Correlation between muscle strength and the degrees of functionality and kinesiophobia reported by patients with chronic hip pain

Correlação entre força muscular e graus de funcionalidade e cinesiofobia relatada por pacientes com dor crônica no quadril

Gustavo Leporace[1,2], Luiz Alberto Batista[3,4], Leonardo Metsavaht[1,2], Jorge Chahla[5], Tainá Oliveira[3,4], Liszt Palmeira de Oliveira[6]

DOI 10.5935/2595-0118.20210015

ABSTRACT

BACKGROUND AND OBJECTIVES: This study aimed to identify the association between hip muscle strength and the scores from subjective functional and psychological evaluation questionnaires in patients with chronic hip pain.
METHODS: Fifty-five patients with painful hip injuries (30 males) performed isometric peak strength tests of the abductors, extensors, and internal and external rotators of the hips with a hand-held dynamometer. The degree of functionality was measured by the Hip Outcome Score (HOS) and Lower Extremity Functional Score (LEFS), pain was estimated by the Visual Analog Scale (VAS) and kinesiophobia was calculated using the Tampa questionnaire. The Pearson correlation coefficient was used (alfa=5%) to test the associations between the muscle strength and the scores from the questionnaires.
RESULTS: There were significant correlations between the strength of all four hip muscles and the HOS (r>0.29). Only the hip external rotators showed a significant correlation with pain (r=-0.30). No significant correlations were found for LEFS (r<0.24) and Tampa questionnaires (r←0.15).
CONCLUSION: The reduction in peak strength of the hip extensors, abductors and external rotators was associated with a reduction in the level of hip functionality but did not correlate with neither the level of overall functionality of the lower limbs nor the degree of kinesiophobia. Also, a reduction of hip external rotators strength was related to an increase in the intensity of pain.
Keywords: Hip joint, Muscle strength, Muscle strength dynamometer, Pain measurement, Quality of life.

RESUMO

JUSTIFICATIVA E OBJETIVOS: Este estudo teve como objetivo identificar a associação entre a força muscular do quadril e os escores de questionários subjetivos de avaliação funcional e psicológica em pacientes com dor crônica no quadril.
MÉTODOS: Cinquenta e cinco pacientes com lesões dolorosas no quadril (30 homens) realizaram testes isométricos do pico de força de abdutores, extensores e rotadores internos e externos do quadril com um dinamômetro portátil. O grau de funcionalidade foi medido pelo *Hip Outcome Score* (HOS) e *Lower Extremity Functional Score* (LEFS), a dor foi avaliada pela escala analógica visual (EAV) e a cinesiofobia foi calculada pelo questionário de Tampa. O coeficiente de correlação de Pearson foi utilizado (alfa=5%) para testar as associações entre a força muscular e os escores dos questionários.
RESULTADOS: Houve correlações significativas entre a força de todos os quatro músculos do quadril e o HOS (r>0,29). Apenas os rotadores externos do quadril apresentaram correlação significativa com a intensidade da dor (r=-0,30). Nenhuma correlação significativa foi encontrada para LEFS (r<0,24) e questionário de Tampa (r←0,15).
CONCLUSÃO: A redução no pico de força dos extensores, abdutores e rotadores externos do quadril foi associada à redução no nível de funcionalidade do quadril, mas não se correlacionou com o nível de funcionalidade geral dos membros inferiores ou com o grau de cinesiofobia. Além disso, uma redução da força dos rotadores externos do quadril foi relacionada a aumento na intensidade da dor.
Descritores: Articulação do quadril, Dinamômetro de força muscular, Força muscular, Medição da dor, Qualidade de vida.

INTRODUCTION

Chronic hip pain is a frequent cause of dysfunction in young adults[1] and may lead to limitations in daily living and sporting

Gustavo Leporace – https://orcid.org/0000-0002-7265-4658;
Luiz Alberto Batista – https://orcid.org/0000-0002-4609-4095;
Leonardo Metsavaht – https://orcid.org/0000-0001-9263-1309;
Jorge Chahla – https://orcid.org/0000-0002-9194-1150;
Tainá Oliveira – https://orcid.org/0000-0002-9726-5528;
Liszt Palmeira de Oliveira – https://orcid.org/0000-0002-9051-937X.

1. Brazil Institute of Health Technologies, Research Department, Rio de Janeiro, RJ, Brazil.
2. Federal University of São Paulo, São Paulo School of Medicine, Diagnostic Imaging Department, São Paulo, SP, Brazil.
3. State University of Rio de Janeiro, Laboratory of Biomechanics and Motor Behavior, Rio de Janeiro, RJ, Brazil.
4. State University of Rio de Janeiro, Post-Graduation Program in Sport and Exercise Science, Rio de Janeiro, RJ, Brazil.
5. Rush University Medical Center, Midwest Orthopaedics at RUSH, Chicago, Illinois, USA.
6. State University of Rio de Janeiro, Medical Sciences Post-Graduation Program, Rio de Janeiro, RJ, Brazil.

