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original article

Strength, muscle quality and markers of cardiometabolic risk in older women

Força, qualidade muscular e marcadores de risco cardiometabólico em mulheres idosas

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Abstract – The aging process is associated with a decline in physiological functions, including a reduction in muscle quality, as well as changes in cardiometabolic risk factors. Thus, the aim of this study was to verify if a correlation exists between muscle strength and quality and cardiometabolic risk markers in older women. Thirty older women (66.13±5.26 years, 67.33±12.45 kg, 1.54±0.07 m, body mass index: 28.20±4.72) were submitted to the evaluation of muscle thickness and strength and blood analysis of cardiometabolic risk markers (glucose, basal insulin, C-reactive protein, total cholesterol, HDL-cholesterol, LDL-cholesterol, VLDL-cholesterol, triglycerides, and HOMA-IR). No significant correlations were found between muscle phenotypes and markers of cardiometabolic risk, even after adjustment for confounding factors. The present study indicates that muscle strength or quality is not correlated with markers of cardiometabolic risk.

Key words: Elderly; Muscle strength; Risk factors.

Resumo – *O processo de envelhecimento está associado a um declínio nas funções fisiológicas, refletindo em reduções na qualidade muscular, bem como em alterações de marcadores de risco cardiometabólico. Nesse sentido, o objetivo do estudo foi verificar a associação entre qualidade muscular e marcadores de risco cardiometabólico em mulheres idosas. Trinta mulheres idosas (66,13±5,26 anos, 67,33±12,45 kg, 1,54±0,07 m, 28,20±4,72 IMC) foram submetidas à avaliação da espessura e força musculares do quadríceps, e à análise sanguínea de marcadores de risco cardiometabólico (glicemia, insulina basal, proteína C-reativa, colesterol total, HDL-colesterol, LDL-colesterol, VLDL-colesterol, triglicerídeos, e índice HOMA-IR). Não foram encontradas correlações significativas entre os fenótipos musculares e os marcadores de risco cardiometabólico estudados, mesmo com controle para fatores de confusão. A presente pesquisa indica não haver correlação entre força e qualidade muscular com os marcadores de risco cardiometabólico estudados.*

Palavras-chave: *Fatores de risco; Força muscular; Idoso.*

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INTRODUCTION

The process of aging is accompanied by different physiological changes that affect the function of organs and tissues, with an impact on the independence of older adults in activities of daily living and on their functional capacity[1]. Among these changes, the reduction in strength levels and muscle mass (i.e., sarcopenia) is negatively associated with the health of older adults, including the occurrence of chronic-degenerative diseases[2] and a higher risk of mortality[3], in addition to a significant impact on healthcare costs[4].

Aging has also been associated with an increase in the circulating levels of inflammatory markers[5] and insulin resistance[6] and with a reduction in cholesterol and its subfractions[7]. Furthermore, studies have shown a relationship between these variables and muscle strength[8-10]. However, this association is not well documented for muscle quality (MQ). Muscle quality, also known as specific tension or strength, can be characterized as the ratio between maximal muscle strength and muscle mass and is a more representative parameter of muscle function than muscle strength or muscle mass alone[11]. As observed for muscle strength and mass, changes in MQ can occur during aging[12].

In the few studies investigating the association between MQ and markers of cardiometabolic risk, only variables related to glycemic control were analyzed[13,14] and the results, methods used for strength evaluation and calculation of MQ differed between studies. Furthermore, there are no studies analyzing the association between MQ and inflammatory markers or lipid profile variables.

One may speculate that the correlation of these variables with MQ is more pronounced than with muscle strength since the former is a more representative measure of the function of the muscle complex. The identification of this correlation is particularly important for the elderly population because of the deleterious effects of aging on both the muscle system[12] and on the levels of some cardiometabolic risk markers[5,6]. The study of muscle phenotypes and blood variables related to cardiometabolic risk in older women is of special interest since women are at higher cardiovascular risk after the age of 60 years[15] and present elevated cholesterol levels[7] and a higher incidence of diabetes[16] when compared to men.

In this respect, the establishment of a relationship between MQ and metabolic variables may contribute to clinical evaluation and to the identification of inflammatory conditions, alterations in glycemic control and other situations of increased cardiometabolic risk. Furthermore, the identification of these conditions can assist non-pharmacological interventions through systematic physical activities in the population studied. Therefore, the objective of the present study was to determine the association between MQ and markers of cardiometabolic risk in older women. The following cardiometabolic risk factors were analyzed: fasting glucose, basal insulin, homeostasis model assessment of insulin resistance (HOMA-IR), total cholesterol and subfractions, C-reactive protein (CRP), and triglycerides.

