MUSCLE PERFORMANCE, PAIN, STIFFNESS, AND FUNCTIONALITY IN ELDERLY WOMEN WITH KNEE OSTEOARTHRITIS

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ABSTRACT

Objective: To determine the correlation between performance of the knee muscles and pain, stiffness, and functionality, through the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Questionnaire applied to an elderly population with osteoarthritis of the knee (OA). Methods: This study uses an observational, cross-sectional approach applied to a convenience sample of 80 elderly individuals (71.2 ± 5.3 years of age) with a clinical diagnosis of OA of the knee. Muscle strength, resistance, and balance of the knee were evaluated using the Biodex System 3 Pro isokinetic dynamometer at angular speeds of 60º/s and 180º/s. The self-reported functionality, presence of pain, and stiffness were evaluated by the WOMAC questionnaire. The correlation between the variables was analyzed by Spearman's coefficient of correlation ($\alpha = 0.05$). Results: A significant inverse correlation was observed between muscle strength and resistance of the quadriceps muscle (Q) and the hamstring muscle (H) at speeds of 60º/s and 180°/s, respectively, as well as in the relation between H/Q muscle balance at 180°/s and all domains of the WOMAC ($p<0.05$). Conclusions: The reduction in strength, resistance, and presence of imbalance in the knee muscles are inversely correlated with all the domains of the WOMAC in elderly individuals with OA. These results indicate a need for intervention that involves strengthening, resistance, and balance of the knee extensor and flexor muscles, aimed at reducing the impact of OA in relation to pain, stiffness, and functionality in elderly individuals. Level of Evidence: Level I, diagnostic studies - investigating a diagnostic test.

Keywords: *Osteoarthritis. Muscle strength. Aged.*

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INTRODUCTION

World population aging is a reality that demands increasing care and services in the area of health of senior citizens. The appearance of chronic degenerative diseases increases exponentially with the greater life expectancy, whereas among the rheumatic diseases, osteoarthritis (OA) is the most prevalent in the elderly population.[1,2]

OA is a chronic degenerative disease of the joints characterized by wear and tear of the articular cartilage, and in which, among the weight-bearing joints, the knee is the most frequently affected. In developed countries, knee OA affects between 17% and 30% of the elderly population over 65 years of age, with greater incidence, prevalence and severity in women than in men.[1,3] In Brazil, in a cross-sectional study with 3038 people on the prevalence of rheumatic diseases, the presence of OA was identified in 4.14% in symptomatic individuals with joint pain and/or edema, and was also predominant in the female sex.[1,2] Several factors can influence the onset and progression of OA, such as: age, changes in the metabolism, genetic and hormonal factors, biomechanical alterations and articular inflammatory processes.[3] The disease is associated with pain, joint stiffness, deformity and progressive loss of function. Thus it affects the individual in the organic, functional, emotional and social dimensions and consequently changes their quality of life.[2]

Individuals with knee OA have greater difficulty in performing functional activities, particularly those that involve mobility and transfers when compared with healthy individuals.[4] Functional decline, increased risk of falls and presence of pain are, in many studies, related to the muscle weakness caused by OA,[4,5] especially weakness of the quadriceps and hamstring muscles.[6] Individuals with knee OA present reduction of strength in the muscles of this joint, which might or might not be associated with muscle atrophy, pain and edema.[7,8] Muscle function impairment can significantly affect the quality of life of elderly individuals, lead to difficulties in the performance of everyday activities, and often making them dependent on the help of others.[8,9]

All the authors declare that there is no potential conflict of interest referring to this article.

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Thus the aim of this study was to verify the correlation between performance of knee extensor and flexor muscles and pain, stiffness and functionality through the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire applied to elderly women from the community with knee osteoarthritis.

METHODS

This is an exploratory cross-sectional study of elderly women with knee OA, residing in the metropolitan region of the city of Belo Horizonte-MG. This study was approved by the Institutional Review Board of UFMG (report ETIC 0124/06).

Sample

A confidence interval of 95% and a power of 90% were defined previously for the sample calculation to detect, as significant, the coefficient of correlation between two variables of magnitude equal to or above 0.35. The calculation resulted in a sample group of 80 elderly women. The group was selected by convenience sampling with recruitment through adverts in local newspapers.