Submitted on September 07, 2020.
Accepted for publication on January 06, 2021.
Conflict of interests: none – Sponsoring sources: none

Correspondence to:
Gustavo Leporace
Instituto Brasil de Tecnologias da Saúde, Departamento de Pesquisa
22410-003 Rio de Janeiro, RJ, Brasil.
E-mail: gustavo@biocinetica.com.br

activities[2]. Subjective evaluation questionnaires related to the degrees of functionality and hip pain are the primary outcomes used to identify the impact of hip diseases on patients' quality of life, as they establish a quantitative interpretation of the patient regarding their level of functionality[3]. Although these questionnaires are routinely used in longitudinal studies, they have limited applicability in selecting objective interventions for improving lower limb functionality. Decreased muscle strength has been reported to be a frequent objective physical finding[4,5]. Study[5] suggested that patients with chronic hip pain tend to have reductions in internal rotator, external rotator and hip abductor peak strength in both the affected and contralateral limbs when compared with healthy subjects. These findings have been corroborated by authors[6,7] in individuals with osteoarthrosis (OA).

Periarticular muscles are important dynamic stabilizers of the hip joint and may be responsible for movement dysfunctions of the hip and lumbopelvic region when they are limited in their capacity to generate force or when there are neuromuscular control deficits[8] because they tend to generate a biomechanical overload in the intra-articular structures[8]. Although a good capacity to generate muscle strength and good motor control are paramount for functionality and maintaining the quality of life of patients with chronic hip pain[4,5], no studies have sought to establish a possible association between the ability to generate hip muscle strength and the level of functional capacity reported by patients with chronic hip pain. Such data could aid the optimization of muscle strengthening exercises in programs aimed at improving the motor function of patients with chronic hip pain.

For the above-mentioned reasons, the purpose of this study was to identify the association between hip muscle strength and the scores from subjective functional and psychological evaluation questionnaires in patients with chronic hip pain. The hypotheses of the study were that: (i) peak muscle strength values are associated with the subjective assessment questionnaire scores and are higher for hip-specific questionnaires than for generalized lower limb questionnaires; (ii) peak muscle strength values are associated with scores on the visual analog scale (VAS) for pain; and (iii) peak muscle strength values are associated with the degree of kinesiophobia.

METHODS

Data from this cross-sectional study were collected from consecutive clinical and biomechanical evaluations of patients with painful hip injuries performed consecutively in a private biomechanics' laboratory from January to August 2016. Fifty-five patients (30 male) were classified according to the classification of hip joint involvement (Table 1)[9]. All the diagnoses were made by the same orthopedic physician (initials blinded for review).

The degree of functionality was measured by applying the validated version of the questionnaires Hip Outcome Score (HOS)[10] and Lower Extremity Functional Score (LEFS)[11], pain was estimated by the VAS and kinesiophobia was estimated using the Tampa questionnaire[12].

Streng measurement

The maximum isometric peak strength levels of the abductors, extensors, and internal and external rotators of the hips were measured with a manual dynamometer (Lafayette Manual Muscle Tester Model 01163; Lafayette Instrument Company, Lafayette, IN, USA). Make tests were performed because they had better reliability than break tests[13]. Intra- and inter-rater reliability of these devices has been previously reported to be excellent, with values above 0.80[14-16]. In cases of patients with unilateral pain, the tests were performed on the limb indicated in the complaint of pain. In cases of bilateral pain, the tests were performed on the limb with greater pain and functional limitation. All patients underwent two attempts to familiarize themselves with the procedures and two more attempts to collect peak strength. The maximum value of the two test attempts for each muscle in each participant was used in the analysis. The participants were instructed to push the dynamometer

Table 1. Charnley[9] classification of hip joint involvements that have a negative influence on walking capacity

Classification	Sample	Diagnosis
A - Unilateral disease	9	- Gluteal enthesopathy (n = 4) - Femoroacetabular impact (n = 3) - Femoral head osteonecrosis (n = 1) - Acetabular dysplasia (n = 1)
B - Bilateral disease	25	- Gluteal enthesopathy (n = 1) - Femoroacetabular impact (n = 19) - Coxarthrosis (n = 3) - Femoral head osteonecrosis (n = 2)
C -Some factor besides the hip impairing function*	21	- Gluteal enthesopathy (n = 10) - Coxarthrosis (n = 9) - Pubalgia (n = 2).

Class A refers to unilateral hip disease; Class B refers to bilateral hip involvement; and Class C refers to some factor besides the hip negatively influencing walking capacity.

* The other impaired body segment in group C was mainly the lumbar spine (n = 19), in addition to one case of bilateral knee osteoarthrosis and one case of iatrogenic sciatic nerve injury.

with the greatest possible effort while avoiding sudden movements so that the force was gradually increased over a period of 5 seconds[17].

The hip abductor muscles were tested with the patient in lateral decubitus with the hip in a neutral position. The manual dynamometer was positioned 5cm proximal to the lateral epicondyle of the femur in a direction perpendicular to the thigh. The subjects were instructed to press their leg toward the ceiling without rotating the pelvis or limbs. For hip extensors, the patient assumed a ventral decubitus position, and the manual dynamometer was positioned 5cm proximal to the posterior articular line of the knee in a direction perpendicular to the thigh. The patient was instructed to press their leg up toward the ceiling, without rotating their pelvis or limb. For the hip rotator evaluation, the patients remained seated with 90° of hip and knee flexion. For the internal rotator examination, the dynamometer was positioned 5cm proximal to the lateral malleolus, and the patient was instructed to exert force to rotate the leg laterally. For the external rotators, the dynamometer was positioned 5 cm above the medial malleolus, and the patient was instructed to exert force to rotate his/her leg in the medial direction.