METHODS

Sample

Thirty older women (66.13±5.26 years, 67.33±12.45 kg, 1.54±0.07 m, body mass index [BMI] of 28.20±4.72 kg/m^2 without any experience in strength training were selected to participate in the study. For recruitment of the sample, the study was previously published at strategical sites of the Federal District through print (banners, billboards and leaflets) and interactive media (radio and television). Older women aged 60 to 80 years who voluntarily agreed to participate in the study were selected. After initial recruitment, the following exclusion criteria were applied: experience in strength training or participation in a guided physical exercise program in the 3 months preceding the evaluations and a history of musculoskeletal injury related to movements in strength tests.

All subjects were informed about the risks and benefits of the study and signed the free informed consent form before participation in the study. The study was conducted by the analysis of data originating from initial assessments of a sample of subjects participating in a more comprehensive study approved by the Ethics Committee on Human Research of the School of Health Sciences, University of Brasília (Universidade de Brasília - UnB) (Registration No. 001/13).

Experimental procedures

Data were collected on two days at an interval of up to 2 weeks. The first visit consisted of anthropometric evaluation and application of a questionnaire containing traditional anamnesis data, sociodemographic data, medical history, and use of medications. The second visit consisted of blood collection (after a fast of ~12 hours) and the evaluation of muscle thickness and isokinetic peak torque. During the second visit, the cited order of evaluations was rigorously followed, i.e., immediately after blood collection the volunteers were invited to have breakfast offered free of charge by the Exercise Physiology and Health Research Group, School of Physical Education, UnB. Muscle thickness was analyzed after a postprandial period of 30 minutes by ultrasonography and muscle strength was then evaluated with an isokinetic dynamometer.

Anthropometric assessment

For anthropometric assessment, the subjects were weighed on a digital scale to the nearest 50 g and height was measured with a wall stadiometer. The BMI was calculated by dividing body weight by the square of the height (kg/m^2) of the volunteers.

Muscle thickness

Rectus femoris muscle thickness was evaluated by ultrasonography (Philips, VMI, Indústria e Comércio Ltda. Lagoa Santa, MG, Brazil). Water-soluble gel was applied at the site of measurement and a 7.5-MHz transducer was

positioned perpendicularly to the muscle analyzed. The transducer was held by the hand of the examiner at a distance of 30 cm from its base and no additional pressure was applied to standardize the compression generated on the skin. Once the examiner found a satisfactory image, it was frozen and stored. Finally, all measurements and analyses were performed three times by the same examiner and the mean value was considered for analysis. The cut-off value for the evaluation of rectus femoris muscle thickness was defined according to Chilibeck et al.[17].

Isokinetic peak torque

Isokinetic peak torque (PT) of the knee extensor was measured with an isokinetic dynamometer (Biodex System III, Biodex Medical Systems, New York, USA). For warm-up and familiarization with the test, the volunteers underwent two series of eight repetitions at an angular velocity of 300°.s^{-1}. The subjects were asked to exercise at submaximal force levels. Next, PT was evaluated after four series of 4 maximal repetitions, the first two performed at 60°.s^{-1} and the last two at 180°.s^{-1}, with an interval of 1 minute between series. Only the PT at 60°.s^{-1} was considered for analysis and the highest value obtained in the two series was used.

The subjects were positioned comfortably on the dynamometer, which was adjusted individually for each subject. After adjustment, the subjects were strapped to minimize movements that could interfere with the results of the tests. The PT values were adjusted for gravity using the Biodex Advantage software. It should be noted that older women do not show differences in PT between the dominant and non-dominant limb[18]. Thus, only the dominant lower limb was evaluated during the strength test, in which all subjects received visual feedback and verbal encouragement.

Muscle quality

Muscle quality, also called specific torque, was defined as the force produced per unit of muscle volume. The quadriceps muscle was chosen for this analysis because it is widely evaluated in older adults and an association with activities of daily living has been well documented. Muscle quality was calculated from the measurements of muscle volume and the force produced by the muscle. Techniques that are well described in the literature were used for the measurements (i.e., isokinetic dynamography and ultrasonography)[11,14]. Thus, muscle strength (isokinetic PT at 60°.s^{-1}) was divided by muscle thickness and the results are expressed as N.m/mm.

Blood markers of cardiometabolic risk

Blood was collected after an overnight fast of 12 hours. The samples were immediately sent for laboratory analysis of glucose levels, CRP, lipid profile, and insulin. Triglycerides, total cholesterol and its subfractions and glucose levels were measured using a colorimetric enzymatic method in the Autohumalyzer A5 (Human-2004). Insulin was assayed using the ACS-180 Chemiluminescence System (Ciba-Corning Diagnostic Corp., 1995, USA).

