Patients Who Present with Functional Limitations, Limited Range of Motion and Reduced Muscle Strength 6 Months after Total Hip Arthroplasty: A Cross-Sectional Study*

Pacientes que apresentam limitações funcionais, amplitude de movimento limitada e força muscular reduzida, 6 meses após a artroplastia total do quadril: um estudo de corte transversal

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Rev Bras Ortop 2022;57(6):953–961.

Abstract

Objective To evaluate levels of pain, range of motion, hip isometric peak torque, and functional task performance in patients 6 months after total hip arthroplasty (THA) and to compare them to asymptomatic control participants (CG).

Methods We recruited participants with unilateral THA due to hip osteoarthritis (OA) within a median of 6 months who had not developed postoperative complications. We assessed the pain levels, hip range of motion, peak isometric torque, self-reported assessment (Harris Hip Score) and objectively measured function (Timed Up & Go Test [TUG]) of the patients. The THA group was compared with a group of asymptomatic participants ≥50 years old recruited in the community. Comparisons are presented as mean differences (MDs) and 95% confidence intervals (CIs).

Keywords
- osteoarthritis
- hip joint
- arthroplasty

* *Work developed at the Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA), Porto Alegre, RS, Brazil*

received
October 17, 2020
accepted
February 19, 2021
published online
October 13, 2021

DOI https://doi.org/10.1055/s-0041-1732388.
ISSN 0102-3616.

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Results A total of 23 participants were included in each group. Pain levels were low in the THA group (1.48 [1.60]), and 91.3% of the patients reported to be satisfied with the surgical procedure. Participants in the THA group reported significantly lower objectively measured (THA 12.2 [10.0–21.6]; CG 9.0 [6.7–12.2]) and self-reported function (THA 78.5 [43.8–93.9]; CG 100.0 [95.8–100.0]) compared with CG. The THA group also had significantly reduced range of motion for flexion ($p < 0.001$), internal ($p < 0.001$) and external rotation ($p = 0.003$) movements and reduced peak torque for flexion ($p < 0.001$), extension ($p < 0.001$), abduction ($p < 0.001$) and adduction ($p = 0.024$) movements compared with participants of the CG.

Conclusions Despite reporting overall low pain scores and satisfaction with the surgery, the patients present with functional limitations, limited range of motion, and reduced muscle strength 6 months after THA.

Evidence Level 3b

Resumo

Objetivos Avaliar os níveis de intensidade da dor, amplitude de movimento, pico de torque isométrico do quadril e desempenho da tarefa funcional em pacientes 6 meses após a artroplastia total do quadril (ATQ), e comparar estes valores com os de participantes assintomáticos do grupo controle (GC).

Métodos Recrutamos participantes com ATQ unilateral devida a osteoartrite (OA) do quadril, dentro de uma mediana de tempo de 6 meses, que não tinham desenvolvido complicações pós-operatórias. Os participantes foram avaliados quanto à intensidade da dor, à amplitude de movimento do quadril, ao pico de torque isométrico, à autoavaliação (questionário de avaliação do quadril Harris Hip Score [HHS, na sigla em inglês) e à função medida objetivamente por meio do teste Timed Up and Go (TUG, na sigla em inglês). O grupo ATQ foi comparado com um grupo de participantes assintomáticos com idade $\geq$ 50 anos recrutados na comunidade. As comparações são apresentadas como diferenças médias (DMs) e intervalos de confiança (ICs) de 95%.

Resultados Cada grupo contou com 23 participantes. A intensidade da dor foi baixa no grupo ATQ (1,48 [1,60]), sendo que 91,3% dos pacientes relataram estar satisfeitos com o procedimento cirúrgico. Os participantes do grupo ATQ relataram uma função medida objetivamente significativamente menor (ATQ 12,2 [10,0-21,6]; GC 9,0 [6,7-12,2]) e a função autoavaliação (ATQ 78,5 [43,8-93,9]; GC 100,0 [95,8-100,0]), em comparação com o GC. O grupo ATQ também teve reduzida de forma significativa a amplitude de movimento para flexão ($p < 0{,}001$), os movimentos internos ($p < 0{,}001$) e de rotação externa ($p = 0{,}003$). O grupo ATQ também apresentou pico de torque reduzido para flexão ($p < 0{,}001$), extensão ($p < 0{,}001$), movimentos de abdução ($p < 0{,}001$) e adução ($p = 0{,}024$) em comparação com os participantes do GC.