The study project was approved by the Institutional Ethics Committee (number 039.3.2010). All participants signed the Free and Informed Consent Term (FICT)

Statistical analysis

Sample size was determined as the number of participants necessary to reach a statistical power of 80%, with a coefficient of determination of 0.15 between variables and a moderate effect size of α=0.05, using a bivariate normal model, defined a priori using GPower software. The Pearson correlation coefficient was used at a significance level of 5% in order to test the associations between the absolute peak muscle strength of the four muscle groups in Newtons and the LEFS questionnaire, the two sub-scales of the HOS, the VAS and the Tampa kinesiophobia questionnaire. MATLAB software (Mathworks, version 8.6.0, USA) was used in data processing and statistical testing.

RESULTS

The mean age of the patients was 48.5±16.7 years old, ranging from 18 to 84 years; the mean height was 167.5±10.9cm, ranging between 146 and 192.5cm and the mean body weight was 74.1±18.9 kg, ranging between 49.5 and 114.4kg.

There were significant correlations between the peak muscle strength levels of the extensors, abductors and external and internal hip rotators and the HOS in the domains activities of daily living (ADL) ($r>0.42$, $p<0.002$) and sports (S) ($r>0.29$, $p<0.04$) (Figures 1 and 2, respectively).

For the pain scale score, there was a significant and inversely proportional correlation only for the external rotators ($r=-0.30$; $p=0.03$) (Figure 3). No significant correlations were found between peak muscle strength and the LEFS questionnaire ($r<0.24$; $p>0.05$) (Figure 4) and between the peak muscle strength and the degree of kinesiophobia ($r<-0.15$, $p>0.05$) (Figure 5).

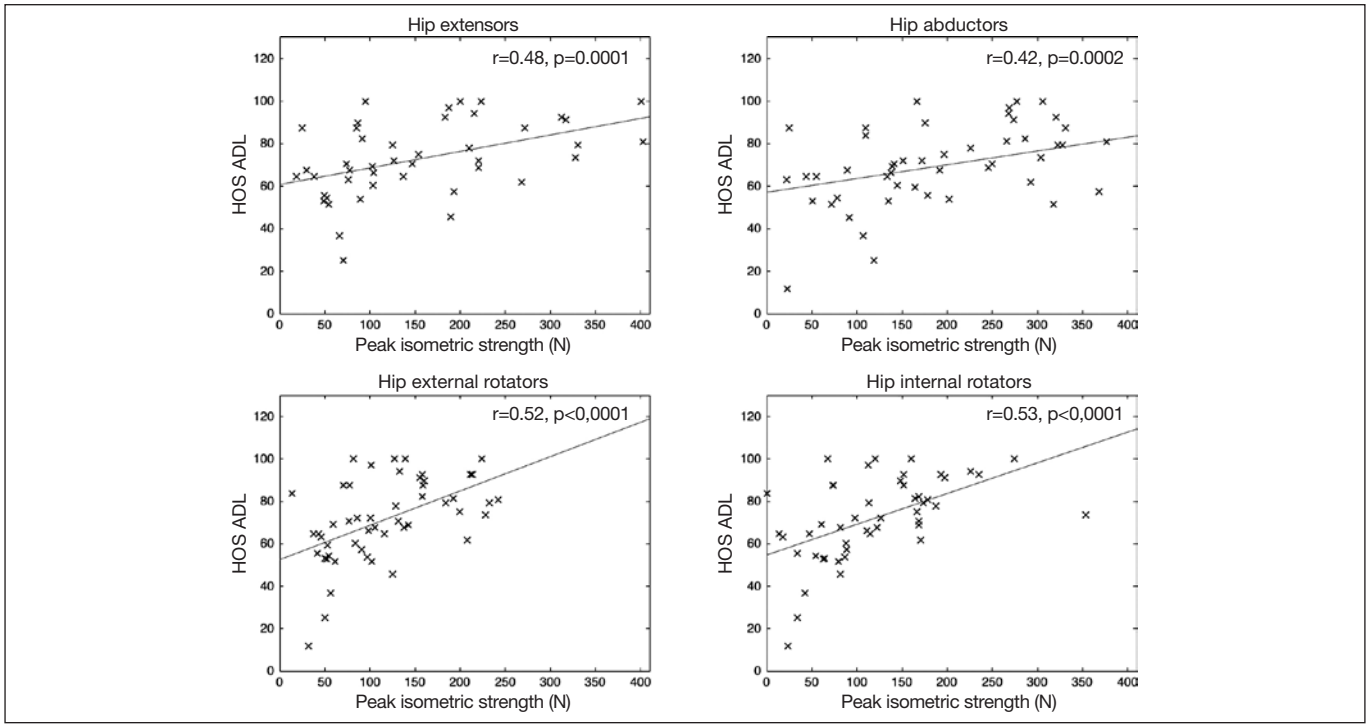

Figure 1. Correlation between peak isometric hip muscles strength, in Newtons, and results of Hip Outcome Score, in the domain of Activities of Daily Living (HOS-ADL).

