Effect of muscle strengthening on pain, functionality, muscle endurance and postural control in women with greater trochanter pain syndrome: a randomized clinical trial

Efeito do fortalecimento muscular na dor, funcionalidade, resistência muscular e controle postural em mulheres com síndrome de dor do trocânter maior: ensaio clínico randomizado

Marieli Araujo Rossoni Marcioli[1], Amanda Paula Ricardo Rodrigues da Cunha[1], Christiane de Souza Guerino Macedo[1]

https://doi.org/10.5935/2595-0118.20240054-en

ABSTRACT

BACKGROUND AND OBJECTIVES: The treatment for greater trochanteric pain syndrome (GTPS) is conservative. However, there are few studies that prove these results. The objective of this study was to analyze the effect of increasing hip and trunk muscle strength on pain, functional capacity, core muscle endurance, and postural control of women with GTPS.

METHODS: This study is a clinical trial. Twenty-six women with GTPS were assigned into Group 1 (G1, n=12, hip strength exercises) and Group 2 (G2, n=14, hip and core strength exercises) and were evaluated before the start, after the intervention protocol, and after the follow-up of 12 weeks (Follow-Up - FU). Pain, functional capacity, core endurance and postural control were evaluated. The Prone Bridge test (PBT) and Supine Bridge test (SBT) established core endurance.

RESULTS: The pain decreased after the interventions and FU (p=0.001), with a strong effect (1.62≤d≤2.35), with no differences between groups (p=0.29). Functional capacity improved after the interventions and FU (p=0.03), with a poor effect (0.19≤d≤0.27), with no differences between groups (p=0.61). The time in the PBT increased for both groups (p=0.62), with a strong effect in G2 (d=1.02). The SBT established that G2 was better after the intervention and FU (p=0.04; d=0.20), with no differences between the moments (p=0.95). Postural control showed no differences.

CONCLUSION: Strength exercises for the hips only or for the hips and core decreased pain and improved functional capacity and core endurance in GTPS.

Keywords: Hip pain, Postural balance, Women.

RESUMO

JUSTIFICATIVA E OBJETIVOS: O tratamento para a síndrome da dor no grande trocanter (SDGT) é conservador. No entanto, existem poucos estudos que comprovam esses resultados. O objetivo deste estudo foi analisar o efeito do aumento da força muscular do quadril e do tronco na dor, capacidade funcional, resistência muscular do *core* e controle postural de mulheres com SDGT.

MÉTODOS: Este estudo é um ensaio clínico. Vinte e seis mulheres com SDGT foram divididas em Grupo 1 (G1, n=12, exercícios de fortalecimento do quadril) e Grupo 2 (G2, n=14, exercícios de fortalecimento do quadril e *core*) e foram avaliadas antes do início, após o protocolo de intervenção e após 12 semanas (*Follow-Up*). Dor, capacidade funcional, resistência do *core* e controle postural foram avaliados. O *Prone Bridge Test* (PBT) e o *Supine Bridge Test* (SBT) estabeleceram a resistência do *core*.

RESULTADOS: A dor diminuiu após as intervenções e *follow-up* (p=0,001), com forte efeito (1,62≤d≤2,35), sem diferenças entre os grupos (p=0,29). A capacidade funcional melhorou após as intervenções e *follow-up* (p=0,03), com efeito ruim (0,19≤d≤0,27), sem diferenças entre os grupos (p=0,61). O tempo no PBT aumentou para ambos os grupos (p=0,62), com efeito forte no G2 (d=1,02). O SBT estabeleceu que o G2 foi melhor após a intervenção e *follow-up* (p=0,04; d=0,20), sem diferenças entre os momentos (p=0,95). O controle postural não apresentou diferenças.

CONCLUSÃO: Exercícios de fortalecimento somente dos músculos do quadril ou para o quadril e *core* diminuíram a dor e melhoraram a capacidade funcional e a resistência do core no SDGT.

Descritores: Controle postural, Dor no quadril, Mulheres.

Marieli Araujo Rossoni Marcioli – https://orcid.org/0000-0002-4094-7018;
Amanda Paula Ricardo Rodrigues da Cunha – https://orcid.org/0000-0002-9687-5690;
Christiane de Souza Guerino Macedo – https://orcid.org/0000-0001-6016-5075.

1. State University of Londrina, Associate Postgraduate Program in Rehabilitation Sciences, Physiotherapy Department, Londrina, PR, Brazil.

Submitted on April 10, 2024.
Accepted for publication on August 16, 2024.
Conflict of interests: none – Sponsoring sources: This study was financed in part by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil* (CAPES) – Finance Code 001.

HIGHLIGHTS

- Hip and core muscle strengthening exercises improve pain and functional capacity of women with Greater Trochanter Pain Syndrome (GTPS).
- Hip and core muscle strengthening exercises did not change the postural control of women with GTPS.
- Hip muscle strengthening exercises and hip + core muscle strengthening exercises have similar effects.

Associate editor in charge: Maíra Junkes Cunha
https://orcid.org/0000-0002-1706-4129

Correspondence to:
Christiane de Souza Guerino Macedo
E-mail: chmacedouel@yahoo.com.br

INTRODUCTION

Greater trochanter pain syndrome (GTPS) is a common cause of pain in the side of the hip and thigh and mainly affects women over 40. Risk factors include being a female, age over 40, changes in the morphology of the pelvis, overweight and biomechanical changes, such as greater hip adductor moment and greater pelvic translation during walking and climbing stairs[1]. The treatment for GTPS is conservative, including rest, modification of activities of daily living, anti-inflammatory drugs, corticosteroid injection, and physiotherapy[1]. However, studies that recommend the conservative approach for GTPS report low remission rates and high relapse rates[2], with the need for several cycles of intervention[3], which makes the treatment of refractory patients a great challenge.