C-reactive protein was measured by a turbidimetric method. Additionally, the HOMA-IR was calculated by dividing the product of insulin (μIU/mL) and glucose (mmol/dL) by 405.

Statistical analysis

The descriptive characteristics are expressed as the mean and standard deviation. Normality of the sample was verified using the Shapiro-Wilk test. The association between variables was then evaluated by partial correlation analysis controlling for the following variables: smoking, hormone replacement therapy, diseases, medications, and regular physical activity. A level of significance of $p < 0.05$ was adopted. All analyses were performed using the SPSS 20.0 software.

RESULTS

The characteristics of the subjects are shown in Table 1.

Table 1. Characteristics of the subjects (n = 30).

Variable	Mean ± standard deviation
Age (years)	66.13 ± 5.26
Body weight (kg)	67.33 ± 12.45
Height (m)	1.54 ± 0.07
BMI (kg/m^2)	28.20 ± 4.72
Muscle thickness (mm)	29.50 ± 7.36
Peak torque (60°.s^{-1}) (N.m)	86.60 ± 23.12
Muscle quality (N.m/mm)	2.99 ± 0.63
Glucose (mg/dL)	91.87 ± 23.69
Basal insulin (μIU/mL)	11.04 ± 6.82
CRP (mg/dL)	0.27 ± 0.34
Total cholesterol (mg/dL)	189.20 ± 40.85
HDL-c (mg/dL)	50.33 ± 8.81
LDL-c (mg/dL)	116.57 ± 38.21
VLDL-c (mg/dL)	22.30 ± 7.88
Triglycerides (mg/dL)	112.73 ± 39.63
HOMA-IR	2.77 ± 2.36

BMI = body mass index; CRP = C-reactive protein; HDL-c = HDL cholesterol; LDL-c = LDL cholesterol; VLDL-c = VLDL cholesterol; HOMA-IR = homeostasis model assessment of insulin resistance.

Analysis of the correlation of muscle strength and MQ with cardiometabolic risk markers is shown in Table 2. No significant associations were observed between strength or MQ and the cardiometabolic risk markers studied. The frequency of the confounding variables was as follows: smoking (1 = yes; 29 = no); hormone replacement therapy (2 = yes; 28 = no); diseases (27 = yes; 3 = no); use of some medication (27 = yes; 3 = no), and regular physical activity (17 = yes; 13 = no). Separate statistical analysis showed that adjustment for the variables cited did not alter the results observed.

Table 2. Partial correlation of peak torque and muscle quality with markers of cardiometabolic risk.

Variable	PT (60 °.s^{-1})		MQ (N.m/mm)	
	r	p	r	p
Glucose (mg/dL)	0.243	0.252	0.215	0.314
Basal insulin (µUI/mL)	0.379	0.068	0.284	0.178
CRP (mg/dL)	-0.268	0.206	-0.230	0.280
Total cholesterol (mg/dL)	0.239	0.260	-0.243	0.253
HDL-c (mg/dL)	0.069	0.748	-0.171	0.423
LDL-c (mg/dL)	0.184	0.390	-0.261	0.217
VLDL-c (mg/dL)	0.215	0.314	0.191	0.370
Triglycerides (mg/dL)	0.204	0.339	0.156	0.465
HOMA-IR	0.364	0.080	0.282	0.182

PT = peak torque; MQ = muscle quality; CRP = C-reactive protein; HDL-c = HDL cholesterol; LDL-c = LDL cholesterol; VLDL-c = VLDL cholesterol; HOMA-IR = homeostasis model assessment of insulin resistance. Values adjusted for the following variables: smoking, hormone replacement therapy, diseases, medications, and regular physical activity.

DISCUSSION

The present results did not show significant correlations between strength or MQ and cardiometabolic risk markers in older women, even after adjustment for possible confounding variables (smoking, hormone replacement therapy, diseases, medications, and regular physical activity). There is special interest in studying this association in older women who are at higher cardiovascular risk after the age of 60 years[15] and who present elevated cholesterol levels[7] and a higher incidence of diabetes[16] when compared to men.

Although the muscle phenotypes studied were not significantly correlated with glucose (r = 0.243 for strength; r = 0.215 for MQ), basal insulin (r = 0.379 for strength; r = 0.284 for MQ) or insulin resistance (r = 0.364 for strength; r = 0.282 for MQ), there is interest in the study of the relationship between these phenotypes and markers of glucose uptake since skeletal muscle is the main site of glucose uptake in the body[19]. The question is particularly interesting for the elderly population since an increase in insulin resistance[6], which indicates the possibility of impaired glucose uptake, is one of the metabolic disorders that accompany the process of aging. In fact, there is evidence indicating a relationship between sarcopenia and increased insulin resistance[20].

