KNEE OSTEOARTHRITIS AND AGING: EVALUATION OF THE DIFFERENT MUSCLES OF THIGH

OSTEOARTRITE DE JOELHO E ENVELHECIMENTO: INVESTIGAÇÃO DE DIFERENTES MÚSCULOS DA COXA

ARTROSIS DE RODILLA Y ENVEJECIMIENTO: INVESTIGACIÓN DE LOS DIFERENTES MÚSCULOS DEL MUSLO

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ABSTRACT

Introduction: Osteoarthritis (OA) is a chronic inflammatory degenerative disease, characterized by progressive degeneration of the articular cartilage, affecting mostly the knee joint. The elderly population is the most affected, intensifying the aging process. The concentration of intramuscular adipose tissue in the thigh muscles and knee OA at different ages remains under investigation. Objective: Investigate the cross-sectional area of thigh muscles at different ages with the relationship of the presence of intramuscular fat and knee OA. Methods: 80 participants were paired into 4 groups: Young Osteoarthritis Group and Old Osteoarthritis Group, both sedentary with knee OA diagnosis II or III; Healthy Young Group and Healthy Old Group, both healthy and sedentary. The groups were paired according to gender and body mass index, submitted to physiotherapeutic evaluation, WOMAC questionnaire, knee X-ray and thigh CT scans. Morphometric analysis was performed manually with ITK-SNAP software (version 3.6), by a single evaluator. Statistical analysis used the one-way ANOVA test followed by Bonferroni post-hoc for dependent variables ($p \leq 0.05$). Results: Comparison of the cross-sectional area of the rectus femoris, vastus lateralis, semitendinosus, sartorius and gracilis muscles between the groups indicated no significant differences ($p > 0.05$). The study of attenuation for muscle adipose tissue indicated no significant difference in the values of between the OA-Young and Aged-S groups for all the muscles evaluated. Conclusion: Young individuals with knee OA present muscle morphological characteristics similar to those found during the aging process, characterizing early aging of the thigh muscles. ***Level of Evidence III; Retrospective cross-sectional and observational study.***

Keywords: Knee Joint; Fats; Tomography; X-Ray Computed; Aging; Osteoarthritis.

RESUMO

Introdução: A osteoartrite (OA) é uma doença inflamatória crônico-degenerativa, caracterizada pela degeneração progressiva da cartilagem articular, acometendo em maior parte a articulação do joelho. A população idosa é a mais atingida, intensificando o processo de envelhecimento. A concentração de tecido adiposo intramuscular nos músculos da coxa e a OA de joelho em diferentes idades permanece em investigação. Objetivo: Investigar a área de secção transversa dos músculos da coxa em diferentes idades com a relação da presença de gordura intramuscular e OA de joelho. Métodos: 80 participantes foram pareados em 4 grupos: Grupo Osteoartrite Jovem e Grupo Osteoartrite Idoso, ambos sedentários com diagnóstico de OA de joelho II ou III; Grupo Jovem Saudável e Grupo Idoso Saudável, ambos saudáveis e sedentários. Os grupos foram pareados de acordo com sexo e índice de massa corporal, submetidos à avaliação fisioterapêutica, questionário WOMAC, exames de raio-x dos joelhos e tomografia computadorizada da coxa. A análise morfométrica foi realizada manualmente com software ITK-SNAP (versão 3.6), por um único avaliador. Análise estatística utilizou o teste ANOVA one-way seguido pelo post-hoc de Bonferroni, para variáveis dependentes ($p \leq 0,05$). Resultados: A comparação da área de secção transversa dos músculos reto femoral, vasto lateral, semitendinoso, sartório e grácil, entre os grupos, não indicou diferenças significativas ($p > 0,05$). O estudo da atenuação para o tecido adiposo muscular não indicou diferença significativa nos valores de entre os grupos OA-Jovem e Idoso-S para todos os músculos avaliados. Conclusão: Indivíduos jovens com OA de joelho apresentam características morfológicas musculares semelhantes às encontradas durante o processo de envelhecimento, caracterizando um envelhecimento precoce dos músculos da coxa. **Nível de Evidência III; Estudo retrospectivo transversal e observacional.**

Descritores: *Articulação do Joelho; Gorduras; Tomografia Computadorizada por Raios X; Envelhecimento; Osteoartrite.*