A reference study[4] demonstrated that physical therapy exercises result in pain improvement in eight weeks and greater satisfaction in one year when compared to a single cortisone steroid injection and the "wait and see" approach. Currently, the best strategy is education associated with exercises to increase muscle strength and neuromuscular control[5], in addition to changes in daily living activities[4,6]. However, there is still a gap in the literature regarding specific exercises for the treatment of GTPS and it is important to investigate which exercises would have the best effects.

Conservative treatment with exercises is based on protecting the hip abductor tendons against excessive tensile and compressive stresses, while applying progressive load in conjunction with anti-inflammatory measures[7]. The implementation of an early progressive tensile load program (in minimally adducted hip positions) aims to reduce pain and improve tendon capacity. In addition, exercises to increase muscle strength together with specific exercises in functional movements, at graduated levels of difficulty, are likely to be the key to rehabilitation[7].

Exercises that stimulate resistance of the core muscles and stabilization of the trunk and pelvis are also indicated, since women with GTPS have less resistance to this muscle complex[8]. The gluteus medius, the main muscle affected in GTPS, is part of the core, and plays an important role in lateral stabilization of the pelvis and abduction of the hip; its stability acts as a protective factor against injuries to the lower limbs[9]. Many researchers have investigated the effects of conservative treatment[6,10,11], however, although it has already been hypothesized that inadequate core stability may be a risk factor for the development of GTPS[12,13], no studies have investigated an exercise protocol focused on increasing the strength of the hip abductor and extensor muscles associated with core resistance training[14].

Therefore, it is assumed that, during the rehabilitation of GTPS, the role of the lumbopelvic stabilizers also cannot be neglected. To contribute to the literature, this study was conducted with the objective of evaluating the effects of hip strength exercises and associated exercises to increase hip and core strength on pain, functional capacity, core muscle endurance, and postural control in women with GTPS. The hypothesis is that increased strength of the core muscles associated with the conventional program would bring better results.

METHODS

The research was approved by the university's Research Ethics Committee (opinion 2.437.326/2017). The participants were informed about the research and signed the Free and Informed Consent Term (FICT). The study was registered as a clinical trial *in clinicaltrials.gov (*NCT05662579).

This is a randomized, longitudinal clinical trial. The evaluators were blinded to the intervention allocation. The participants were informed that they would be distributed into two different exercise protocols, but they did not know which exercises would be performed or the differences between the two intervention protocols. In all reassessments, the participants were instructed not to disclose details of their treatment to the evaluators. The intervention consisted of two exercise protocols performed for four weeks, twice a week, and if they missed a session, it needed to be replaced in the same week. The variables of interest were measured in the pre-treatment period, at the end of 4 weeks (immediately at the end of the protocol), and at the 12-week *follow-up*.

Sample

The sample calculation was performed using the *Power and Sample* Size software, with a confidence interval of 95%, alpha of 5%, and test power of 80%, considering 3.5 points for the difference in means and 0.9 points for the difference in standard deviations of the pain variable at *Baseline* and after 16 months in the exercise group, presented in the article "*Home Training, Local Corticosteroid Injection, or Radial Shock Wave Therapy for Greater Trochanter Pain Syndrome*"[15]. A minimum sample of 24 participants was established, 12 for each group; however, considering the possible losses, 30 women with GTPS were recruited.

Women who sought care from an orthopedic physician, specialist in hip diseases, from December 2018 to December 2019, were invited to participate in the research. After the clinical evaluation, the physician requested Magnetic Resonance of the hip (to exclude degenerative joint processes) and referred the patients for assessment and treatment with physiotherapy. As inclusion criteria, the participants were required to be postmenopausal (amenorrhea for at least 12 months or hysterectomy)[16] and have been diagnosed with GTPS for at least three months, established by an orthopedic physician specialized in hip diseases and by magnetic resonance imaging.

Patients who had undergone surgery on the lower limbs or spine in the previous 12 months, those who presented symptoms compatible with osteoarthritis or intraarticular hip disease (joint block, limitation of range of motion, and difficulty in manipulating socks and shoes)[17], those who had not undergone previous infiltration of the hip with corticosteroids in the previous 6 months, and those who had not undergone physiotherapy (conventional or Pilates) in the previous 12 months were excluded. Furthermore, participants who required the use of anti-inflammatory drugs were only included in the study 10 days after the end of the drug treatment. It was established that the participants perform two sessions per week, and if they missed a session, it needed to be replaced in the same week. Participants who were unable to perform the replacement were also excluded from the study.

The randomization of the participants to each intervention group was previously carried out by a researcher who was not part of the research through www.random.org and the sequences were stored in opaque, sealed, and numbered envelopes in increasing sequence. Group one performed only exercises to increase hip muscle strength (G1, n=15), and group two performed exercises to increase hip and core muscles strength (G2, n=15).

Settings, locations, data collection and instrumentation

The evaluations, treatment, reassessments, and follow-up were developed at the Center for Specialization in Research and Graduate Studies in Health, at the Center for Health Sciences of the University. In the evaluation, participants responded to a characterization form on age, height, weight, body mass index (BMI), occupation, and history of the current disease. They also indicated the intensity of their current pain through the Visual Analog Pain Scale (VAS), with scores ranging between zero and 10.