Conclusões Apesar de informarem escores gerais de dor de baixa intensidade e satisfação com a cirurgia, os pacientes apresentaram limitações funcionais, amplitude de movimento limitada e redução da força muscular após 6 meses do procedimento cirúrgico de ATQ.

Nível de Evidência 3B

Palavras-chave
- osteoartrite
- articulação do quadril
- artroplastia

Introduction

Total hip arthroplasty (THA) is a last resort procedure for the treatment of advanced osteoarthritis (OA) of the hip, usually when outcomes of nonsurgical treatments have not been satisfactory.[1] More THAs are being performed every year worldwide. For example, from 2003 to 2013, the rate of THAs in Australia increased from 88 to 119 per 100,000 inhabitants.[2] In the United States, rates of THA have increased from 142 in 2000 to 257 per

100,00 inhabitants in 2010, corresponding to 310,800 surgeries.[3] The THA rates are expected to increase even more by 2030; 175% in the United States and 208% in Australia.[3]

The success rates of THA are high, reported as ranging from 84 to 97%.[4] An important predictor of patient satisfaction with THA is postoperative function.[5] Previous studies have shown that patients post-THA display reduced function and ability to perform domestic and social activities,[6] as well as increased risk of falls.[7] These studies, however, have many limitations. For example, some included patients within a broad age range (between 24 and 70 years old),[8] with very different postoperative periods (ranging from 9 to 72 months),[6] with OS in other lower limb joints,[9] and patients who needed THA surgery due to trauma instead of to degenerative diseases.[6] Combining patients with such different characteristics ignores the fact that the prognosis of patients who undergo THA due to fracture or degenerative disease is different,[10,11] and so are the function levels in people with different postoperative times.[12] Other studies did not have a control group (CG),[8,13] which limits the understanding of differences between people with similar demographic characteristics with and without THA. Furthermore, because post-THA patients are at increased risk of falls due to muscle weakness, among other factors, and because the rate of falls among these patients is typically higher shortly after the surgery,[14] early investigation of functional and strength deficits in post-THA patients could be helpful to obtain insights into potential strategies to prevent falls and other functional complications.

Therefore, the aim of the present study was to assess a cohort of post-THA patients in terms of objectively-measured and self-reported function, pain levels, hip range of motion (ROM), and peak isometric torque, and to compare them with a group of participants with similar characteristics from the community. We hypothesized that post-THA patients would have low pain scores and high satisfaction rates, but would have decreased function, both in terms of objectively-measured and self-reported function when compared with control individuals.

Methods

Participants and Settings

The present cross-sectional study is reported according to the STROBE statement recommendations.[15] The present study was approved by the Ethics Committee (approval number: 925.402). We registered the study retrospectively at ClinicalTrials.gov (NCT03657680). All participants provided informed consent prior do data collection.

We examined electronic medical records from three hospitals to obtain from data collection a list of patients who had undergone primary unilateral THA (lateral and posterolateral approach) due to hip OA within 5 to 8 months (mean: 6 months [5 to 10]) and who did not develop postoperative complications (infections, deep vein thrombosis and/or dislocation of the prosthetic component). We excluded individuals who had previously undergone any type of surgery in the lower limbs, who had clinical signs of OA in other lower limb joints according to the American College of Rheumatology criteria,[16] and who presented with disabling neurological or cardiovascular conditions (such as cardiac insufficiency, stroke damage, and neurodegenerative diseases). To serve as a CG, we recruited participants $\geq$ 50 years old living in the community with an asymptomatic hip and who were not engaged in any form of physical activity.

Data Collection

The participants attended a single evaluation session with the same experienced and trained assessor.

Objectively-measured function was determined using the Timed Up and Go (TUG) test.[17,18] To perform the TUG test, the participants were instructed to stand up from an armless chair and walk for three meters, at their usual speed, using their assistive devices if needed, to a mark drawn on the floor, then to turn around, return to the chair, and sit down.[17,18] The test was first demonstrated by the evaluator and practiced by the participant once before it was officially recorded by the evaluator. We used range values reported in the population[19] to dichotomize participants into those with and without objectively-measured functional impairment.