RESUMEN

Introducción: La artrosis (OA) es una enfermedad inflamatoria degenerativa crónica, caracterizada por la degeneración progresiva del cartílago articular, que afecta principalmente a la articulación de la rodilla. La población anciana es la más afectada, intensificándose el proceso de envejecimiento. La concentración de tejido adiposo intramuscular en los músculos del muslo y la OA de rodilla a diferentes edades sigue siendo objeto de investigación. Objetivo: Investigar el área transversal de los músculos del muslo a diferentes edades con la relación de la presencia de grasa intramuscular y la OA de rodilla. Métodos: Se emparejó a 80 participantes en 4 grupos: Grupo de jóvenes con osteoartritis y Grupo de mayores con osteoartritis, ambos sedentarios y con diagnóstico de OA de rodilla II o III; Grupo *de jóvenes sanos y Grupo de mayores sanos, ambos sanos y sedentarios. Los grupos fueron emparejados según sexo e índice de masa corporal, sometidos a evaluación fisioterapéutica, cuestionario WOMAC, exámenes radiográficos de las rodillas y tomografía computarizada del muslo. El análisis morfométrico se realizó manualmente con el software ITK-SNAP (versión 3.6), por un único evaluador. En el análisis estadístico se utilizó la prueba ANOVA unidireccional seguida del post-hoc de Bonferroni para las variables dependientes (p≤0,05). Resultados: La comparación del área transversal de los músculos recto femoral, vasto lateral, semitendinoso, sartorio y gracilis entre los grupos no indicó diferencias significativas (p>0,05). El estudio de la atenuación para el tejido adiposo muscular no indicó diferencias significativas en los valores de entre los grupos OA-Young y Aged-S para todos los músculos evaluados. Conclusión: Individuos jóvenes con OA de rodilla presentan características morfológicas musculares similares a las encontradas durante el proceso de envejecimiento, caracterizando el envejecimiento precoz de los músculos del muslo.* ***Nivel de Evidencia III; Estudio transversal y observacional retrospectivo.***

Descriptores: *Articulación de la rodilla; Grasas; Tomografía Computarizada por Rayos X; Envejecimiento; Osteoartritis.*

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INTRODUCTION

Osteoarthritis (OA) is a chronic degenerative inflammatory joint disease characterized by the degeneration of articular cartilage and impairment of adjacente tissues.[1] Among the body's joints, the knee stands out as one of the most affected,[2,3] resulting in several functional, social, and economic consequences.[4]

Muscle tissue is one of the most affected by the presence of OA.[5] Moreover, the increased presence of adipose tissue in the muscle belly (intramuscular fat) and between muscle bundles (intermuscular fat) has been related to reduced ability to produce muscle strength and physical function.[6]

Studies have shown, through tomography images, that the amount of intramuscular fat infiltration may affect the mass of musculoskeletal structure and, consequently, the muscular performance and mobility of the muscle group involved.[7] Therefore, as a way of analyzing the relationship between muscle weakness and aging, it is necessary to investigate which components of the muscles lead to this functional loss[8] and what other factors related to this process can be similar to the development of knee OA.[9] Currently, there are no studies in the literature that investigate these components.

Santos et al. (2011),[10] in a study comprising 80 elderly women diagnosed with knee OA, evaluated strength, endurance, and muscle balance using an isokinetic dynamometer. The authors concluded that in the aging process, important changes occur in the cross-sectional area, such as a decrease in muscle mass and an increase in the concentration of intramuscular adipose tissue. Therefore, although the changes that occur in the composition of muscles during the aging process are known, it is not yet clear how knee OA can intensify them.

The similarity between the aging process and the risk factors related to knee OA may be a hypothesis for the relationship between the disease and the observed changes over time in adults and elderly individuals. Thus, the decrease in muscle mass and the increase in intramuscular fat infiltration are conditions related to both the presence of knee OA and the aging process.[11] Recent studies have listed several predisposing factors to knee OA and aging-related changes in the cross-sectional area of the thigh muscles. However, it is also necessary to investigate the concentration of intramuscular adipose tissue in different thigh muscles.

Therefore, the aim of this study was to evaluate and compare the cross-sectional area and muscle attenuation of different thigh muscles in individuals with and without knee OA, distributed across different age groups.

METHODS

The evaluations were performed at the Joint Function Analysis Laboratory (LAFAr) of the Physiotherapy Department of the Federal University of São Carlos (UFSCar), and imaging tests were performed at the University Hospital (HU) in São Carlos, São Paulo.

A total of 80 participants of both sexes were included in the study, divided into four groups matched by gender and body mass index. Participants aged between 40 and 50 years old, sedentary, and clinically diagnosed with knee OA grade II or III by radiography were allocated to the Young Osteoarthritis Group. Participants aged 70 years or older, sedentary, and clinically diagnosed with knee OA grade II or III by radiography were allocated to the Elderly Osteoarthritis Group. Individuals aged between 40 and 50 years old, sedentary, and healthy were allocated to the Young Healthy Group, and individuals aged 70 or over, sedentary, and healthy were allocated to the Elderly Healthy Group. The research project was publicized through local media, social networks, the University's website, and radio in the city of São Carlos. Participants were contacted by phone calls, email, or face-to-face visits.