For the subjective assessment of functional capacity, the participants completed the VISA-G.Br questionnaire, which is a specific self-answered instrument to evaluate the severity of GTPS, that was previously translated and validated into Portuguese[18]. This tool is currently the preferred option to capture disability associated with gluteal tendinopathy[19]. The questionnaire quantifies the level of pain and allows the estimation of the functional limitations present in this specific condition[20] and has been proven to be a reliable and responsive tool, which is valid concerning internal consistency, test-retest reliability, and construct validity[21]. Total scores range from zero to 100, with higher scores indicating lower pain and better function; the maximum total score of 100 points represents an asymptomatic and fully functional individual.

In order to verify the core endurance, the Prone Bridge Test (PBT) and Supine Bridge Test (SBT) were performed, with the order randomized using opaque envelopes. For PBT, the participant was instructed to remain in the position of ventral plank[22], and for the SBT, the participant started in dorsal decubitus, lifted the pelvis off the ground until it was aligned with the trunk, hips and thighs, and remained in this position until reaching fatigue[23]. The participant was instructed to perform the first test to understand the proposed exercise, to minimize the learning effect. Three repetitions were performed, remaining for the maximum time in the posture, with an interval of 90 seconds between attempts. The test was interrupted when the participant reported exhaustion or when they could no longer maintain the proper position and restarted after 90 seconds of rest. For the result, an average length of stay in the test, in seconds, between the three attempts was used.

For the evaluation of semi-static and dynamic postural control, the participants were tested on the BIOMEC411 force platform (serial number: NS_BIO1470**,** EMG System do Brasil®, SP Ltda.), composed of four load cells in a rectangular position, that quantified the vertical force distribution at these 4 points. The channels configured for force had filters with frequency bands between 0 and 35 Hz, and a sampling frequency of 100 Hz. The order of evaluations (semi-static and dynamic) was randomized using opaque envelopes.

The participants were positioned in single leg support on the force platform, with their gaze fixed on a point on the wall, at eye level. For the evaluation of semi-static postural control, the participant remained standing, with as little movement as possible. For the dynamic assessment of postural control, the participant was instructed to perform cycles of "mini-squats", slowly flexing the knee up to 30 degrees of flexion (established by digital goniometer), at a pace of 60 bpm (controlled by a metronome). For this, in the first repetition, the evaluator positioned a goniometer on the joint, and informed the participant when the joint reached the desired angle so that they had feedback. The duration of each evaluation (semi-static and dynamic) was 30 seconds, and three repetitions were performed, with a 90-second interval between attempts. The variables for postural control analysis were the total area of the center of pressure oscillation (A-COP), amplitude, and oscillation velocity of the COP in the anterior-posterior and medial-lateral directions.

Intervention protocol

The sessions for the implementation of the exercise protocols lasted 45 minutes in G1 and 50 minutes in G2. They were carried out in the afternoon, twice a week, for a period of four weeks, in the research laboratory of the graduate program, with the room temperature set at 25 degrees and at different times for each group.

The exercise protocol to increase hip muscle strength was exactly the same for both groups and was performed bilaterally. The exercises were individually graded so that the participant could perform three sets with 10 repetitions, with the last three repetitions considered "challenging" in terms of intensity, while still allowing the correct performance of the movement. Using an 11-point perceived exertion scale[24], participants were encouraged to maintain exercise intensity between grades 5 and 7 ("heavy" to "very heavy"). The contraction phase of each exercise was two concentric seconds, one isometric second, and two eccentric seconds, followed by one second of rest; there were approximately 90 seconds of rest between each set, while the other limb was being exercised.

The exercises for the hip were adapted from the protocols applied by reference authors[25-27], and divided into two phases, with progression carried out according to the individual evolution of the participants, and resistance to exercises in phase II was applied through elastics bands. The exercise protocol to increase hip muscle strength muscles are presented in the online supplement (Attachment 1).

Group 2 performed the exercise protocol to increase hip muscle strength and exercises were added to increase core muscle strength and resistance. The increase muscle strength and resistance program for the core was divided into 2 phases and is presented in the online supplement (Attachment 2). Phase I included exercises with low difficulty and involving less need for the correct technique to perform them, focusing mainly on awareness of the contraction of the core*;* and phase II was composed of exercises that required more central stability.

After the end of the exercise protocols, two reevaluations were performed, in the same way as the initial evaluation, one at the

end of the exercise protocol and another as a follow-up, 12 weeks after the end of the protocol.

Statistical analysis

Data were analyzed for normality using the Shapiro Wilk test, and the results were presented as mean and standard deviation. Sample characterization data were compared between groups using the Student's t-test for independent samples. Comparisons between groups and evaluation times were established by two--way ANOVA. Statistical significance was set at 5%. The effect size was established by Cohen's d, defined as weak when ≤0.49, moderate when between >0.5 and ≤0.79, and strong for results >0.8[28]. The results were established using SPSS® 20.0 software.

RESULTS

Initially, 30 participants were recruited, however, 4 did not attend all the necessary appointments due to unavailability of schedules. Thus, the final study sample was established with 12 participants in G1 and 14 participants in G2 (Figure 1).

The study was developed between December 2018 and December 2019. The results established that at baseline, the groups presented similar characteristics for age, weight, height, and body mass index (Table 1).

The pain assessment results showed that the two groups presented significantly decreased intensities after performing the exercises, with a strong effect, but with no differences between the groups (Table 2). The functional capacity assessed by VISA-G improved equally between the groups after the intervention and *follow-up*, but with a weak effect (Table 2).

The results of the core muscle endurance in the Prone Bridge Test (PBT) showed no differences between the groups and assessment moments; however, only group 2 showed a strong effect on the performance in this test. For the Supine Bridge Test (SPT), group 2 performed significantly better in the moments after the intervention and in the follow-up, but with a small effect size (Table 2). No interaction was found between the groups and assessment moments for the variables analyzed (Table 2).