Self-reported function was measured with the Harris Hip Score (HHS) (with scores ranging from zero to 100, where 100 means perfect function).[20] The HHS assesses multiple domains, including pain, function, deformity, and ROM. We classified the participants according to the following cutoffs: poor ($<$ 70 points); normal (70–79); good (80–89); and excellent (90–100).[20,21]

Active hip flexion, extension, abduction, external and internal rotation ROM were measured on both limbs in the THA group and in the dominant limb in participants in the CG by a single examiner using a fleximeter (FL6010 model, Sanny, Brazil). Prior to collecting data, we conducted a test-retest reliability assessment of hip ROM measurements using the fleximeter. The reliability assessment consisted of 2 ROM measurements supervised by the same examiner performed with a 20-minute interval between them in 15 patients with unilateral THA for hip flexion, extension, abduction, internal rotation, and external rotation. Our reliability for the measures was considered excellent (intraclass correlation coefficient – ICC = 0.935–0.994; $p = 0.02$–0.001) for all movements. Movements were assessed in the following positions: hip flexion, lying in supine, starting with the knee extended and ending with it flexed; hip extension and abduction, in standing position; and hip internal and external rotation, with the patient sitting on the edge of the table, with the hip and the knee flexed at 90° (►**Fig. 1**). The

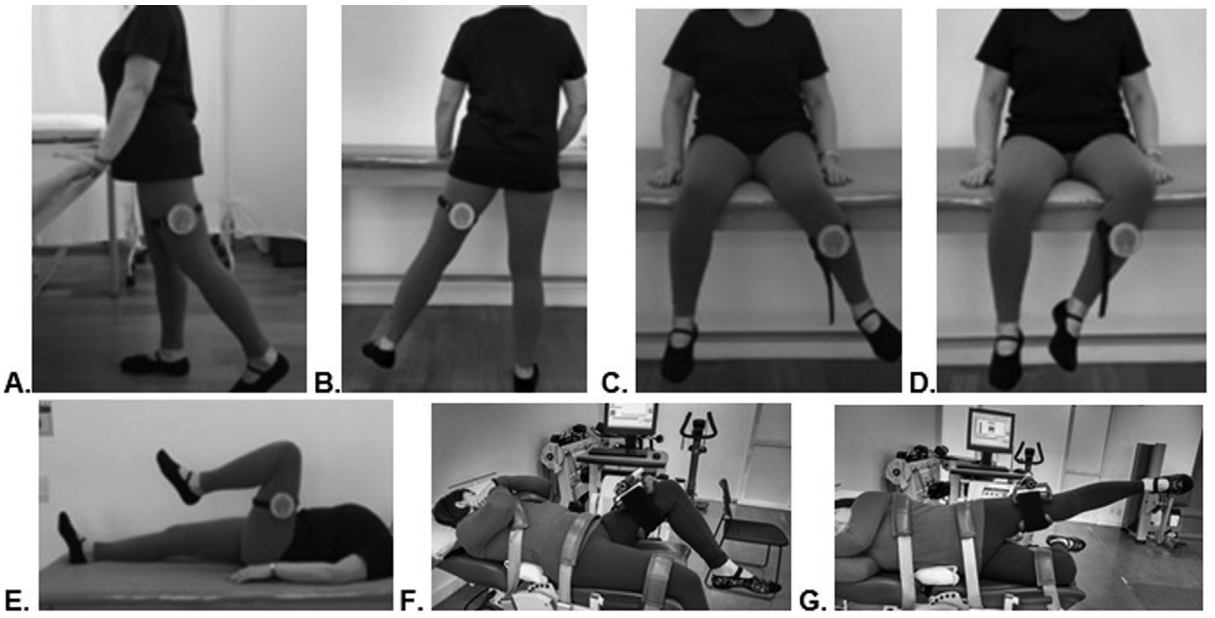

Fig. 1 Range of motion and muscle torque assessment positions. **A.** Assessment of left hip extension; **B.** Assessment of left hip abduction; **C.** Assessment of left hip internal rotation; **D.** Assessment of left hip external rotation; **E.** Assessment of left hip flexion; **F.** Assessment of left lower limb hip flexors and extensors muscle torque; **G.** Assessment of left lower limb hip abductors and adductors muscle torque.

participants performed every movement once. One of the evaluators observed if any compensation occurred, such as inclination of the pelvis and/or of the trunk. If compensations were observed, the test was interrupted and performed again (►**Fig. 1**). Hip adduction ROM was not tested to respect postoperative precautions.