The continuous line represents the regression curve between variables. Upper left: Hip extensors strength; Upper right: Hip abductors strength; Lower left: Hip external rotators strength; Lower right: Hip internal rotators strength. "r" refers to the correlation coefficient; and "p" to p-value (significance level at 0.05). The more diagonal the continuous line is, the better the correlation between variables.

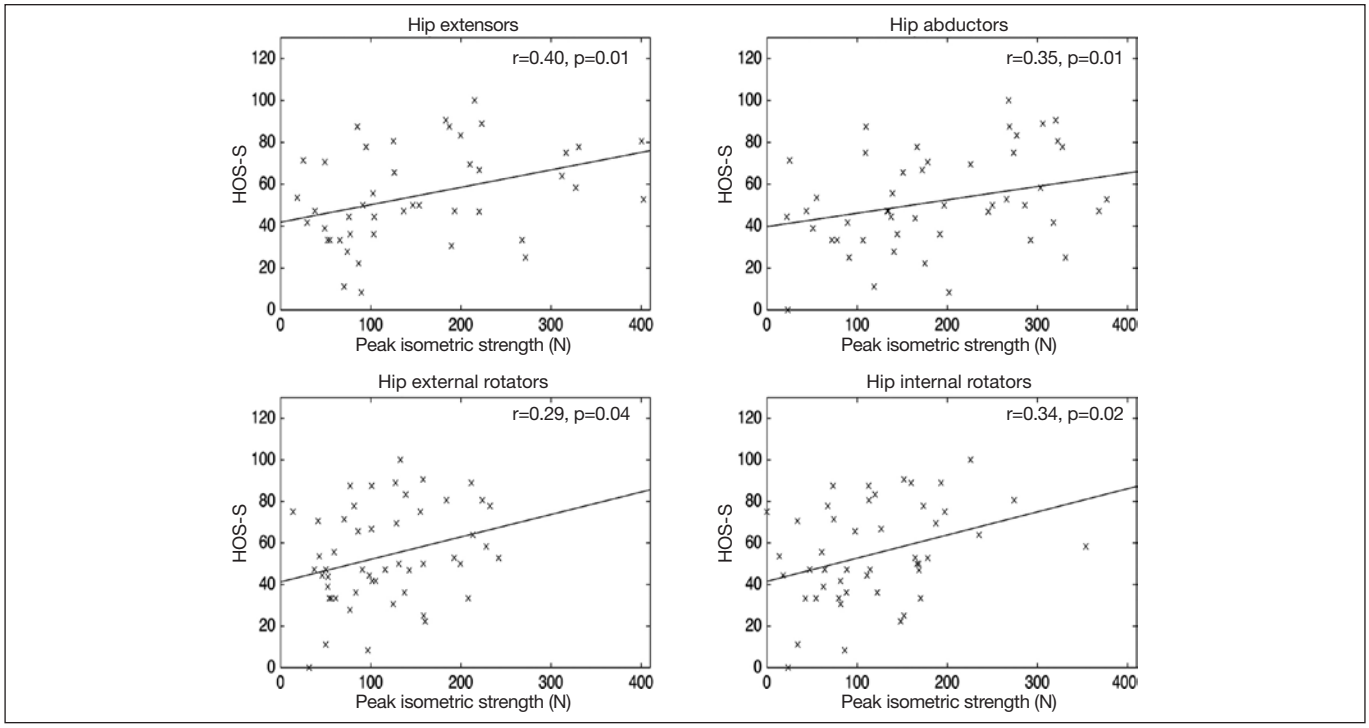

Figure 2. Correlation between peak isometric hip muscles strength, in Newtons, and results of Hip Outcome Score, in the domain of Sports (HOS-S).

The continuous line represents the regression curve between variables. Upper left: Hip extensors strength; Upper right: Hip abductors strength; Lower left: Hip external rotators strength; Lower right: Hip internal rotators strength. "r" refers to the correlation coefficient; and "p" to p-value (significance level at 0.05). The more diagonal the continuous line is, the better the correlation between variables.