No significant correlations were observed between muscle strength and glucose levels, in agreement with the study of Wijndaele et al.[10]. In contrast to the present results, several studies[8,13,14,21,22] have demonstrated associations between strength and indicators of glycemic control. With respect to glucose levels, Jurca et al.[8] found an inverse correlation between muscle strength and glucose levels in 8,570 men. For insulin resistance, Nomura et al.[22] reported inverse correlations of lower limb strength with insulin levels and HOMA-IR, in agreement with the study of Barzilay et al.[21]. The divergences between the present study and the articles cited may be explained by differences in the variables studied and in the methods used for muscle strength assessment in those studies.

The lack of a correlation between MQ and markers of glycemic control agrees in part with the study of Park et al.[14], but is not supported by previous studies[13,21,23]. Park et al.[14] observed no significant correlation between MQ and glycemic control. These authors also identified a negative correlation between the duration of diabetes and MQ, although the effect of diabetes on MQ was eliminated after adjusting for confounding factors in the female population, in agreement with the findings of the present study. In contrast, Volpato et al.[23] found diabetes to be associated with poor MQ in older adults, even after adjustment for age and gender. In agreement with these findings, Lee et al.[13] observed significant correlations between MQ and insulin sensitivity in 40 obese adolescents. Similar results have been reported by Barzilay et al.[21]. It should be noted that the studies cited used different methods for the evaluation of muscle strength and thickness, with a direct influence on the values used for the calculation of MQ. The lack of standardization in the choice of these variables may have interfered with the results and their interpretation, as well as with the comparisons between previous studies and the present one.

The lack of a correlation between muscle strength and lipid profile (total cholesterol, r = 0.239; HDL-c, r = 0.069; LDL-c, r = 0.184; VLDL-c, r = 0.215; triglycerides, r = 0.204) agrees with previous studies[22,24], although not all have corroborated these findings[8,10]. Kohl et al.[24] compared the relationship between muscle strength and lipid profile in men and women and found no significant correlations for women. These results are supported by the study of Nomura et al.[22] who also observed no correlations between strength and LDL-c, HDL-c or triglycerides, as demonstrated in the present study. In contrast, Wijndaele et al.[10] found a negative correlation between muscle strength and triglycerides and a positive correlation between muscle strength and HDL-c in women, correlations corroborated by Jurca et al.[8], but not observed in the present study.

Intramuscular fat content is known to be higher in older adults when compared to younger individuals[25], a fact that may explain the reduction in MQ observed during aging[12]. However, although intramuscular fat is associated with the availability of circulating lipids[26], no significant correlations were observed between MQ and lipid profile variables (total cholesterol, r = -0.243; HDL-c, r = -0.171; LDL-c, r = -0.261; VLDL-c, r = 0.191; triglycerides, r = 0.156). To our knowledge, this is the first study investigating this association since we found no studies in the literature correlating MQ with triglyceride or cholesterol levels. Methodological differences compared to other studies may explain in part the results found.

There was no significant correlation between muscle strength and CRP levels (r = -0.268). The findings of the present study agree in part with the results reported by Schaap et al.[9] who observed no association between CRP levels and the relative loss of muscle strength over a period of 3 years in a study including men and women, although elevated CRP levels were found to increase the risk of muscle strength loss in this population. However, there is evidence indicating an association between muscle

strength and inflammatory markers[27-29], in contrast to the results of the present study. In fact, studies suggest that high levels of inflammatory proteins are related to catabolic processes in muscle tissue that lead to the loss of muscle strength and muscle mass - consequently accelerating the process of sarcopenia – and to functional limitations in older adults[29,30]. However, such association was not observed in the present study.

No correlation between MQ and CRP levels was observed in the present study (r = -0.230). This finding was expected since MQ is a more functional measure of muscle capacity. It was not possible to identify the reason for the lack of correlation between these variables, a fact indicating the need for further studies with similar objectives. Additionally, there are no studies in the literature evaluating the association between MQ and CRP.

The lack of standardization observed for the calculation of MQ impairs comparisons with the results of other studies and is a potential limitation of this study. In fact, there is no consensus in the literature regarding the measurement of MQ. Well-described techniques (i.e., isokinetic dynamometry and ultrasonography) were used in the present study[11,14].

In summary, no significant correlations were observed between muscle strength or MQ and markers of cardiometabolic risk in older women.

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