria (Figure 1), the final sample consisted of 99 participants (age: 61.0±3.0 years; body mass: 72.9±13.4 kg; height: 1.5±0.1 m; BMI: 31.2±5.7 kg/m^2), who were classified according to the radiographic analysis criteria for KOA described by Kellgren and Lawrence (1957). The sample size including the produced statistical power considered a confidence level of 95% and 5%, considering Chilean women in the 55-65 years old population. Figure 1 shows the participant selection and group composition.

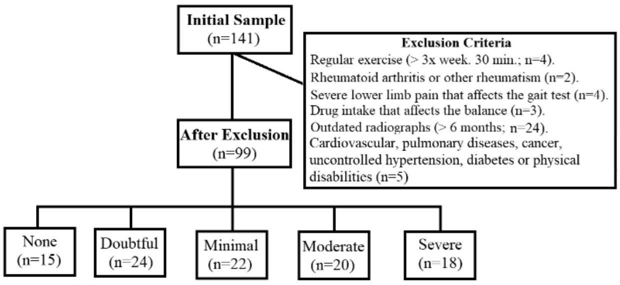

Fig. 1. Chart of participants' selection.

Functional performance in gait with accelerometer

Gait analysis was performed through a 25-meter walking test on smooth ground, free of objects and good illumination. A cone was placed at each end to determine the start and end of the track (Gacto-Sánchez, Lozano-Meca, Lozano-Guadalajara & Montilla-Herrador, 2023). The date was recorded using a triaxial accelerometer (antero-posterior AP, medio-lateral ML, and supero-inferior V) with multiple sensitivity (±2, ±4, ±8, ±16 g; G-Sensor®, BTS Bio-engineering, Italia) and sampling frequency of 100 Hz. It was attached to the participant's trunk (at L5-S1 vertebrae level) using a semi-elastic belt (Cimolin et al., 2017), the device transmits the frequency via Bluetooth to a computer.

All participants were instructed to walk at a normal speed. The variables obtained for gait analysis were: Cadence (steps/minute): the rate at which a participant walks (Gill & O'Connor, 2003); Monopodal Support Phase (%): percentage of cycle gait with monopodal support (Mansfield & Lyons, 2003); Stride Length (m): the longitudinal distance between successive ground contacts by the same foot (Gill & O'Connor, 2003). These values were calculated discounting the first and second strides of the gait test, and then the values were averaged to obtain a single value. Figure 2 presents the test application scheme.

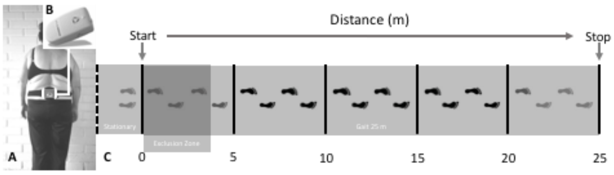

Figure 2. Testing schematic. Ubication accelerometer L5-S1 (A). Triaxial accelerometer Gsensor® (B). 25-m walking track.

Statistical analysis

We initially performed an exploratory data analysis. The Kolmogorov-Smirnov test verified normality, One-way ANOVA (SPSS 20.0) was performed to compare the groups, and Bonferroni post-hoc was applied when necessary. Eta-squared (η2) was applied to estimate the magnitude of the effects. The level of significance was set at $p<0.05$.

Results

To avoid biases regarding the time of diagnosis and disease progression, all participants in this study had between 1 and 6 months of treatment. Furthermore, data on body mass index and unilateral or bilateral presence of OA were compared (Table 1). There was no significant difference for the BMI (F=1.42; p=0.17; η2=0.03) and uni or bilateral occurrence for OA (χ^2=3.568; p=0.31).

Table 1.
Body mass index and uni or bilateral frequency for OA.

			Osteoarthritis grade		
Variable	None	Doubtful	Minimal	Moderate	Severe
BMI (kg/m^2)	29.6±4.2	28.7±4.3	31.1±3.9	34.7±6.6	32.7±7.2
Bilateral	-	n=13 (54,2%)	n=16 (72,7%)	n=9 (45.0%)	n=11 (61,1%)
Unilateral	-	n=11	n=6	n=11	n=7

BMI – body mass index.