The women included in the study were aged 65 years or over, had a diagnosis of knee OA according to clinical and radiographic criteria of the American College of Rheumatology,[10] and were able to walk independently, with or without gait aid devices. The exclusion criteria were elderly women that presented unstable cardiovascular diseases, acute or terminal diseases, cerebrovascular diseases; amputations and fractures of lower limbs, arthroplasty of the knee and hips; cognitive disorder detectable by the Mini-Mental State Examination.[11]

Initially, 392 elderly female volunteers with knee OA were selected. Of these, 90 that met the pre-established inclusion and exclusion criteria and signed the Informed Consent Form took part in the study. Ten volunteers desisted from taking part in the survey: six due to difficulty getting from their homes to the venue of the evaluations and four due to associated diseases, totaling 80 participants at the end of the measurements.

Instruments and Measurements

To characterize the sample, the socio-demographic data and information relating to the clinical conditions of the elderly women were obtained by means of a structured questionnaire, applied by a previously trained evaluator.

Since obesity is considered an important cause and exacerbating factor for OA,[12,13] weight and height were measured and the BMI (Kg/m^2) of the elderly women was calculated. The classification of the nutritional state was based on the WHO cut-off points for adults and elderly citizens: low weight (BMI$<$18.5kg/m^2), eutrophy (BMI 18.5-24.9kg/m^2), excess weight (BMI$>$25kg/m^2) and obesity (BMI$>$30kg/m^2).

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Questionnaire

WOMAC is a valid and reliable instrument, specific for OA translated into and adapted to the Portuguese language.[14] This questionnaire is composed of three domains: Pain (5 questions), Stiffness (2 questions) and Functionality (17 questions), with questions to be answered by the volunteer about her perception in the last 72 hours.

The WOMAC scores were calculated by the Likert scale (0-100), obtaining the values for each domain. The calculation of the average score was followed by that of the overall score, which aggregates a global dimension of OA.[13,14] Higher scores indicate a worse profile of pain, stiffness or functionality.

Muscle Strength and Balance – Isokinetic Dynamometry

The Biodex System 3 Pro® isokinetic dynamometer (Biodex Medical Systems Inc., Shirley, NY, USA) was used to assess the muscle performance of the knee extensors and flexors. This instrument has been accepted as gold standard in muscle performance assessments.[15] The tests were conducted bilaterally at the angular speeds of 60°/s and 180°/s in concentric contractions, with five and fifteen repetitions, respectively, with a 30-second interval between each speed.

The muscle performance measurements were analyzed by the peak torque/body mass (Nm/Kg) variable at the angular speeds of 60°/s for muscle strength and of 180°/s for resistance.[15] When torque is measured by the isokinetic dynamometer at a higher speed, with a larger number of repetitions per second, it is possible to measure the muscle resistance or endurance of the individual.[15] The muscle balance of the knee joint, considering as a parameter the agonist/antagonist ratio between hamstring and quadriceps muscles (H/Q), was evaluated at the angular speeds of 60 °/s and 180°/s.

The systemic arterial pressure was measured prior to the evaluation, with a five-minute walk as a warm-up exercise. All the precautions and actions of the evaluation protocol suggested by the manufacturer, such as positioning, calibration, familiarization and vigorous verbal incentive, were observed.

Statistical analysis

The sample description was performed by means of measures of central tendency (mean and standard deviation) and frequency for the socioeconomic and clinical variables. Data normality was verified by the Shapiro-Wilk test.

Correlation between the muscle performance variables and pain, stiffness and function of the WOMAC questionnaire was analyzed by calculating Spearman's coefficient of correlation, since the data from the sample were not distributed in the usual fashion. Correlation between the domains of WOMAC and the BMI was also investigated.

The index of significance α=0.05 was considered in all the analyses, which were conducted using the Statistical Package for the Social Sciences (SPSS) program for Windows (Version 11.0).

RESULTS

The study subjects were 80 elderly women with mean age of 71.2±5.3 years. Table 1 shows the results of the socio-demographic and clinical profile and the aspects concerning manifestation of OA in the group studied. The right knee was the most symptomatic for 52% of the participants.