Finally, in the analysis of the results of semi-static and dynamic postural control, it was not possible to establish differences between the groups and moments evaluated, nor was it possible to

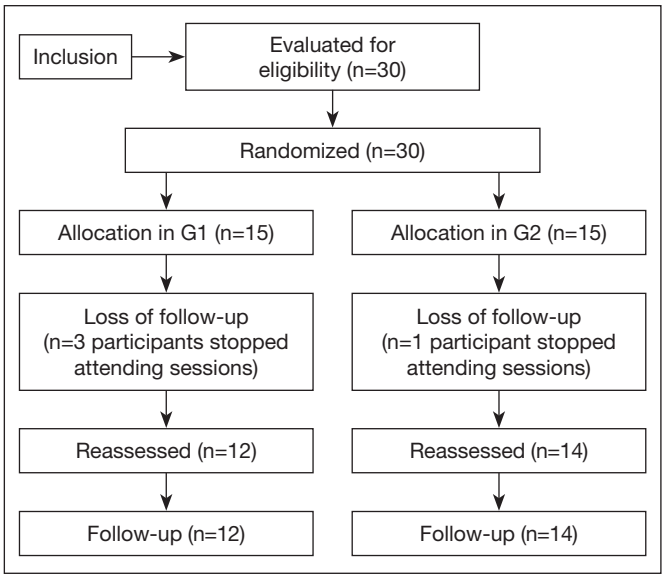

Figure 1. Flow diagram of the study.

G1 = exercises to strengthen the hip muscles. G2 = exercises to strengthen the hip muscles + core.

Table 1. Characterization of groups undergoing hip strengthening exercises (G1) and hip and core strengthening exercises (G2)

	Group 1 (n=12)	Group 2 (n=14)	p-value
Age (years)	56.54 (8.59)	60.83 (9.34)	0.238
Weight (kilos)	67.42 (10.60)	67.24 (10.73)	0.966
Height (Meter)	1.60 (0.064)	1.57 (0.06)	0.178
BMI (Kg/m²)	26.28 (4.68)	26.91 (3.28)	0.691

BMI = Body Mass Index. Data presented as mean and standard deviation.

Table 2. Results of pain and functional capacity for women with GTPS undergoing strengthening of the hip muscles (G1) and strengthening exercises of the hip and core muscles (G2).

Variables		Groups				Effect size*		Two-way ANOVA		
		Group 1	Group 1 IC 95%	Group 2	Group 2 IC 95%	Group 1	Group 2	Group	Time	Interaction
VAS (cm)	PRE	6.00 (2.21)	4.59 - 7.40	6.21(1.84)	5.14 – 7.28	2.35	1.62	0.29	0.001	0.10
	POST	2.00(1.20)	1.23 - 2.76	3.50(1.51)	2.62 – 4.37					
	Follow-Up	3.50(1.88)	2.30 - 4.69	3.00(1.17)	2.32 – 3.67					
VISA-G (points)	PRE	53.50(22.35)	39.29 – 67.70	57.46(14.70)	48.97 – 65.94	0.19	0.27	0.61	0.03	0.84
	POST	57.66(21.21)	44.18 – 71.14	61.42(13.70)	53.51 – 69.34					
	Follow-Up	69.63(24.28)	54.20 – 85.06	68.30(15.50)	59.34 – 77.25					
Prone Bridge test (seconds)	PRE	33.94 (16.77)	23.28 – 44.60	26.47(15.11)	17.74 – 35.20	0.06	1.02	0.62	0.28	0.14
	POST	32.77(17.38)	21.73 – 43.82	40.21(11.67)	33.47 – 46.95					
	Follow-Up	29.78(17.68)	18.55 – 41.02	34.73(5.94)	31.30 – 38.16					
Supine Bridge test (seconds)	PRE	92.80(63.54)	52.43 – 133.17	92.45(59.76)	57.94 – 126.96	-0.32	0.20	0.04	0.95	0.29
	POST	75.47(43.76)	47.66 – 103.27	102.11(34.21)	82.36 – 121.86					
	Follow-Up	70.24(40.95)	44.22 – 96.26	114.00(55.49)	81.96 – 146.04					

Values presented as mean and standard deviation. Differences established through the two-way ANOVA test. VAS = Visual analog scale. VISA-G = Victorian Institute of Sports Assessment – Gluteal Tendinopathy. * Effect size established between pre and post intervention times.

Table 3. Semi-static and dynamic postural control of women with GTPS submitted to strengthening of the hip muscles (G1) and strengthening exercises of the hip and CORE muscles (G2).