Table 2 presents the results for gait analysis for the control group (None) and the four osteoarthritis grades. There was no significant difference for the Cadence (F=0.73; p=0.57; η2=0.01); Monopodal support phase (F=0.61; p=0.65; η2=0.01); or Stride Length (F=1.44; p=0.22; η2=0.03).

Table 2.
Spatiotemporal gait parameters for four osteoarthritis grades. Data showed by mean ± standard deviation (95%CI)

	Osteoarthritis grade				
Variable	None	Doubtful	Minimal	Moderate	Severe
Cadence (steps/min)	112.7±12.5 (105.8-119.6)	110.4±8.2 (106.9-113.9)	113.3±7.9 (109.8-116.8)	114.3±7.8 (110.6-117.9)	115.1±13.0 (108.7-121.6)
Monopodal Support Phase (%) *	39.1±2.1 (37.9-40.2)	38.8±1.9 (38.0-39.6)	38.9±3.3 (37.5-40.4)	39.3±2.0 (38.4-40.2)	39.9±2.1 (38.8-40.9)
Stride Length (m)	1.4±0.1 (1.4-1.5)	1.4±0.1 (1.4-1.5)	1.5±0.2 (1.4-1.5)	1.4±0.1 (1.3-1.4)	1.4±0.1 (1.3-1.4)

* % = cycle gait with monopodal support.

Discussion

Osteoarthritis represents more frequently problems in musculoskeletal system (Almhdie-Imjabbar et al., 2023; di Laura Frattura et al., 2018; Kopp et al., 2021) and affect biomechanical of the knee joint (Astephen et al., 2008). Due to the impact of the disease on the health and quality of life of patients, some treatments have been proposed as exercise physical (Masyitah, Mashudi, Tumanggor, & Fadriyanti, 2024), platelet-rich plasma (Elik, Doğu, Yılmaz, Begoğlu, & Kuran, 2020), local muscle vibration (Rabini et al., 2015), hyaluronic acid (Thakker, Sharma, Johnson, & Dias, 2023) and ozone (de Sire et al., 2020), to decrease the inflammatory state and pain (Kopp et al., 2021). Studies show that diagnosis by radiography is a good predictor of pain and impaired of gait (Kaufman et al., 2001; Elbaz et al., 2012; Taş, Güneri, Baki, Yildirim, Kaymak, & Erden., 2014; Kohn, Sassoon, & Fernando, 2016a; Teo, Hinman, Egerton, Dziedzic, & Bennell, 2019). However, a systematic review (Bedson & Croft, 2008) shows that there may be disagreements between the diagnose by imaging, knee pain and disabilities. These authors suggest that radiography should not be used alone for the diagnosis of OA. This imprecision suggests that new protocols should investigate whether radiographic images can predict OA progression. Zeng et al. (2017) observed in a mixed sample that the degree of AO affects some parameters in a 3D kinematic gait analysis, while that for Kiss (2011) showed the variability of SPG values associated with knee OA is gender-dependent being higher in women, but in this last study the assessment was carried out on a treadmill without incline and barefoot subjects, which presents differences in joint displacement, electromyography activity, cadence and stride length (Vickery-Howe, Bonanno & Middleton, 2023) compared to walking floor. The main findings of our study indicate our hypothesis was refuted, despite the descriptive difference in terms of the main SPG of the four groups investigated (doubtful, minimal, moderate and several), these differences are not representative. In fact, our data suggest that people with different osteoarthritis grades do not have distinct SGP values in walking floor. According to Astephen et al. (2008), the pathomechanics aspects of OA are not yet fully understood. Different studies have attempted to establish an agreement between the degree of osteoarthritis and knee biomechanical variables (Debi et al., 2009; Elbaz et al., 2012; Kaufman et al., 2001); however, it is difficult to associate changes in the biomechanical pattern and OA (Zeng et al., 2017). One hypothesis would be compensatory adjustments, possibly muscle, as the disease progresses (Astephen et al., 2008). In this line, Zeng et al. (2017) observed that the OA severity result in a lower anterior/posterior translation of the heel. However, the cadence analysis indicated a similar frequency (102.8±14.7 steps/min) when compared to the results of Debi et al. (2009) in a women group with KOA (age 67.5±9.8 yrs.). This similarity could be related to the higher equivalence of the distribution of the severity of OA in the subjects (17.1% grade I; 22.4% grade II; 31.6% grade III and 28.9% grade IV). Staab et al. (2014) observed a lower cadence (97.8±11.5 steps/min); however, the control group (116.3±7.4 steps/min) was similar to our study, and probably these differences may be related to the older age of the participants (Hollman, McDade, & Petersen, 2011).