The results referring to the application of WOMAC showed that the mean score was 46.94 ± 19.40 for pain, 35.00±31.41 for stiffness, 47.92±20.61 for functionality and 46.64±19.61 in the overall score. The mean BMI was 30.27±4.75, whereas this variable was positively and significantly correlated with all the domains of WOMAC. The strongest correlations were with function (r=0.348, p=0.02) and with the overall score of the instrument (r=0.364 and p=0.001).

The H/Q ratio found in this study was 49.13 ± 14.83 (%) at the

Table 1. *Clinical and socio-demographic profile and manifestations of OA in the group evaluated.*

Variable	Individuals (n = 80)
Age	71.2 years 5.3
Marital Status	single = 9 (11.3%)
	married = 33 (41.3%)
	divorced / widow = 38 (47.5)
School Education	6.8 4.5
BMI	30.27 4.72
Time suffering pain	10.9 years 29.17
Most symptomatic knee	right = 42 (52.5%)
	left = 38 (47.5%)
Manifestation of Symptoms	unilateral = 11 (13.7%)
	bilateral = 69 (86.3%)

In the categorical variables (marital status, most symptomatic knee and manifestations of symptoms): frequency and percentage; in the continuous variables (age, school education, BMI, time suffering pain): mean and standard deviation.

speed of 60°/s and 52.64 ± 14.57 (%) at the speed of 180°/s. This percentage was lower than the mean value estimated for the healthy adult population (60% to 73%), characterizing the presence of muscle imbalance in this sample. These measurements presented estimated error of the variable within the acceptable range (5%-10%)[15], which demonstrated its consistency.

According to Spearman's coefficient of correlation, there was significant inverse correlation between muscle strength and resistance evaluated by the peak torque/body mass of the quadriceps (Q) and hamstring (H) muscles at the speeds of 60°/s and 180°/s, respectively, and in the relation of H/Q muscle balance at 180°/s with all the domains of WOMAC and the overall score of the instrument ($p<0.05$). The strongest correlations were verified between peak torque/body mass at 60°/s of the hamstring muscles and self-reported function ($r=-0.437$ and $p<0.001$) and the peak torque/body mass at 60°/s of the quadriceps muscles and pain of WOMAC ($r=-0.437$ and $p=0.000$). (Table 2)

DISCUSSION

Significant inverse correlation was verified between the peak torque/body mass of the knee extensor and flexor muscles at the angular speeds of 60°/s (muscle strength) and 180°/s (resistance) in this study, with all the domains of the WOMAC questionnaire (pain, functionality and stiffness), corroborating results of other investigations.[7,8,16]

In a study by Teixeira and Olney[7], the authors observed significant reduction of torque and of the work executed by the knee flexor and extensor muscles in elderly individuals with knee OA. Pain and joint stiffness appeared as the main determinants of alterations in these variables evaluated by the isokinetic dynamometer in elderly individuals with OA.[7] Ferrucci *et al*.[16], while investigating a sample group of patients with OA, verified decrease of strength in the quadriceps and hamstring muscles as determinants in the evolution of OA and its incapacities. These findings are extremely important in the preparation of treatment programs, considering that OA is a chronic degenerative disease, irreversible and highly prevalent in elderly individuals. Quadriceps weakness is common in elderly patients diagnosed with OA.[3,4,6] In asymptomatic individuals, minor incoordination in muscle recruitment can result in failure to decelerate the limb before initial contact in gait, generating increased reaction

Table 2. *Correlation between performance in WOMAC and the variables evaluated in the isokinetic dynamometer.*