	Variables		Groups				Effect size*		Two-way ANOVA		
			Group 1	Group 1 IC 95%	Group 2	Group 2 IC 95%	Group 1	Group 2	Group	Time	Interaction
Semi-static postural control	COP Area	PRE	13.13 (6.94)	8.71 – 17.54	23.84 (15.23)	14.16 – 33.51	0.09	0.51	0.274	0.291	0.181
		POST	14.08 (12.36)	6.22 – 21.94	17.82 (8.19)	12.61 – 23.02					
		Follow-Up	22.37 (16.44)	11.93 – 32.82	17.79 (11.46)	12.51 – 27.07					
	AP Amplitude	PRE	4.79 (1.30)	3.96 – 5.62	5.96 (2.22)	4.54 – 7.37	0.14	0.35	0.081	0.587	0.757
		POST	4.56 (1.80)	3.41 – 5.70	5.37 (1.14)	4.64 – 6.10					
		Follow-Up	5.16 (1.54)	4.17 – 6.14	5.54 (1.58)	4.53 – 6.54					
	ML Amplitude	PRE	5.25 (1.98)	3.99 – 6.50	7.43 (3.36)	5.29 – 9.57	0.03	0.37	0.134	0.630	0.493
		POST	5.33 (3.15)	3.32 – 7.33	6.43(2.02)	5.14 – 7.71					
		Follow-Up	6.47 (2.53)	4.86 – 8.07	6.71 (2.53)	5.09 – 8.32					
Dynamic postural control	COP Area	PRE	22.31 (7.62)	17.47 – 27.15	32.11 (16.01)	21.94 – 42.29	0.56	0.02	0.276	0.846	0.678
		POST	27.63 (12.09)	19.95 – 35.32	29.26 (14.75)	19.89 – 38.64					
		Follow-Up	27.11 (16.31)	16.75 – 37.48	31.00 (23.26)	16.21 – 45.78					
	AP Amplitude	PRE	6.92 (1.24)	6.14 – 7.71	7.28 (1.87)	6.09 – 8.46	0.49	0.28	0.845	0.359	0.842
		POST	7.65 (1.89)	6.44 – 8.86	7.67 (1.96)	6.42 – 8.91					
		Follow-Up	7.18 (1.51)	6.22 – 8.14	6.90 (1.86)	5.71 - `8.08					
	ML Amplitude	PRE	6.57 (3.14)	4.57 – 8.57	8.37 (3.23)	6.32 – 10.43	0,003	0.31	0.348	0.597	0,672
		POST	6.69 (2.87)	4.87 – 8.51	6.88 (3.44)	4.96 – 9.07					
		Follow-Up	6.04 (2.01)	4.76 – 7.33	7.01 (3.59)	4.73 – 9.29					

Values presented as mean and standard deviation. Differences established through the two-way ANOVA test. * Effect size established between pre and post intervention times.

establish interactions between the analyses (Table 3). Although not significantly different, it can be noted that in group 2 the values are consistently better than in group 1.

DISCUSSION

Although greater trochanteric pain syndrome (GTPS) is common and painful in adult women, there is no consensus on conservative treatment, since the literature does not yet establish which are the best exercises or therapeutic resources. More studies are needed with better methodologies and a higher level of scientific evidence to conclude on the best management[3]. To contribute to the literature, the present study was the first randomized clinical trial to evaluate and treat women with GTPS. The results established those exercises to increase strength only for the hip and exercises to increase strength of the hip and core muscles (abdominal muscles) improved pain and functional capacity but did not change postural control.

The use of exercises for the treatment of tendinopathies and chronic pain has already been established by other studies[7,29]. In addition, the present results established that performing exercises to increase strength for the hip or for the hip and core decreases the intensity of pain in a similar way, and this improvement is maintained for 12 weeks. These findings also agree with one reference study[15], in establishing that exercises performed at home are better than corticosteroid injection or repetitive shock wave treatment for pain and functionality in GTPS.

Another research[4] demonstrated that an eight-week exercise program (14 sessions) together with the guided education of patients to prevent postures that overloaded the tendon, resulted in better pain scores and better patient satisfaction when compared to a single cortisone steroid injection and the "wait and see" approach. The present results also agree with other authors[30], who recommend the execution of abdominal core stabilization exercises from the initial acute phase of GTPS rehabilitation, and a reference study[27], which pointed out that activation of the abdominal core muscles increases the recruitment of the hip muscles during the exercises. Furthermore, the authors[27] suggest adding the activation of the abdominal core to the rehabilitation of the lower limbs, since it can increase the therapeutic effects of exercises to increase hip muscle strength.

The Consensus of the 2019 International Scientific Symposium on Tendinopathy points out that the impact of lower limb tendinopathies should be measured by validated instruments that can capture domains, such as functional capacity, participation in life activities, psychological factors, and disability through patient-reported outcome measures (PROMs)[31]. The Victorian Institute of Sport Assessment (VISA) questionnaires were recommended by the 2019 consensus statement[32] and are used globally in research and clinical practice to assess symptom severity and functional disability. For participants with GTPS in the present study, the VISA-G questionnaire established reference values, with an average score of 53.5 and 57.4 points found in the initial evaluation (for G1 and G2, respectively), similar to that presented by other authors: 55 points[29], 59.9 points[4], and 61 points[33]. These studies showed that the two exercise protocols improved the functional capacity assessed by the VISA-G and that this improvement was greater after 12 weeks. It was evidenced that initially, women with GTPS were not able to perform day-to-day activities and did not perform any type of physical activity, while after the intervention, the women were able to perform these activities. These results were confirmed by study[15], demonstrating

that a home exercise program improved the physical capacity of women with GTPS, and by yet another study[34], which pointed to positive results on functional capacity in GTPS when comparing hormone replacement therapy and exercise.

The present study also evaluated functional capacity, through endurance of the core muscles, using the Prone Bridge test (PBT) and Supine Bridge test (SBT), which present high reliability[35] and validity[23] to evaluate the muscles of the trunk, and lower and upper limbs. However, the assessment of the length of stay in the ventral plank position (PBT) did not show changes between the groups and moments analyzed. It should be noted that the results presented by group 2, submitted to exercises to increase the strength of the hip and core muscles, demonstrated a strong treatment effect, which was expected since plank exercises were included in the protocol of this group, which could favor the improvement in PBT performance. In the SBT, group 2 was better at the moment after the intervention and at the follow-up.