Another possible explanation for the discrepancy between SGP and radiographic diagnosis is associated with limited information obtained by imaging. The knee has 3 compartments, however, the radiograph only shows the anteroposterior view, thus losing the ability to perform a mediolateral analysis (Bedson & Croft, 2008; Guermazi, Roemer, Burstein, & Hayashi, 2011). Therefore, radiography alone can result in a false positive. On the other hand, our gait analysis, which was performed by accelerometry, allows a triaxial assessment of knee movement. Taken together, our results show that the diagnosis of OA can become more accurate if accompanied by gait analysis with SPG parameters. Due this limitation, Guermazi et al. (2011) recommend that magnetic resonance be used as an imaging tool, as traditional radiography is limited in providing a clear visualization of joint space narrowing, which is considered an interesting marker of cartilaginous tissue loss. Following this line, the narrative review of Almhdie-Imjabbar et al. (2023), points out that evaluation using the Kellgren-Lawrence scale is limited as a diagnostic tool for KOA.

The monopodal support phase percentage in this study is considered to be normal values (Elbaz et al., 2012), as other similar studies with osteoarthritic patients also showed similar values (Debi et al., 2009; Elbaz et al., 2012), where it is necessary to mention that this support phase, in these studies, is a continuous movement without leaving inertia (Whittle, 2007). The stride length is also similar to the other assessment variables in this study, so it does not show the difference in osteoarthritic level regarding gait, this no difference can be explained by the similar height of the sample (6% CV), which is a determining factor in the lower limbs length (Moshkdanian et al., 2014; Biswas et al., 2022). However, A. Elbaz et al. (2014) observed that gait analysis of spatiotemporal stride length was the main discriminatory variable and the cadence represented the secondary parameter, which separated the osteoarthritic groups from the knee. It could be argued that the discrimination capacity of the classification grades and of the present study could be related to differences in the size and age of the study sample (n=99, age 61±3 yrs.) and that of A. Elbaz et al. (2014) (n=1701, age 60.5±16.5 yrs.). Contrasting our results, Astephen et al. (2008) observed differences between biomechanical patterns, but only the cases of severe OA differed from the other groups.

Our study did not show significant differences for variable BMI, unlike other studies (Ferrari et al., 2024; Jordan et al., 2009; Kaufman et al., 2001). However, in the study conducted by Ferrari et al. (2024), where the BMI showed a good relation with OA, there was only a better relation between the WOMAC index and BMI. The WOMAC index is a perception questionnaire of OA in three domains: pain, stiffness, and physical incapacity. Nevertheless, there are better assessments to determine OA, such as a radiological scale. Obesity is a relevant factor that could increase the risk of knee osteoarthritis (Samma et al., 2021). However, this association makes sense when patients lose mobility and functionality in tasks such as walking (Houck, 2023), which our study did not demonstrate. We propose that obesity may be an effect of osteoarthritis due to low physical activity and energy imbalance (Dhurandhar et al., 2021) and not a cause.

Among the limitations of our results, the absence of time for OA diagnosis and the use of some kinematic measures is highlighted. We understand that differences could be observed in a deeper analysis, which may be the object of future investigations. In conclusion, we found that women who have different OA classification by radiography (Kellgren-Lawrence radiological scale) showed the same performance for SGP measures (cadence, monopodal support phase and stride length) obtained in the 25 m walking track test. In conclusion, our results support previous studies that do not recommend the use of radiographic imaging as an isolated method for diagnosing OA.

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