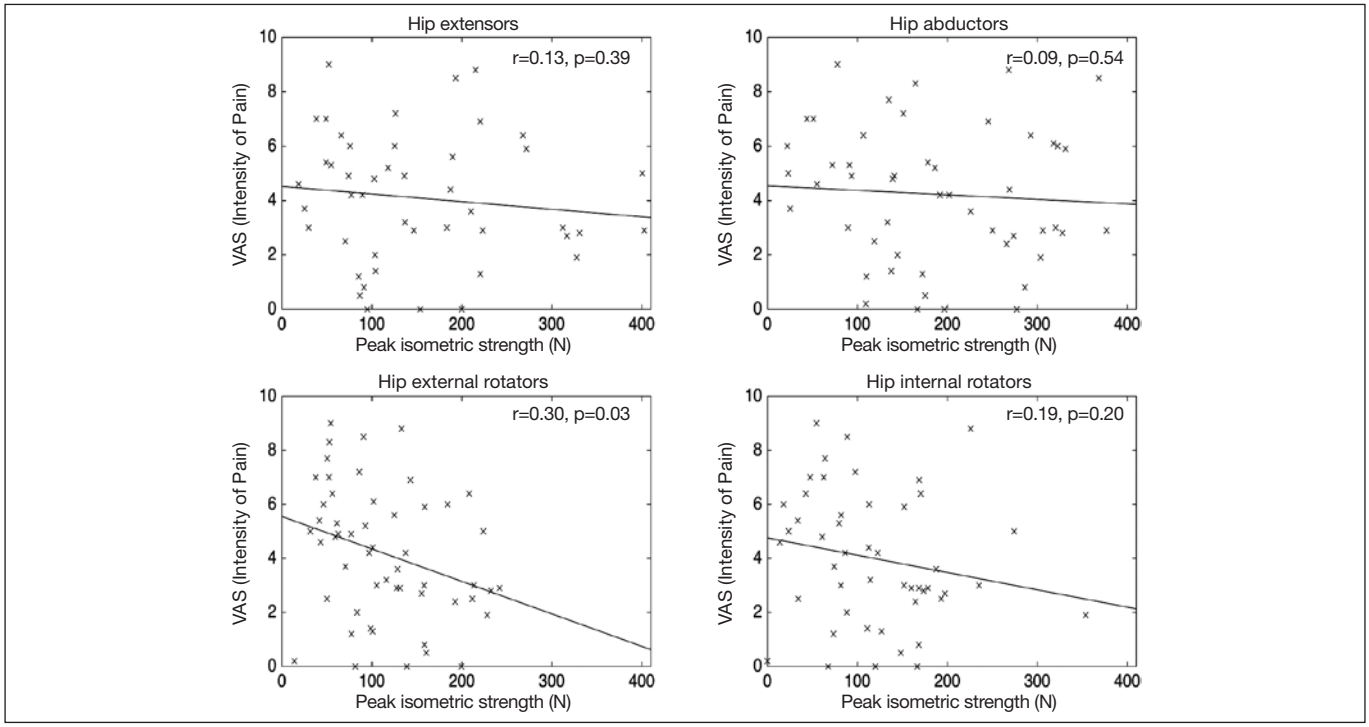

Figure 3. Correlation between peak isometric hip muscles strength, in Newtons, and results of visual analog scale for intensity of pain

The continuous line represents the regression curve between variables. Upper left: Hip extensors strength; Upper right: Hip abductors strength; Lower left: Hip external rotators strength; Lower right: Hip internal rotators strength. "r" refers to the correlation coefficient; and "p" to p-value (significance level at 0.05). The more diagonal the continuous line is, the better the correlation between variables.

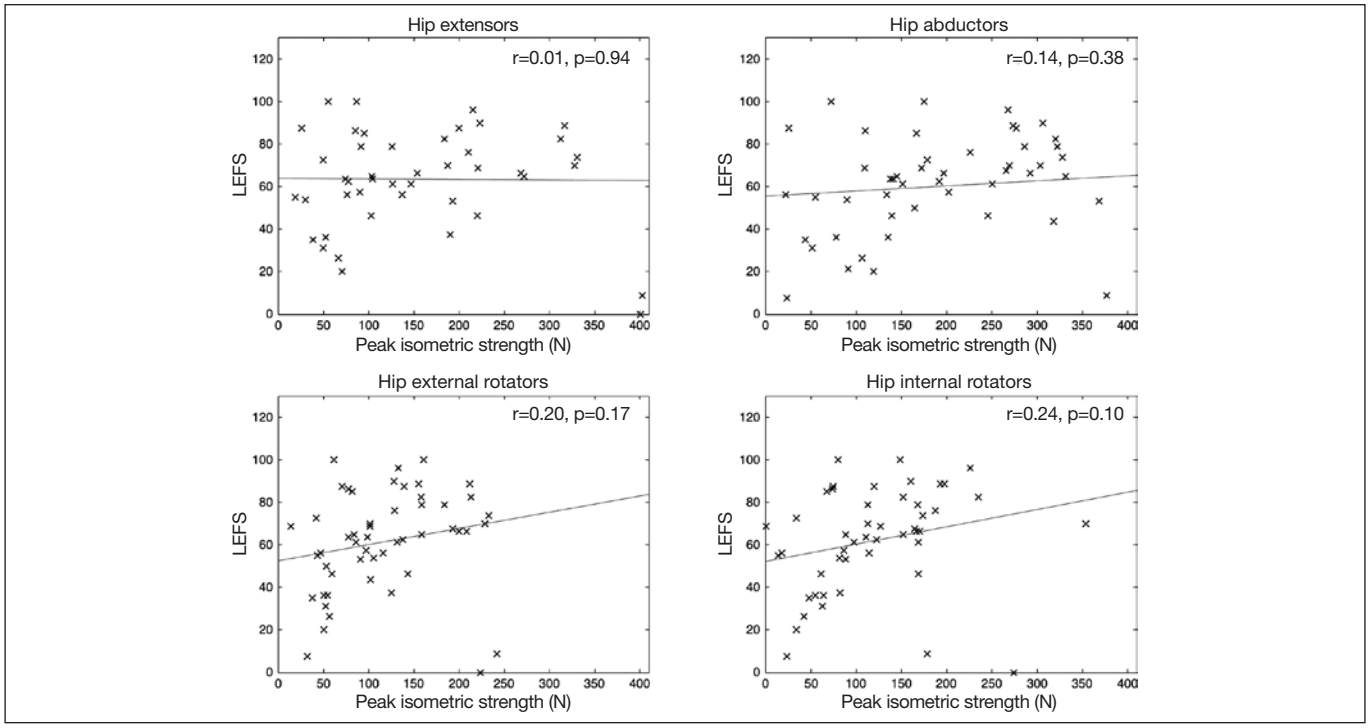

Figure 4. Correlation between peak isometric hip muscles strength, in Newtons, and results of Lower Extremity Functional Score (LEFS).