We assessed peak isometric torque of the hip muscles using the BiodexTM Multi Joint System 4 Pro isokinetic dynamometer (Biodex Medical Systems, New York, NY, USA).[12,22,23] Participants in the THA group had both limbs assessed, whereas participants in the CG had the dominant limb assessed.

For hip flexor and extensor torque assessment, the chair was set with 0° inclination and the greater trochanter was used as reference for alignment of the rotation axis of the dynamometer.[24] Both hip flexors and extensors were evaluated with the participant in the supine position, the tested limb in 45° of hip flexion, and the contralateral limb in extension (►**Fig. 1**). The resistance pad of the lever arm was set ~ 3 centimeters above the patella. For hip abductor and adductor torque assessment, the chair was set with 0° inclination and the greater trochanter was used as reference for alignment of the rotation axis of the dynamometer.[24] Both hip abductors and adductors assessments were performed in the side-lying position (►**Fig. 1**), with the tested limb placed in 15° of hip abduction with the resistance pad of the lever arm lateral to the thigh, while the contralateral limb remained in flexion.

The position of the participants was maintained using stabilizing straps around the trunk, the pelvis and the contralateral limb.[11] The positions considered the posoperative limitations of THA and were base on the studies of Bertocci et al[24]. and Bijur et al.[24]. Each muscle group evaluation was preceded by an explanation of the test, as well as three submaximal muscle contractions for familiarization and warm-up.[24] Three attempts with a duration of 5 seconds were performed for each muscle group, with a 90 seconds interval between each attempt. The participants were encouraged to exert their maximum strength during each attempt through verbal incentive by the examiner. The peak hip torque was normalized according to body weight, using the equation: normalized peak torque = peak torque (Nm)/ body weight (kg) x 100.

Sample-size estimation calculations were based on detecting a 7.5Nm/kg difference on hip abductors muscle torque,[24] assuming a standard deviation (SD) of 5.4 for the THA group and of 11.3 for the CG, two-tailed, an alpha level of 0.05, an effect size of 0.93, and a 95% power. A sample size of 42 subjects, 21 per group, was determined.

We assessed the intensity of hip pain in the operated limb from participants in the THA group, and in the dominant limb from participants in the CG. A 10-centimeter visual analog scale (VAS) was used.[25] The participants were instructed to consider the worst pain they felt in the last week. The satisfaction of the patients with the procedure was assessed through direct questions, with "yes" or "no" answers.

Data normality was determined by means of the Shapiro-Wilk test. We used means (SD) or medians (95%CI) or median (min-max) to describe continuous variables when appropriate, and frequencies and proportions to describe categorical variables. The Mann-Whitney test was used to compare THA and control participants in terms of objectively-measured function (TUG test), self-reported function (HHS), and pain.