This project was submitted and approved by the Research Ethics Committee on Human Beings of the Federal University of São Carlos-SP (CAAE: 64171617.9.0000.5504). The participants were informed about the procedures to which they would be submitted and, after agreeing to participate, signed a consent form free and clear. The work was carried out in accordance with the norms of Resolution 466/2012 of the National Health Council on research involving human beings.

The study included participants between 40 and 50 years of age and ≥70 years of age in good health, and participants in the same age group who had a radiographic diagnosis of unilateral or bilateral knee OA, grade II or III, according to the criteria of Kellgren and Lawrence (1956) (12) and the American College of Rheumatology (2000). For participants with bilateral knee OA, the most symptomatic side was used for assessment.

The exclusion criteria were the same as those previously described by Aily et al. (2019).[13]

Experimental procedure

On the first visit, held at LAFAr/UFSCar, participants underwent a physiotherapeutic assessment consisting of inspection, palpation, strength tests, flexibility, and range of motion (ROM) of the knee and hip, in addition to tests for assessing ligament integrity. Subsequently, the participants were instructed and familiarized with the experimental procedures to be performed. They completed an evaluation form and the informed consent form. On this same visit, the participant received a referral to perform an X-ray examination of the knees. The second visit was scheduled after the diagnosis and classification of OA through radiography. In this visit, the participants underwent a body composition exam (Dual-Energy X-Ray Absorptiometry) and the application of the questionnaire.

The radiographic examination was performed bilaterally in posteroanterior views with the knee semiflexed (45°) with weight bearing (orthostatic position), axial to the patellofemoral joint[14] and profile or lateral, in the supine position at 45° of flexion of the knee. Knee OA classification was performed by a radiologist who was a collaborator of this study according to the criteria of Kellgren & Lawrence (1956) and from the American College of Rheumatology (2000).

To assess pain, joint stiffness, and physical function, a questionnaire called WOMAC (Western Ontario and McMaster Universities) was used. The questionnaire consisted of 24 self-reported questions based on information from the 48 hours prior to the application. The questionnaire is divided into three domains: pain, stiffness, and physical function, and the score is determined using a Likert-type scale.[15] The final score was obtained by taking the maximum score in each domain, with a higher score indicating worse outcomes.

Thigh images were obtained using a Multislice CT scanner (Brilliance CT 16-slice, Philips) at the University Hospital of UFSCar. The exam was performed by a specialized professional under the supervision of a radiologist.

To acquire the images, criteria from the Eastwood study were used.[16] The suggested protocol provided an image of the mid-thigh of the most affected leg or one chosen at random. The images of thigh muscles were obtained using a 5 mm thick cut, halfway between the greater trochanter and the intercondylar notch of the femur.

Muscle areas were analyzed manually by a single evaluator who had been trained using the ITK-SNAP software (version 3.6). The area of interest was selected based on the desired tissue attenuation rate (in mm2). The attenuation rate for intramuscular adipose tissue (IMAT) corresponded to the range from -190 to -30 Hounsfield units (HU).[17]

Inter-rater and test-retest reliabilities were calculated with 10 participants on two different days. The intraclass correlation coefficients for the rectus femoris, vastus lateralis, semimembranosus, semitendinosus, gracilis, long head biceps, sartorius, and adductor magnus and longus were 0.971, 0.865, 0.794, 0.675, 0.986, 0.992, 0.916, and 0.909, respectively.

Statistical Analyses

The data were analyzed using the Statistical Package for the Social Sciences software version 20.0 (SPSS Inc, Chicago, IL, USA). Descriptive analyses of the studied variables were initially performed using the mean, standard deviation, and coefficient of variation. Subsequently, normality and homogeneity of variances were assessed using the Kolmogorov-Smirnov and Levene tests, respectively.

If a normal distribution was not observed, the data were transformed to enable the application of parametric tests. One-way ANOVA was used to compare the dependent variables between groups, followed by Bonferroni's post-hoc test. A significance level of 5% ($p \leq 0.05$) was used for all analyses.

RESULTS

Table 1 summarizes the sample characteristics and anthropometric variables of the osteoarthritis groups and the control group. No significant difference was found between groups regarding BMI and total WOMAC score ($p>0.05$). The cross-sectional area and muscle attenuation of the thigh muscles are described in Table 2.