The continuous line represents the regression curve between variables. Upper left: Hip extensors strength; Upper right: Hip abductors strength; Lower left: Hip external rotators strength; Lower right: Hip internal rotators strength. "r" refers to the correlation coefficient; and "p" to p-value (significance level at 0.05). The more diagonal the continuous line is, the better the correlation between variables.

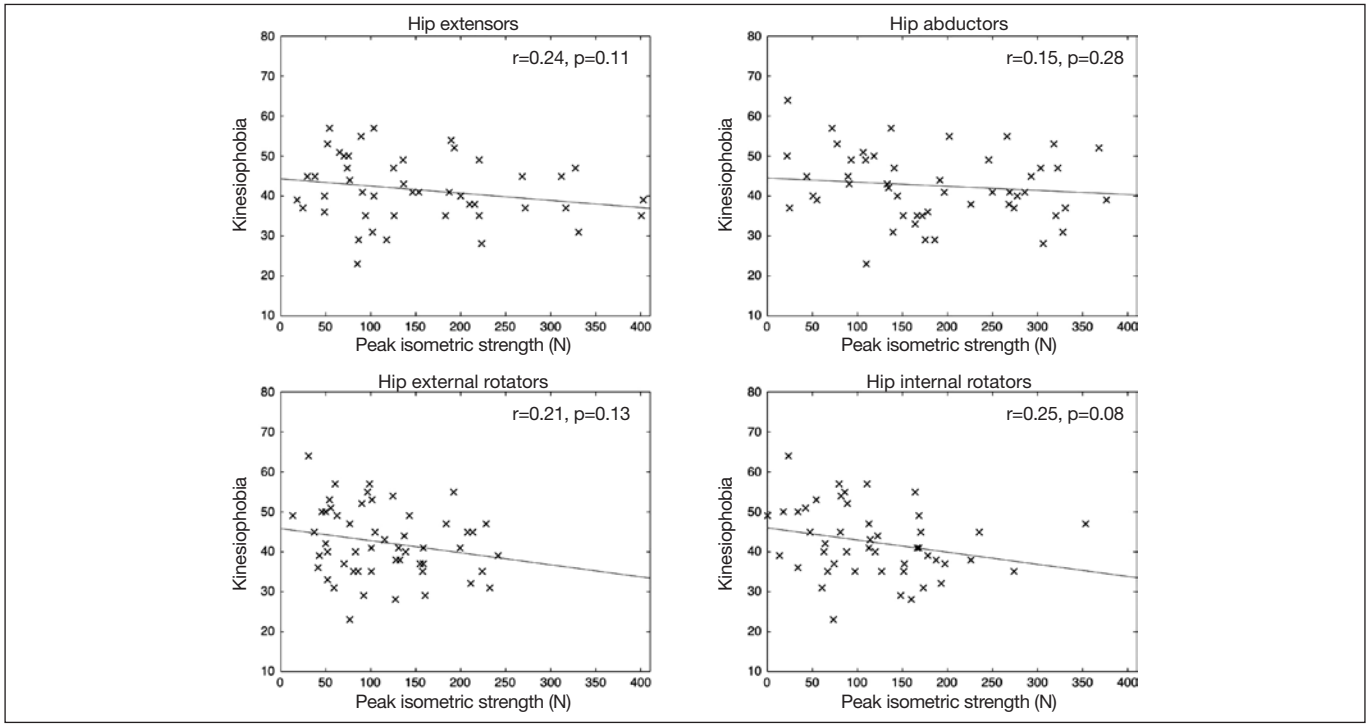

Figure 5. Correlation between peak isometric hip muscles strength, in Newtons, and results of Tampa Scale for Kinesiophobia.

The continuous line represents the regression curve between variables. Upper left: Hip extensors strength; Upper right: Hip abductors strength; Lower left: Hip external rotators strength; Lower right: Hip internal rotators strength. "r" refers to the correlation coefficient; and "p" to p-value (significance level at 0.05). The more diagonal the continuous line is, the better the correlation between variables.

DISCUSSION

The main findings of this study were that the peak hip muscle strength correlated significantly with the level of hip functionality, but not with the levels of overall functionality of the lower limbs and the degree of kinesiophobia. The significant correlation between the HOS-ADL and HOS-S and peak hip strength is consistent with the results of others studies[5-7]. Results from previous studies show that individuals with chronic hip pain tended to have lower levels of muscle strength compared with asymptomatic individuals[5].

The correlation between hip extensors, abductors and external rotators strength and hip functionality in patients with chronic pain might be explained by the tendency for the individual to reduce their physical activity as a result of the pain[18], resulting in a reduction in the maximum capacity to generate muscle force. However, only a part of the variability in the functional capacity of the hip seems to be related to muscle strength, which suggests that other aspects also influence the functionality of patients with chronic hip pain, a hypothesis based on the findings of the study[19]. This finding highlights the importance of physical and functional assessments for every patient to identify specific disorders and to develop individual physical rehabilitation programs, instead of predefined protocols.