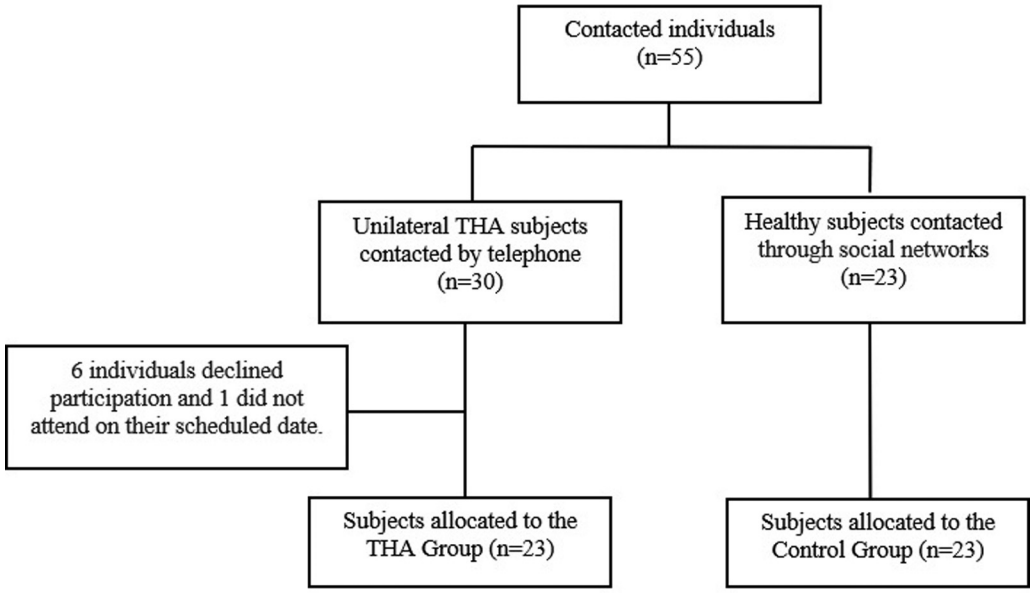

Fig. 2 Sample flowchart.

Hip ROM and peak isometric torque were compared within participants in the THA group (operated versus nonoperated limb) and between groups (operated versus dominant limb in the CG). For that, we used a 2×3 analysis of covariance (ANCOVA) followed by the Sidak post-hoc test. We adjusted between-group comparisons by body mass index (BMI) and age. A significance level of 0.05 was adopted, and the analyses were completed using SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

From June 2015 to January 2016, 55 potential participants were contacted. Six declined to participate and one did not attend the assessment session. Of these, 23 participants met the eligibility criteria and were included in the THA group, and another 23 asymptomatic participants were included in the CG (►**Fig. 2**). The characteristics of the participants are shown in ►**Table 1**.

Table 1 Total hip arthroplasty group (THA) and control group (CG) characterization

	THA ($n = 23$)	CG ($n = 23$)	*p-value*
Gender (M/F)	13/10	10/13	0.382
Age (years old)	62.91 ± 6.69	57.86 ± 6.67	0.015
BMI (kg/m^2)	31.18 ± 5.83	27.05 ± 3.48	0.012
VAS Pain	1.48 ± 1.60	0.28 ± 0.51	0.001
PO rehabilitation program (Y/N)	9/14	–	–
PO period (months)	6.52 ± 1.44	–	–
Prosthesis type (H/C)	8/15	–	–
Surgical approach (L/PL)	7/16	–	–
Assistive device – one crutch (Y/N)	8/15	–	–
HHS	78.55 (43.84–93.80)	100.00 (95.80–100.00)	0.001
TUG (s)	12.24 (10.00–21.60)	9.00 (6.66–12.24)	0.001
Functional impairment (Y/N)	22/1	11/12	0.001

Abbreviations: BMI, body mass index; C, cemented; CG, control group; F, female; H, hybrid; HHS, Harris hip score; L, lateral; M, male; N, no; PL, post-lateral; PO, postoperative; THA, total hip arthroplasty; TUG, timed up and go; VAS, visual analogue scale; Y: yes.
Values expressed as median (min-max) or mean $\pm$ standard deviation.

The THA group showed higher values of age and BMI than the CG. Only 9 (39.13%) of the 23 patients in the THA group participated in rehabilitation programs, which were unrelated to the present study. The other patients were still waiting for a vacancy in the public health system for physical therapy sessions. Out of the 23 participants in the THA group, 9 (39.13%) were using assistive devices (one crutch) for walking. Most patients (91.3%) in the THA group reported to be satisfied with surgical procedure and underwent surgery with a posterolateral approach (70%) and implementation of cemented prosthesis (65%). Regardless of how the prosthesis was fixed, all patients had an early weight-bearing release on the operated limb.

Objectively-measured Function

Compared with control participants, the THA group demonstrated significantly reduced performance on the TUG test (THA 12.2 [10.0–21.6] versus CG 9.0 [6.7–12.2]; $p = 0.001$) (►**Table 1**).

Self-reported Function

Participants in the THA group had significantly lower self-reported function compared with the CG (THA 78.5 [43.8–93.9] versus CG 100.0 [95.8–100.0]; $p = 0.001$) (►**Table 1**).

Pain

Participants in the THA group had slightly more pain (1.48 [1.60]) compared with participants in the CG (0.28 [0.51]). The difference between groups was statistically significant (1.20 [0.49–1.92]; $p < 0.001$), but of questionable clinical importance (►**Table 1**).