It can be highlighted that only the protocol developed in group 2 allowed the improvement and maintenance of the resistance of the hip extensor muscles, evaluated in the SBT, with the maintenance of this resistance for at least 12 weeks. Thus, in agreement with other authors[22], it is highlighted that PBT and SBT recruit the posterior muscles of the trunk and demand an increase in the challenge of neuromuscular control while the individual supports the position and develops ctiveity of the posterior muscles of the hip, which could contribute to the long stay in the reassessments of group 2.

Postural control was the last variable analyzed in this study and did not indicate any differences between the groups and assessment moments, which was contrary to the initial hypothesis of this study. The deficit in postural control has already been reported in degenerative pathologies of the hip[36]. Previous studies[37] demonstrated that women with GTPS present worse postural control than healthy controls. There are already reports in the literature of a strong association between the strength of the hip abductor muscles and the results of dynamic postural control[38]. Thus, it was expected that protocols with exercises to increase hip and core muscle strength could improve the results of postural control, but this effect was not verified. However, it is possible that four weeks was not long enough to achieve noticeable changes. In addition, since postural control is multifactorial, several aspects may have influenced the present results.

The study has limitations. The duration of the protocol and follow-up could be longer, with 8 or 12 weeks of intervention, as more sessions of physiotherapy could lead to better or more consistent results. Future studies with exercises should include "Patient Education", to avoid postures that could harm their condition by overloading the abductor tendons, which may have been a confounding factor. In addition, as a clinical contribution, this study provided evidence that performing exercises to increase strength for the hip and/or hip + core improve pain and functional capacity in women with GTSD, which directs the pathway to rehabilitation in this syndrome and should be implemented in rehabilitation protocols.

CONCLUSION

It can be concluded that both exercise protocols for increasing the strength of the hip and CORE muscles, for four weeks, resulted in significant improvements in the pain and functional capacity of women with GTPS, that when the exercise protocol is directed to the CORE, there is an improvement in the result of muscular endurance in the SBT, and that the interventions do not alter the postural control of women with GTPS.

AUTHORS' CONTRIBUTIONS

Marieli Marcioli
Data Collection, Project Management, Research, Methodology, Writing - Preparation of the original

Amanda Paula Ricardo Rodrigues da Cunha
Statistical Analysis, Data Collection, Research, Methodology, Visualization

Christiane de Souza Guerino Macedo
Statistical Analysis, Funding Acquisition, Data Collection, Conceptualization, Resource Management, Methodology, Writing - Preparation of the original , Writing - Review and Editing, Supervision, Validation, Visualization

Attachment 1. Description of the exercise protocol for strengthening the hip muscles

PHASE I: (sessions 1 to 4)
Active exercise without weight bearing (standing) for hip abductors, adductors, flexors, and extensors: standing, holding on a parallel bar to maintain balance, the participant performed the hip abduction movement, keeping the knee in full extension and without trunk inclination. With each set of repetitions, the participant alternated the limb that performed the exercise to avoid fatigue in the support limb. After the abductors, they performed the same for adductors, flexors, and hip extensors.
Hip extension exercise in four supports: this exercise was performed without weight, only with the resistance of the lower limb. The participant started in the position of four supports on a board, with the hip and knee flexed at 90°, which was maintained while extending the hip until the femur was aligned with the axis of the body, taking care that the lumbar spine remained in a neutral position. The participant then returned to the starting position.
Hip abduction exercise on four supports ("hydrant"): this exercise is similar to the previous one, with the difference that the movement performed was hip abduction. Starting from the same starting position, the participant abducted the hip as far as possible, keeping the knee at 90° of flexion.
Oyster Exercise[27]: starting from the initial position in lateral decubitus, with the hips flexed at 45° and knees flexed at 90°, the participant abducted and externally rotated the hip of the upper limb while maintaining contact between the ankles.
Hip abduction exercise in lateral decubitus: Performed without weight, only with the resistance of the limb weight. The initial position was in lateral decubitus, lower limb bent at 45° in both hip and knee, to ensure stability, while the other was kept at all times with the hip and knee at 0° of flexion. The limb to be exercised was abducted to a height that was comfortable for the participant, taking care that the trunk did not rotate[27].

Hip extension exercise in the prone position: Performed without weight. Starting from the prone position, with the knee flexed at 90°, the participant extended the hip until the knee detached from the stretcher, avoiding alteration in the positioning of the lumbar spine.

PHASE II: (sessions 5 to 8)

Hip abduction exercise in lateral decubitus: Performed with resistance applied by theraband around the knees. In lateral decubitus, extended lower limbs, the participant abducted the hip until the femur formed a 30-degree angle with the support limb. On the first day of this exercise, the physiotherapist, using a goniometer, informed the distance that the participant should reach between the lower limbs for the pattern to be followed.

Progressive resistance exercise for hip abductors, adductors, flexors, and extenders with standing theraband: the participant stood, with an upper limb supported on the bar, and performed the movements against the resistance of the theraband (positioned around the ankles), moving the limb until the force performed was within the stipulated pattern (between 5 and 7 on the Borg scale).

Sidewalk with theraband positioned at the ankle joint: the participant performed the sidewalk, taking steps with the abduction of one limb and adduction of the other, in a straight line, against the resistance of the theraband stuck around the ankles.

Squat exercise: the participant remained standing, with their back resting on the wall, and performed the squat until the hip aligned with the knee. While returning, the participant was instructed not to detach the pelvis from the wall.

Forward exercise: the initial position was standing, hands resting on the waist, with feet parallel. The participant advanced one step with one of the lower limbs, flexed the knees until the knee supported in front presented 90 degrees of flexion, and then return to the initial position.