Table 1. Participant Characteristics.

	Osteoarthritis Groups		Healthy Groups	
	Young (n=20)	Elderly (n=20)	Young (n=20)	Elderly (n=20)
Age (years)	45.35 (2.70) a	74.35 (2.82) b	45.20 (3.75) c	74.60 (3.12)
Age group (years)	40-50	70-80	40-50	70-80
KOA unilateral	8	5	-	-
KOA bilateral	12	15	-	-
Body mass index (kg/m^2)	26.79 (2.73)	27.21 (2.95)	26.02 (3.30)	25.41 (3.02)
WOMAC total, un	37.90 (18.07)	69.15 (16.44)	-	-

Abbreviations: KOA, knee osteoarthritis; DXA, Dual energy x-ray absorptiometry. All values are expressed as mean (SD); a $p<0.05$, significantly different compared to the Elderly-OA group. b $p<0.05$, significantly different compared to the Young-H group. c $p<0.05$, significantly different compared to the Elderly-H group.

Rectus Femoris

The cross-sectional area of the rectus femoris muscle did not differ between the groups ($p>0.05$). However, the average muscle attenuation of the Young-H group showed the highest values of muscle density compared to the other three groups, while the Elderly-OA group had the smallest. Finally, the Young-OA and Elderly-H groups did not present significant differences.

Vastus Lateralis

There was no difference between groups for the cross-sectional area of the vastus lateralis muscle ($p>0.05$). However, the mean muscle attenuation of the Young-H group showed the highest values of muscle density compared to the other groups, while the Elderly-OA group had the smallest. However, the Young-OA and Elderly-H groups showed no significant differences.

Semitendinosus

The cross-sectional area of the semitendinosus muscle also showed no difference between the groups ($p>0.05$). However, the analysis of the mean muscle attenuation showed that the Young-H group obtained the highest muscle density values among the groups, and the Elderly-OA group, the smallest. However, the Young-OA and Elderly-H groups showed no significant differences.

Biceps Femoris (Long Head)

The cross-sectional area of the long head of the biceps muscle of the Young-OA group showed significant differences when compared to the Elderly-OA group ($p<0.05$). The average muscle attenuation of the Young-H group was the highest for muscle density among the groups, while the Elderly-OA group had the lowest. The Young-OA and Elderly-H groups did not show significant differences between them.

Sartorius

The cross-sectional area of the sartorius muscle did not differ between the groups ($p>0.05$). On the other hand, the average muscle attenuation of the Young-H group showed the highest values for muscle density in relation to the other groups, while the Elderly-OA group had the lowest. The Young-OA group obtained significantly different results when compared to the Elderly-OA group ($p<0.05$), and the Elderly-OA group also showed different results when compared to the Young-H group.

Gracilis

For the cross-sectional area of the gracilis muscle, there was no difference between the groups ($p>0.05$). However, the mean muscle attenuation of the Elderly-OA group was significantly lower in relation to the Young-H group. In addition, the highest average of muscle attenuation found was that of the Young-H group, and the lowest was from the Elderly-OA group.

Adductor Magnus and Longus

The cross-sectional area of the adductor magnus and longus muscles of the Young-OA group were significantly different when compared to the Elderly-OA group. The mean muscle attenuation of the Young-H group was the highest, while the Elderly-OA group was the lowest.

Semimembranosus

For the cross-sectional area of the semimembranosus muscle, it was found that the Elderly-OA group had significantly different results in relation to the Young-H group. The Young-H group also had different results when compared to the Elderly-OA group. The muscle attenuation area of the Young-H group had the highest value for muscle density, while the Elderly-OA group had the lowest. (Table 2)

DISCUSSION

To the best of the authors' knowledge, this is the first study to investigate the relationship between intramuscular fat infiltration in the presence or absence of knee OA in different age groups. The main findings occurred between the Elderly-H and Young-OA groups, where there were no differences in muscle attenuation between these groups in different thigh muscles.

The findings of the present study demonstrate a similarity between the amount of muscle fat infiltration during the physiological aging process and the presence of early knee OA. In this sense, there was no difference between the Young-OA and Elderly-H groups for all assessed muscles. In a similar vein, AILY et al. (2018)[13] analyzed the architecture and muscle strength of 80 individuals with and without knee OA who were allocated into the following groups: Middle Age Healthy (40-50 years old), Middle Age with OA (40-50 years old), Elderly Healthy (70-80 years old), and Elderly with OA (70-80 years old). The authors indicated that there were no differences between the Middle Age with OA and Elderly Healthy groups for any of the described variables (pennation angle, fascicle length, muscle thickness, and isometric strength). Thus, the authors suggest that the presence of knee OA may be associated with early muscle changes similar to those observed in the aging process. The aging process is linked to marked changes in body composition, characterized by a significant increase in body fat mass and a decrease in skeletal muscle mass. Previous studies reported that musculoskeletal changes related to aging can be observed through the reduction in the values of muscle attenuation.[18] Thus, the present study corroborates the findings of the literature and demonstrates that not only aging but also the presence of knee OA influence the musculoskeletal system.