Variables	WOMAC							
Isokinetic Dynamometer			Pain		Stiffness		Function		Overall	
	s	p	s	p	s	p	s	p
PTQ/bm Q 60°/s R	-0.337	*0.002	-0.395	*0.000	-0.412	*0.000	-0.418	*0.000
PTQ/bm Q 60°/s L	-0.446	*0.000	-0.394	*0.000	-0.436	*0.000	-0.408	*0.000
PTQ/bm H 60°/s R	-0.316	*0.004	-0.349	*0.002	-0.437	*0.000	-0.453	*0.000
PTQ/bm H 60°/s L	-0.301	*0.007	-0.360	*0.001	-0.396	*0.000	-0.410	*0.000
H/Q 60°/s R	0.078	0.490	0.087	0.443	0.005	0.964	0.021	0.852
H/Q 60°/ L	0.152	0.17	-0.035	0.756	-0.029	0.705	0.007	0.952
PTQ/bm Q 180°/s R	-0.299	*0.007	-0.380	*0.001	-0.401	*0.000	-0.414	*0.000
PTQ/bm Q 180°/s L	-0.369	*0.001	-0.353	*0.001	-0.354	*0.001	-0.356	*0.000
PTQ/bm H 180°/s R	-0.278	*0.013	-0.397	*0.000	-0.412	*0.000	-0.478	*0.000
PTQ/bm H 180°/s L	-0.287	*0.010	-0.385	*0.000	-0.371	*0.001	-0.476	*0.000
H/Q 180°/s R	-0.109	0.335	-0.239	*0.033	-0.226	*0.044	-0.303	*0.006
H/Q 180°/s L	0.071	0.532	-0.092	0.415	-0.071	0.529	-0.234	*0.037

The variables were analyzed by Spearman's correlation coefficient, considering as significance $p<0.05$*. s = Spearman's correlation; p = significance; R = right, L = left; H = hamstring muscle; Q = quadriceps muscle; PTQ/bm =peak torque/body mass.

forces in the knee joint. This alteration can result in progressive degeneration of the articular cartilage and constitutes one of the major risk factors for pain.[3] Considering that adequate function of the articular cartilage needs biomechanical and muscular stability for the maintenance of its structure and of the integrity of the extracellular matrix,[2,3] the alterations found in this study, could possibly give rise to the exacerbation of articular destruction. In addition to these factors, in the aging process it is possible to observe reduction of muscle strength in the quadriceps or an increase in the latent period for its contraction, which also contributes to the alterations related to the pathogenesis of OA.[2,3]

As regards the knee extensors, the strongest correlations presented in the sample analyzed were of peak torque/body mass at 60°/s and pain in WOMAC. The quadriceps, largest antigravity muscle of the lower limbs, has a protective effect in the knee as it acts by decelerating the pendulum movement of the limb during gait. This action minimizes the forces transmitted to the proximal joints in initial contact in gait. Accordingly, this muscle is important in knee stabilization and its weakness can generate abnormal stress mechanisms in the joint, leading to pain,[13] and resulting in postural instability and often falls.[2]

In a study by O'Reilly *et al*.[8] the authors also demonstrated inverse correlation of muscle strength of the quadriceps muscle in individuals with knee OA and reports of pain and functional disability. Both the strength of the quadriceps muscle and its level of activation were significantly lower in the individuals with complaints of pain. It was also observed that in the group with pain compared to the control group, functional disability was inversely associated with strength of the quadriceps muscle. Since the extensor mechanism of the quadriceps is important for activities such as walking and climbing stairs, the reduction in the strength of this muscle directly affects functionality.[8] Thus, alterations relating to OA, together with those related to the aging process, lead to reduction of the effectiveness of the shock absorption mechanism promoted by the quadriceps muscle, justifying the results found in this study.

Another important finding in this study was the inverse correlation between all the domains evaluated by WOMAC and the peak torque/body mass of knee extensors and flexors, at the speed of 180°/s in 15 repetitions. Such results suggest that the elderly women assessed presented decreased muscle resistance with negative impact on pain, stiffness, and particularly, on the functional performance of WOMAC. These findings are relevant for clinical practice, considering that the repetition of movements at higher speeds and over longer periods can reproduce the daily functional activities of elderly women.

Another relevant aspect is the association of the presence of pain with the occurrence of stiffness and alterations in functional activities, especially those related to knee flexion.[5,13,17] Leveille *et al*.[17] demonstrated that in elderly individuals with OA the greatest difficulty in the performance of daily functions was related to muscle weakness developed in avoiding the execution of tasks that produced pain, such as climbing stairs or walking for a longer distance. Therefore, pain is an important and common clinical symptom in patients with OA, and can constitute a limiting factor of functional ability. For this reason control of pain symptoms in elderly patients with OA can signify an increase of functionality and reduced risk of falls in this clinical group.