Step-down exercise: The starting position was parallel feet on one step. The participant lowered one of the lower limbs, until touching the ground, and returned to the initial position.

Attachment 2. Strengthening and resistance exercises for the core muscles

PHASE I: (sessions 1 to 4)

Exercise for contraction of the transverse abdomen: the participant was lying in dorsal decubitus, with hips and knees flexed at 45 degrees, and feet resting on the stretcher. They were instructed to perform contraction of the transverse muscle of the abdomen ("push your belly button toward your back") and then relax.

Bridge exercise: starting from the same initial position as the previous exercise. The participant was instructed to lift the pelvis until it aligned with the knees and shoulders. Three repetitions were performed, up to the maximum length of stay.

Plank exercise: the initial position was the prone position on the mat. The participant was instructed to support the weight of their body on the elbows, which were supported and aligned below the shoulders. Three repetitions were performed, up to the maximum length of stay.

PHASE II: (sessions 5 to 8)

Side bridge exercise: the participant was lying in the supine position, with hips and knees bent at 45 degrees, and feet resting on the stretcher. They were instructed to lift the pelvis until it aligned with the knees and shoulders and then extend one of the knees until the lower limb was completely aligned with the trunk. The participant performed three repetitions with each lower limb, up to the maximum time they could remain in the position.

Plank exercise: the initial position was in prone position on the mat, the participant was instructed to support the weight of their body on the elbows, which were supported and aligned below the shoulders. The participant was required to extend one of the hips until the foot was aligned at the hip. Three repetitions were performed with each lower limb, up to the maximum length of stay.

Side plank exercise: Starting from the lateral decubitus, the participant was required to support the weight of their body on one of the upper limbs and on the feet, which were supported on the stretcher, one in front of the other. The participant kept the body aligned, and performed 3 repetitions for each side.

REFERENCES

1. Lustenberger DP, Ng VY, Best TM, Ellis TJ. Efficacy of treatment of trochanteric bursitis: a systematic review. Clin J Sport Med. 2011;21(5):447-53.
2. LaPorte C, Vasaris M, Gossett L, Boykin R, Menge T. Gluteus medius tears of the hip: a comprehensive approach. Phys Sportsmed. 2019;47(1):15-20.
3. Torres A, Fernández-Fairen M, Sueiro-Fernández J. Greater trochanteric pain syndrome and gluteus medius and minimus tendinosis: nonsurgical treatment. Pain Manag. 2018;8(1):45-55.
4. Mellor R, Bennell K, Grimaldi A, Nicolson P, Kasza J, Hodges P, Wajswelner H, Vicenzino B. Education plus exercise versus corticosteroid injection use versus a wait and see approach on global outcome and pain from gluteal tendinopathy: prospective, single blinded, randomised clinical trial. Br J Sports Med. 2018;52(22):1464-72.
5. French HP, Jong CC, McCallan M. Do features of central sensitisation exist in Greater Trochanteric Pain Syndrome (GTPS)? A case control study. Musculoskelet Sci Pract. 2019;43:6-11.
6. Reid D. The management of greater trochanteric pain syndrome: a systematic literature review. J Orthop. 2016;13(1):15-28.
7. Ilizaliturri VM, Zepeda Mora R, Rodríguez Vega LP. Rehabilitation after gluteus medius and minimus treatment. Arthrosc Sport Med Rehabil. 2022;4(1):e41-50.
8. Miyasaki MR, Marcioli MAR, Cunha APRRD, Polesello GC, Marini MG, Fernandes KBP, Macedo CSG. Greater trochanteric pain syndrome in women: analysis of magnetic resonance, sagittal alignment, muscular strength and endurance of the hip and trunk. Int J Rheum Dis. 2021;24(7):941-7.
9. Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. Med Sci Sport Exerc. 2004;36(6):926-34.
10. Mallow M, Nazarian LN. Greater trochanteric pain syndrome diagnosis and treatment. Phys Med Rehabil Clin N Am. 2014;25(2):279-89.
11. Nurkovic J, Jovasevic L, Konicanin A, Bajin Z, Ilic KP, Grbovic V, Skevin AJ, Dolicanin Z. Treatment of trochanteric bursitis: our experience. J Phys Ther Sci. 2016;28(7):2078-81.
12. Ho GWK, Howard TM. Greater trochanteric pain syndrome: more than bursitis and iliotibial tract friction. Curr Sports Med Rep. 2012;11(5):232-8.
13. Mulligan EP, Middleton EF, Brunette M. Evaluation and management of greater trochanter pain syndrome. Phys Ther Sport. 2015;16(3):205-14.
14. Thomaz de Aquino Nava G, Baldini Prudencio C, Krasic Alaiti R, Mendes Tozim B, Mellor R, Rodrigues Pedroni C, Mércia Pascon Barbosa A, Tavella Navega M. Motor control exercises versus general exercises for greater trochanteric pain syndrome: A protocol of a randomized controlled trial. PLoS One. 2022;17(6):e0269230.
15. Rompe JD, Segal NA, Cacchio A, Furia JP, Morral A, Maffulli N. Home training, local corticosteroid injection, or radial shock wave therapy for greater trochanter pain syndrome. Am J Sports Med. 2009;37(10):1981-90.
16. Ganderton C, Semciw A, Cook J, Pizzari T. Demystifying the clinical diagnosis of greater trochanteric pain syndrome in women. J Womens Health (Larchmt). 2017;26(6):633-43.
17. Fearon AM, Scarvell JM, Neeman T, Cook JL, Cormick W, Smith PN. Greater trochanteric pain syndrome: defining the clinical syndrome. Br J Sports Med. 2013;47(10):649-53.
18. Paiva EB, Azevedo DC, Pereira AL, Garcia AN, Percope de Andrade MA. Translation, cross-cultural adaptation and validation of the Brazilian Portuguese version of the Victorian Institute of Sports Assessment for Gluteal Tendinopathy patient reported--outcome measure (VISA-G.BR). Musculoskelet Sci Pract. 2021;52:102341.
19. Nasser AM, Fearon AM, Grimaldi A, Vicenzino B, Mellor R, Spencer T, Semciw AI. Outcome measures in the management of gluteal tendinopathy: a systematic review of their measurement properties. Br J Sports Med. 2022;56(15):877-87.
20. Fearon AM, Ganderton C, Scarvell JM, Smith PN, Neeman T, Nash C, Cook JL. Development and validation of a VISA tendinopathy questionnaire for greater trochanteric pain syndrome, the VISA-G. Man Ther. 2015;20(6):805-13.
21. Korakakis V, Kotsifaki A, Stefanakis M, Sotiralis Y, Whiteley R, Thorborg K. Evaluating lower limb tendinopathy with Victorian Institute of Sport Assessment (VISA) questionnaires: a systematic review shows very-low-quality evidence for their content and structural validity—part I. Knee Surgery, Sport Traumatol Arthrosc. 2021;29(9):2749-64.