Because this study covered a large age range, there may have been a tendency to have a sample of individuals that performed low-intensity physical activities. Therefore, the questions of the sports sub-scale were less relevant to their daily realities. However, impairments in their capacity to generate muscle strength appear to exert an important influence on activities of daily living. The significant relationship between muscle strength and functional capacity identified in the present study may explain the success of strengthening programs in improving the functionality of patients with hip injuries[20], which could lead to future studies primarily designed to examine possible causal links.

The LEFS did not have a significant relationship with the peak strength of the hip muscle groups investigated. The LEFS is designed to measure the functional status of the lower limbs as a whole[21] and does not have specific questions related to tasks that induce greater demand on the hip joint. Other muscles and structures are also important for an adequate level of functional capacity of the lower limb[22]. This result is based on the fact that other structures should be approached therapeutically in patients with chronic hip pain, besides hip muscles[23]. Similarly, study[24] reported a more pronounced improvement in LEFS in patients with patellofemoral pain who underwent strengthening programs involving the trunk, hip and knee muscles compared with isolated strengthening of the knee joint muscles. However, there are no data on whether the same response can be applied to patients with hip pain. In fact, there is a possibility that patients with low LEFS benefit from rehabilitation programs that involve more segments than those primarily affected, but future studies are needed to confirm this hypothesis.

There was an inverse relationship between the peak strength of the external hip rotators and the VAS scores; that is, as the peak strength of external rotators of the hip increased, there was less pain and, consequently, increased functionality. The non-significant correlation between peak muscle strength and the degree of kinesiophobia indicates the possibility that the maximum strength was not directly influenced by psychological parameters. The absence of a significant association between psychological factors and maximal hip strength observed in the present study is like that found by study[25], for patients with chronic pain in the cervical region, and by other study[26], for patients after meniscectomy of the knee. However, there is evidence that psychological factors can influence the success of rehabilitation[27,28]. Study[29] suggests that the most important factor in patients with kinesiophobic components is muscle activation deficit due to arthrogenic muscle inhibition, rather than a reduction in maximum force.

The use of an isometric dynamometer is a limitation of the present study. Despite the high correlation between measurements with isometric and isokinetic dynamometers[30], the use of an isometric dynamometer did not allow for an evaluation of the functionality of concentric and eccentric forces. A second limitation was the use of subjective patient-reported questionnaires to measure hip and overall functionality. The use of quantitative variables, such as walking speed and hip mobility during gait and squatting, could allow more precise indicators of functionality and should be performed in future studies.

CONCLUSION

The reduction in peak strength of the hip extensors, abductors and external rotators was associated with a reduction in the level of hip functionality but did not correlate with either the level of overall functionality of the lower limbs or the degree of kinesiophobia. Also, a reduction of hip external rotators strength was related to an increase in the degree of pain.

ACKNOWLEDGMENTS

The authors would like to thank Carla Mattos and Gabriel Zeitoune for their assistance in data collection.

AUTHORS' CONTRIBUTION

Gustavo Leporace
Data Collection, Methodology, Writing – Preparation of the original, Writing – Review and Editing, Supervision
Luiz Alberto Batista
Methodology, Writing – Preparation of the original, Writing – Review and Editing, Supervision
Leonardo Metsavaht
Statistical Analysis, Methodology, Writing – Preparation of the original, Writing – Review and Editing
Jorge Chahla
Statistical Analysis, Writing – Review and Editing
Tainá Oliveira
Data Collection, Writing – Review and Editing
Liszt Palmeira de Oliveira
Statistical Analysis, Writing – Review and Editing, Supervision