Tseng *et al*.[9] demonstrated that the decrease of muscle strength and resistance (endurance) associated with aging is related to and can explain the difficulty in the performance of habitual functional activities by elderly individuals, such as, for example, difficulty getting up from a chair, going up and down stairs, walking and others. The decrease in knee extensor and flexor strength leads to a reduction of the capacity of these muscles to protect the joint against mechanical overloads.[6,8]

Moreover, the balance between these muscles, and not only their isolated function, has been considered important for joint protection. The relation between maximum isokinetic torque of the hamstring muscles and maximum isokinetic torque of the quadriceps muscle (H/Q ratio) is a parameter commonly used to describe the muscle balance of the knee joint.[18] The expected value of the H/Q ratio for asymptomatic adults, evaluated by the isokinetic dynamometer, tends to be from 60% to 76%, varying with the angular speed.[19] However, data on this percentage in the elderly population are scarce.

In a Brazilian study, the H/Q ratio for elderly women from the community was 47.95±10.99 (%) and 59.59±13.40 (%), at the angular speeds of 60°/s and of 180°/s, respectively,[20] similar to the values found in our sample. These values were 27.35% and 23.60% below those presented by young adults, indicating a decrease in this ratio with the increase in age.[19] The reduction of torque both for flexor and for extensor muscles occurs with the increase in age, as well as in individuals with musculoskeletal diseases.[20] The decrease in the H/Q ratio occurs due to the more accentuated decline of torque of the hamstring muscles in comparison with the torque of the quadriceps muscles.[19] According to Dahmane *et al*.[21] type II fibers are more numerous in the H muscles than in the Q muscles. Since there is a more accentuated decline of type II fibers (glycolytic, of fast contraction) in elderly people, both in the number and in size of these fibers,[13,17] this alteration could explain the greater decline of the flexor torque, leading to muscle imbalance of the knee joint.

Inverse correlation of the relation between H/Q and functionality from the WOMAC questionnaire was verified at the speed of 180°/s. Studies investigating the relation between muscle balance of the knee joint muscles and functional aspects in elderly patients with OA are not known, hindering the comparison of this study's results with those of others. Alterations in the H/Q ratio indicate that there is muscle imbalance, predisposing both the joint and the muscle group to lesions due to their weakening. The integrity of the articular cartilage can be seriously impaired by excess load, stress and muscle imbalance.[3,19,20] These factors induce the production of cytokines and metalloproteins, which stimulate the production of nitric oxide, superoxide and proteolytic enzymes by taking part in angiogenesis, remodeling and contributing to synovitis and

destruction of the articular cartilage with cellular apoptosis.[22]

In this study, the elderly women with higher BMIs presented a worse profile of pain, stiffness and functionality. Moreover, significant correlation was observed between BMI and stiffness, self-reported function and with the overall score of the WOMAC questionnaire. These findings corroborate the literature that indicates obesity as a risk factor for the development of knee OA and also a predisposing factor for functional disability.[12,13] In an epidemiologic study with obese individuals aged between 24 and 76 years, without clinical diagnosis of OA or rheumatoid arthritis, monitored over a period of 10 years, the incidence of OA was 5.8% in the hips, 7.3% in the knees and 5.6% in the hands, while the elevated BMI was significantly related to OA of knees and hands.[12] However, it is not known to what extent functional impairment is a result of excess weight.

Some limitations of this study should be considered. Besides muscle performance, other factors such as age, living habits, practice of physical activity and psychological factors may affect the functionality of elderly individuals with knee OA. Furthermore, the fact that it is a convenience sample prevents the results of this investigation from being generalized, limiting its external validity.

CONCLUSION

The results found in this study point toward the need for interventions aimed at muscle strengthening and increase in muscle resistance, for an improvement of functional capacity. The intervention should focus both on the hamstrings and quadriceps muscles, in an attempt, through the strengthening of both muscles, to reestablish or improve muscle balance, reducing the impact of OA on the functionality of elderly individuals. Guidelines and referrals for specialized professionals on body weight control should be encouraged by physiotherapists as well, in view of the fact that the causes of OA are multifactorial, and physiotherapeutic approaches will not present satisfactory results in individuals with articular overload. Studies on the effective modes of exercise to improve functionality and quality of life should be encouraged.

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