22. Ikezaki F, Krueger E, de Souza Guerino Macedo C. Performance, reliability and fatigue in prone bridge test and supine unilateral bridge test. J Bodyw Mov Ther. 2021;26:238-45.
23. Schellenberg KL, Lang JM, Chan KM, Burnham RS. A clinical tool for office assessment of lumbar spine stabilization endurance: prone and supine bridge maneuvers. Am J Phys Med Rehabil. 2007;86(5):380-6.
24. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sport Exerc. 1982;14(5):377-81.
25. Ferber R, Bolgla L, Earl-Boehm JE, Emery C, Hamstra-Wright K. Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: a multicenter randomized controlled trial. J Athl Train. 2015;50(4):366-77.
26. Matthews M, Rathleff MS, Claus A, McPoil T, Nee R, Crossley K, Kasza J, Paul S, Mellor R, Vicenzino B. The Foot Orthoses versus Hip eXercises (FOHX) trial for patellofemoral pain: a protocol for a randomized clinical trial to determine if foot mobility is associated with better outcomes from foot orthoses. J Foot Ankle Res. 2017;10:5.
27. Chan MK, Chow KW, Lai AY, Mak NK, Sze JC, Tsang SM. The effects of therapeutic hip exercise with abdominal core activation on recruitment of the hip muscles. BMC Musculoskelet Disord. 2017;18(1):313.
28. Cohen J. Statistical power analysis for the behavioral sciences. 1990. 567p.
29. Clifford C, Paul L, Syme G, Millar NL. Isometric versus isotonic exercise for greater trochanteric pain syndrome: a randomised controlled pilot study. BMJ Open Sport Exerc Med. 2019;5(1):e000558.
30. Hammond KE, Kneer L, Cicinelli P. Rehabilitation of soft tissue injuries of the hip and pelvis. Clin Sports Med. 2021;40(2):409-28.
31. Macdermid JC, Silbernagel KG. Outcome evaluation in tendinopathy: foundations of assessment and a summary of selected measures. J Orthop Sport Phys Ther. 2015;45(11):950-64.
32. Vicenzino B, de Vos RJ, Alfredson H, Bahr R, Cook JL, Coombes BK, Fu SN, Gravare Silbernagel K, Grimaldi A, Lewis JS, Maffulli N, Magnusson SP, Malliaras P, Mc Auliffe S, Oei EHG, Purdam C, Rees JD, Rio EK, Scott A, Speed C, Akker-Scheek IVD, Weir A, Wolf JM, Zwerver J. ICON 2019-International Scientific Tendinopathy Symposium Consensus: There are nine core health-related domains for tendinopathy (CORE DOMAINS): Delphi study of healthcare professionals and patients. Br J Sports Med. 2020;54(8):444-51.
33. Robinson NA, Spratford W, Welvaert M, Gaida J, Fearon AM. Does Dynamic Tape change the walking biomechanics of women with greater trochanteric pain syndrome? A blinded randomised controlled crossover trial. Gait Posture. 2019;70:275-83.
34. Cowan RM, Ganderton CL, Cook J, Semciw AI, Long DM, Pizzari T. Does menopausal hormone therapy, exercise, or both improve pain and function in postmenopausal women with greater trochanteric pain syndrome? a 2 × 2 factorial randomized clinical trial. Am J Sports Med. 2022;50(2):515-25.
35. Bohannon RW, Steffl M, Glenney SS, Green M, Cashwell L, Prajerova K, Bunn J. The prone bridge test: performance, validity, and reliability among older and younger adults. J Bodyw Mov Ther. 2018;22(2):385-9.
36. Sziver E, Nagy E, Preszner-Domján A, Pósa G, Horvath G, Balog A, Tóth K. Postural control in degenerative diseases of the hip joint. Clin Biomech (Bristol, Avon). 2016;35:1-6.
37. Marcioli MAR, Cunha APRR, Miyasaki MR, Macedo CSG. Capacidade funcional e déficits do controle postural em mulheres com síndrome da dor no grande trocânter. Acta Fisiátrica. 2023;30(1):1-6.
38. Wilson BR, Robertson KE, Burnham JM, Yonz MC, Ireland ML, Noehren B. The relationship between hip strength and the y balance test. J Sport Rehabil. 2018;27(5):445-50.