REFERENCES

1. Burnett RS, Della Rocca GJ, Prather H, Curry M, Maloney WJ, Clohisy JC. Clinical presentation of patients with tears of the acetabular labrum. J Bone Joint Surg Am. 2006;88(7):1448-57.
2. Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. Knee Surg Sports Traumatol Arthrosc. 2007;15(7):908-14.
3. Rosenlund S, Broeng L, Holsgaard-Larsen A, Jensen C, Overgaard S. Patient-reported outcome after total hip arthroplasty: comparison between lateral and posterior approach. Acta Orthop. 2017;88(3):239-47.
4. Allison K, Bennell KL, Grimaldi A, Vicenzino B, Wrigley TV, Hodges PW. Single leg stance control in individuals with symptomatic gluteal tendinopathy. Gait Posture. 2016;49:108-13.
5. Harris-Hayes M, Mueller MJ, Sahrmann SA, Bloom NJ, Steger-May K, Clohisy JC, et al. Persons with chronic hip joint pain exhibit reduced hip muscle strength. J Orthop Sports Phys Ther. 2014;44(11):890-8.
6. Arokoski MH, Arokoski JP, Haara M, Kankaanpää M, Vesterinen M, Niemitukia LH, et al. Hip muscle strength and muscle cross sectional area in men with and without hip osteoarthritis. J Rheumatol. 2002;29(10):2185-95.
7. Loureiro A, Mills PM, Barrett RS. Muscle weakness in hip osteoarthritis: a systematic review. Arthritis Care Res. (Hoboken) 2013;65(3):340-52.
8. Neumann DA. Kinesiology of the hip: a focus on muscular actions. J Orthop Sports Phys Ther. 2010;40(2):82-94.
9. Charnley J. The long-term results of low-friction arthroplasty of the hip performed as a primary intervention. J Bone Joint Surg Br. 1972;54(1):61-76.
10. Oliveira LP, Moura Cardinot T, Nunes Carreras Del Castillo L, Cavalheiro Queiroz M, Cavalli Polesello G. Translation and cultural adaptation of the Hip Outcome Score to the Portuguese language. Rev Bras Ortop. 2014;49(3):297-304.
11. Metsavaht L, Leporace G, Riberto M, Sposito MM, Del Castillo LN, Oliveira LP, et al. Translation and cross-cultural adaptation of the lower extremity functional scale into a Brazilian Portuguese version and validation on patients with knee injuries. J Orthop Sports Phys Ther. 2012;42(11):932-9.
12. de Souza FS, Marinho Cda S, Siqueira FB, Maher CG, Costa LO. Psychometric testing confirms that the Brazilian-Portuguese adaptations, the original versions of the Fear-Avoidance Beliefs Questionnaire, and the Tampa Scale of Kinesiophobia have similar measurement properties. Spine (Phila Pa 1976) 2008;33(9):1028-33.
13. Stratford PW, Balsor BE. A comparison of make and break tests using a hand-held dynamometer and the Kin-Com. J Orthop Sports Phys Ther. 1994;19(1):28-32.
14. Ieiri A, Tushima E, Ishida K, Inoue M, Kanno T, Masuda T. Reliability of measurements of hip abduction strength obtained with a hand-held dynamometer. Physiother Theory Pract. 2015;31(2):146-52.
15. Katoh M. Reliability of isometric knee extension muscle strength measurements made by a hand-held dynamometer and a belt: a comparison of two types of device. J Phys Ther Sci. 2015;27(3):851-4.
16. Kim SG, Lee YS. The intra- and inter-rater reliabilities of lower extremity muscle strength assessment of healthy adults using a hand held dynamometer. J Phys Ther Sci. 2015;27(6):1799-801.
17. Malloy PJ, Morgan AM, Meinerz CM, Geiser CF, Kipp K. Hip external rotator strength is associated with better dynamic control of the lower extremity during landing tasks. J Strength Cond Res. 2016;30(1):282-91.
18. Swarup I, Shields M, Mayer EN, Hendow CJ, Burket JC, Figgie MP. Outcomes after total hip arthroplasty in young patients with osteonecrosis of the hip. Hip Int. 2017;27(3):286-92.
19. Casartelli NC, Maffiuletti NA, Item-Glatthorn JF, Impellizzeri FM, Leunig M. Hip muscle strength recovery after hip arthroscopy in a series of patients with symptomatic femoroacetabular impingement. Hip Int. 2014;24(4):387-93.
20. Harris-Hayes M, Czuppon S, Van Dillen LR, Steger-May K, Sahrmann S, Schootman M, et al. Movement-pattern training to improve function in people with chronic hip joint pain: a feasibility randomized clinical trial. J Orthop Sports Phys Ther. 2016;46(6):452-61.
21. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network. Phys Ther. 1999;79(4):371-83.
22. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH. Physical activity and exercise for chronic pain in adults: an overview of Cochrane Reviews. Cochrane Database Syst Rev 2017;4:CD011279.
23. Rydevik K, Fernandes L, Nordsletten L, Risberg MA. Functioning and disability in patients with hip osteoarthritis with mild to moderate pain. J Orthop Sports Phys Ther. 2010;40(10):616-24.
24. Baldon Rde M, Serrão FV, Scattone Silva R, Piva SR. Effects of functional stabilization training on pain, function, and lower extremity biomechanics in women with patellofemoral pain: a randomized clinical trial. J Orthop Sports Phys Ther. 2014;44(4):240-51.
25. Pearson I, Reichert A, De Serres SJ, Dumas JP, Côté JN. Maximal voluntary isometric neck strength deficits in adults with whiplash-associated disorders and association with pain and fear of movement. J Orthop Sports Phys Ther. 2009;39(3):179-87.
26. Hsu CJ, George SZ, Chmielewski TL. Association of quadriceps strength and psychosocial factors with single-leg hop performance in patients with meniscectomy. Orthop J Sports Med. 2016;4(12):2325967116676078.
27. Cotchett M, Lennecke A, Medica VG, Whittaker GA, Bonanno DR. The association between pain catastrophising and kinesiophobia with pain and function in people with plantar heel pain. Foot (Edinb). 2017;32:8-14.
28. Løchting I, Garratt AM, Storheim K, Werner EL, Grotle M. The impact of psychological factors on condition-specific, generic and individualized patient reported outcomes in low back pain. Health Qual Life Outcomes. 2017;15(1):40.
29. Freeman S, Mascia A, McGill S. Arthrogenic neuromusculature inhibition: a foundational investigation of existence in the hip joint. Clin Biomech. (Bristol, Avon) 2013;28(2):171-7.
30. Stark T, Walker B, Phillips JK, Fejer R, Beck R. Hand-held dynamometry correlation with the gold standard isokinetic dynamometry: a systematic review. PM R. 2011;3(5):472-9.