Differences in muscle attenuation values found between the Young-OA and Elderly-OA groups were important findings in this study, as the results varied across the evaluated muscles. In a study conducted by Ikeda et al. in 2005,[18] CT scans of middle-aged (approximately 30 years old) and elderly women (above 60 years old) were analyzed to compare the values obtained for possible morphological alterations. The elderly group had smaller cross-sectional areas of the quadriceps and lower values of muscle density than the middle-aged group. Therefore, the present study supports the findings of Ikeda et al. (2005), which describe higher values of muscle attenuation in young people when compared to elderly individuals, regardless of the presence of OA in the knees. It is worth highlighting the limitations of the present study, such as the impossibility of analyzing tomography images of all thigh muscles due to the reduced quality of the acquired images in some samples. The greatest measurement difficulty was found for the adductor brevis and short head of the biceps femoral muscles.

Table 2. Cross-sectional area and muscle attenuation of thigh muscles.

	Osteoarthritis Groups		Healthy Groups	
	Young (n=20)	Elderly (n=20)	Young (n=20)	Elderly (n=20)
Rectus Femoris				
Area, mm^2	702.3 (178.4)	677.6 (163.5)	719.1 (166.7)	698.9 (185.6)
Average muscle attenuation, HU	46.9 (3.3) a	42.2 (35.5) b	51.9 (4.5) c	47.5 (4.7)
Vastus Lateralis				
Area, mm^2	25.2 (13.6)	23.2 (14.2)	27.2 (11.6)	26.7 (13.9)
Average muscle attenuation, HU	45.0 (5.3) a	41.3 (4.6) b	50.0 (5.1) c	46.6 (5.2)
Semitendinosus				
Area, mm^2	913.3 (461.03)	762.1 (167.8)	897.3 (348.1)	659.2 (263.3)
Average muscle attenuation, HU	37.1 (6.8) a	35.7 (4.5) b	39.3 (6.8) c	37.4 (5.2)
Biceps Femoris (Long Head)				
Area, mm^2	1206.5 (367.0) a	1077.5 (254.4)	1168.4 (373.8)	1027.4 (347.6)
Average muscle attenuation, HU	41.9 (3.1) a	36.3 (5.3) b	42.3 (4.1) c	38.5 (4.1)
Sartorius				
Area, mm^2	452.3 (154.5)	377.8 (108.1)	403.9 (141.7)	355.1 (109.3)
Average muscle attenuation, HU	33.0 (6.2) a	27.2 (4.4) b	34.5 (6.6)	29.9 (4.3)
Gracilis				
Area, mm^2	474.2 (206.5)	400.2 (132.4)	496.7 (215.2)	360.1 (98.8)
Average muscle attenuation, HU	36.7 (5.1)	34.4 (5.7) b	39.1 (4.2)	35.2 (4.8)
Adductor Magnus and Longus				
Area, mm^2	3057.5 (1038.1) a	2300.1 (725.7)	2712.9 (959.8)	2500.8 (547.9)
Average muscle attenuation, HU	44.4 (2.4) a	40.1 (4.1) b	46.7 (3.2) c	42.3 (3.5)
Semimembranosus				
Area, mm^2	860.6 (374.1)	691.2 (255.1) b	951.0 (266.3) c	636.4 (181.9)
Average muscle attenuation, HU	36.7 (5.5) a	32.7 (6.0) b	43.2 (4.9) c	37.2 (5.4)

Abbreviations: HU, Hounsfield. All values were expressed as mean (SD); a $p<0.05$, significantly different compared to the Elderly-OA group; b $p<0.05$, significantly different compared to the Young-H group; c $p<0.05$, significantly different compared to the Elderly-H group.

CONCLUSION

Knee OA can cause damage to the architecture of thigh muscles similar to those found in the aging process. Decrease in cross-sectional area, attenuation, and muscle density are some examples, which can be observed even in younger individuals. Therefore, future studies should confirm the findings described here, as well as investigate the effects of interventions through physical exercises, considering these parameters.

All authors declare no potential conflict of interest related to this article

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