Range of Motion

There was a significant group-by-limb interaction for flexion ($F = 36.2$; $p < 0.001$), abduction ($F = 15.1$; $p < 0.001$), internal rotation ($F = 25.5$; $p < 0.001$), external rotation ($F = 27.8$; $p < 0.001$), but not for extension ($F = 2.1$; $p = 0.098$). Compared with the unaffected limb, the affected limb of participants with THA had significantly reduced flexion, internal, and external rotations. Compared with control participants, participants in the THA group showed significantly reduced flexion, internal, and external rotations in both the affected and unaffected limbs. The magnitude of differences was more pronounced in the comparisons between the operated limb and the dominant limb in participants of the CG (►**Table 2**).

Peak Torque

There was a significant group-by-limb interaction for flexion ($F = 8.7$; $p < 0.001$), extension ($F = 4.0$; $p = 0.009$), abduction ($F = 20.9$; $p < 0.001$), and adduction ($F = 4.3$; $p = 0.016$). Participants in the THA group showed significant reduced torque values in the affected limb for flexion and abduction when compared with the unaffected limb. Compared with control participants, the THA group showed significantly reduced peak torque values for all movements (flexion, extension, abduction, and adduction). The magnitude of differences was more pronounced in the comparisons

Table 2 Total hip arthroplasty group (THAG) and control group (CG) range of motion (ROM) (degrees)

	THAG (23)		CG (23)	Post-hoc Multiple Comparison 95% CI		
	AL	UAL	DL	AL vs UAL	AL vs DL	UAL vs DL
Flexion	55.00 (15.00–79.00)	68.00 (44.00–92.00)	86.00 (67.00–106.00)	− 16.19(− 26.49;− 5.90)*	− 36.81(− 47.78;− 25,83)*	− 20.68(− 31.60;− 9.64)*
Extension	20.00 (4.00–26.00)	17.00 (7.00–30.00)	20.00 (10.00–30.00)	0.24(− 3.84;4.32)	− 3.38(− 7.73;0.97)	− 3.62(− 7.98;0.73)
Abduction	16.00 (6.00–32.00)	23.00 (9.00–31.00)	30.00 (10.00–40.00)	− 4.52(− 9.76;0.71)	− 10.74(− 16.33;− 5.16)	− 6.22(− 11.80;− 0.64)
IR	12.00 (5.00–24.00)	19.00 (10.00–32.00)	25.00 (16.00–35.00)	− 5.38(− 9.32;−1.43)*	− 13.09(− 17.29;− 8.88)*	− 7.70(− 11.91;− 3.50)*
ER	11.00 (3.00–29.00)	17.00 (10.00–33.00)	25.00 (15.00–41.00)	− 7.09(− 12.19;− 2.00)*	− 14.87(− 20.30;− 9.43)*	− 7.77(−1 3.21;− 2.34)*

Abbreviations: AL, affected limb; CG, control group; DL, dominant limb; ER, external rotation; IR, internal rotation; THAG, total hip arthroplasty group; UAL, unaffected limb.
Values expressed as median (min-max) and as mean difference (95% Confidence Interval); * $p < 0.05$.

Table 3 Total hip arthroplasty group (THAG) and control group (CG) normalized peak torque (Nm/kg)

	THAG (23)		CG (23)	Post-hoc Multiple Comparison 95% CI		
	AL	UAL	DL	AL vs UAL	AL vs DL	UAL vs DL
Flexion	61.80 (18.00–93.90)	78.00 (32.00–112.80)	82.00 (51.30–158.80)	− 23.43(− 43.94; −2.91)*	− 48.66(− 71.19;− 26.13)*	− 25.23(− 47.76;− 2.07)*
Extension	86.00 (30.10–135.40)	101.80 (34.00–153.40)	125.40 (39.10–265.50)	− 18.12(− 51.37;15.12)	− 73.24(− 109.78;− 36.73)*	− 55.12(− 91.63;− 18.60)*
Abduction	49.20 (19.80–82.90)	61.50 (25.60–112.20)	92.60 (51.80–132.20)	− 21.75(− 38.95;−4.54)*	− 63.92(− 82.82;− 45.03)*	− 42.17(− 61.07;− 23.28)*
Adduction	71.70 (26.30–150.90)	70.60 (29.20–118.40)	79.10 (35.80–159.40)	− 2.32(− 21.21;25.86)	− 28.87(−54.73;− 3.02)*	− 26.55(− 52.40;− 0.70)*

Abbreviations: **AL,** affected limb; **CG,** control group; **DL,** dominant limb; **THAG,** total hip arthroplasty group; **UAL,** unaffected limb. Values expressed as median (min-max) and as mean difference (95% Confidence Interval); $^{*}p < 0.05$.

between the operated limb and the dominant limb in participants of the CG (►**Table 3**).

Discussion

Six months after THA, the participants in our study reported minimal levels of pain and high satisfaction with the procedure. However, these participants had significant objectively and subjectively measured functional limitations, reduced ROM and hip torque. These findings were observed in both the affected and unaffected limbs when compared with healthy controls.

Differently from previous studies,[6,8,9,13] our sample was more homogeneous and included patients submitted to THA only as a result of hip OA, within a similar age range and with a similar postoperative period. We also compared post-THA patients with a CG, which allowed us to ascertain the magnitude of differences in function, ROM, and muscle torque between post-THA patients and healthy matched individuals.

The main purpose of THA surgery is to reduce pain, but also to improve function early after the surgery.[12,26] In our study, pain levels 6 months post-THA were indeed mild, and most patients were satisfied with the procedure. However, upon closer examination of the functional status of the patients, we showed that the patients present with significant functional deficits.

The functional deficits we showed in our study can be minimized through several different strategies; for example, with surgery planning and rehabilitation programs. Different rehabilitation protocols (for example, functional exercises, walking, muscle strengthening)[1,7,13,23,27–29] are described in the literature and have shown to be beneficial for this population in increasing function and muscle strength.

The greatest deficits in muscle torque were for rotational movements, particularly external rotation. This indicates that greater emphasis should be placed on strengthening external hip rotators. Interestingly, we observed deficits in both legs in patients when compared with the CG. This finding points out not only to the need to address muscle impairments on the operated side, but also to consider the nonoperated leg as a target for strengthening exercises.

Due to the differences we found in terms of ROM and hip muscle torque, future prospective studies should investigate whether these aspects constitute risk factors for falls in post-THA patients. Previous systematic reviews examining risk factors for falls in patients with THA are limited in their conclusions due to the sample heterogeneity within studies (for example, studies with mixed populations of primary and revision THA).

Study Limitations

The present study also has limitations, which include the inability to stratify the sample according to prosthesis type or to surgical approach due to the small sample size. We also did not have information on the postoperative rehabilitation

protocols participants were submitted to, and a large percentage of the included patients were still waiting for a vacancy in the public health system for physical therapy sessions, which may limit the interpretation of the results of the present paper. Our matched CG was slightly younger and had a lower BMI. Nevertheless, those differences were accounted for in the statistical analysis.

Conclusions

Post-THA patients still present with reduced functional capacity, as well as decreased joint ROM and active strength of hip muscle groups in both lower limbs 6 months postoperatively. Rotational movements demonstrated greater restriction in ROM, while hip flexors and abductors showed larger strength deficits. The unaffected limb of participants undergoing THA also showed limitations compared with asymptomatic individuals. Attention should be paid to both the affected and unaffected limbs during rehabilitation of post-THA patients, and the contralateral limb should not be used as a parameter when assessing muscle strength and ROM in these patients.

Conflict of Interests
The authors have no conflict of interests to declare.

Acknowledgements
The authors acknowledge the professionals of the orthopedic and traumatology services of the Hospital de Clínicas de Porto Alegre (Porto Alegre, RS, Brazil), of the Hospital Santa Clara da Santa Casa de Misericórdia de Porto Alegre (Porto Alegre, RS, Brazil), and of the Hospital Cristo Redentor do Grupo Nossa Senhora da Conceição (Porto Alegre, RS, Brazil), as well as to the Universidade Federal de Ciências da Saúde de Porto Alegre (Porto Alegre, RS, Brazil) for their collaboration. The authors would also like to thank Mauricio Scholl Schell for his advice on the statistical analyses. The present study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES, in the Portuguese acronym) – Finance Code 001.

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