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Vascular Occlusion of the Quadriceps Muscle in Postural Control of Women with Patellofemoral Dysfunction

Oclusão Vascular do Músculo Quadríceps no Controle Postural de Mulheres com Disfunção Patelofemoral

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Abstract

The partial vascular occlusion (PVO) associated with exercises, proposed by the KAATSU Training method, has the objective of strengthening and muscle hypertrophy with low joint overload. Currently, PVO has been associated with exercises to strengthen then quadriceps, however it is not known about its influence on postural control or the possibility of imbalances during the performance of exercises. Objectives: To evaluate the effect of quadriceps vascular occlusion on postural control in women with patellofemoral pain syndrome (PFPS). Methods: The sample in this study was composed of four sedentary women, aged between 18 and 40 years, with a clinical diagnosis of patellofemoral dysfunction. Participants responded to the Visual Analog Pain Scale (VAS) and the Anterior Knee Pain Scale (AKPS). They were submitted to an evaluation of postural control over the force platform, by means of dynamic one-legged squat activity, with and without PVO. The variables of postural control analyzed were Area of pressure center (A-COP), Anteroposterior (AP) and medium-lateral (ML), Velocity AP and ML. Results: No significant differences were found for the variables of postural control analyzed when comparing the moments with and without peripheral vascular occlusion during single-legged squat activities. Conclusion: The single leg squat with vascular occlusion does not change the postural control of patients with PFPS with and without PVO, and that the method can be used for training these patients, without impairments related to postural control.

Keywords: Patellofemoral Pain Syndrome. Therapeutic Occlusion. Postural Balance. Physical Therapy Modalities.

Resumo

A oclusão vascular parcial (OVP) associada a exercícios, proposta pelo método KAATSU Training, tem como objetivo o fortalecimento e hipertrofia muscular com baixa sobrecarga articular. Atualmente, a OVP tem sido associada a exercícios de fortalecimento do quadríceps, porém não se sabe sobre sua influência no controle postural ou na possibilidade de desequilíbrios durante a execução dos exercícios. Objetivos: Avaliar o efeito da oclusão vascular do quadríceps no controle postural de mulheres com síndrome da dor patelofemoral (SDFP). Métodos: A amostra deste estudo foi composta por quatro mulheres sedentárias, com idade entre 18 e 40 anos, com diagnóstico clínico de disfunção femoropatelar. Os participantes responderam à Escala Visual Analógica de Dor (VAS) e à Escala de Dor Anterior no Joelho (AKPS). Elas foram submetidas à avaliação do controle postural sobre a plataforma de força, por meio da atividade de agachamento unipodal dinâmico, com e sem OVP. As variáveis de controle postural analisadas foram área do centro de pressão (A-COP), ântero-posterior (AP) e médio-lateral (ML), velocidade AP e ML. Resultados: Não foram encontradas diferenças significativas para as variáveis de controle postural analisadas na comparação dos momentos com e sem OVP durante o agachamento unipodal. Conclusão: O agachamento unipodal com OVP não alterou o controle postural de mulheres com SDFP, e o método pode ser utilizado para treinar esses pacientes, sem prejuízos relacionados ao controle postural.

Palavras-chave: *Síndrome da Dor Patelofemoral. Oclusão Terapeutica. Equilíbrio Postural. Modalidades de Fisioterapia.*

1 Introduction

The vascular occlusion method was created with the objective of contributing to muscle hypertrophy, and its effect involves mechanical, neuroneal and hormonal factors[1]. The method was initially developed for muscle hypertrophy of healthy individuals, and establishes that when oxygen availability is reduced during vascular occlusion, there is an increase in metabolic accumulation with recruitment of additional motor units through afferent stimulation of muscle fibers[2]. The method summarizes positioning the cuff (vascular occlusion band) at the desired anatomic site, aiming at vascular occlusion of the muscle and regulating the pressure values of the cuff before and during exercises, which are more efficient when performed with resistance[3]. Low-load exercises 20-50% of a full-load repetition (1RM) are recommended[4].

It is pointed out that partial vascular occlusion (PVP) during low-load exercises may increase muscle strength by means of greater activation of type II rapid contraction fibers[4]. Training protocols aimed at gains in strength and hypertrophy guide training with loads of at least 70% of 1 RM, but many people cannot or are not able to perform force training with high intensity due to joint pain, surgical and neurological injuries, among other causes. For these reasons, vascular occlusion may be a training strategy, not only for clinical

populations, but also for athletes at different stages of the periodization, due to the possibility of training in much lower loads and still to obtain improvement in muscle strength.

Vascular occlusion has been used to strengthen the muscles of patients with pathologies and knee surgeries. Hughes et al.[5] compared training efficacy with vascular occlusion and conventional training in improving skeletal muscle hypertrophy and strength, physical function and pain in post-surgical patients reconstruction of anterior cruciate ligament, and they found similar results in both groups, however, patients with vascular occlusion perform exercises with less pain. In the same sense, Giles et al found similar results among the groups with and without vascular occlusion in the improvement of quadriceps muscle strength in patients with patellofemoral pain. It is noteworthy that this is the only study found in the literature in patients with PFPS who performed vascular occlusion exercises.

The Pathofemoral Pain Syndrome (PFPS) is one of the main disorders affecting the knee, with a higher incidence in the female population and reaches approximately 13% of women aged between 18 and 35 years[6]. The etiology of patellofemoral pain is multifactorial, with emphasis on positioning in knee valgus, shortening of the ischiotibial muscles, poor patellar alignment, increase in angle Q [7]greater intra-articular contact and consequent degenerative changes of cartilage and subchondral bone[8]. In addition, it is pointed out that knee and hip muscles, especially hip abductor and quadriceps, play an important role in the alignment of lower limbs and postural stability, with importance to posture and balance[9].

Many clinical interventions have been performed with the objective of correcting the patellar alignment and joint movement, which include muscle strengthening of hip and knee muscles, especially quadriceps, stretching of hamstrings and iliotibial band, patellar mobilization, patellar banding, among others,according to the changes presented by each patient [8]. The need to improve quadriceps muscle stability in women with PFPS is well defined in the literature, preferably with exercises that do not overload knee joint, due to exacerbated pain and increased joint contact presented by these patients. Due to this, it is believed that PVP is indicated and a good treatment strategy for women with PFPS, since the method has shown results similar to conventional strengthening in other knee pathologies[10] with the advantage of assigning less load to the patient and consequently less pain. Despite the advantages demonstrated after certain intervention periods, at the time of exercise, the muscle is found to have partial blood flow restriction and less local oxygenation, and the benefits or prejudice to the quality of performance of the movement are not known.

Then, it is questioned whether the PVP device, used with a great increase in frequency in strength training with the objective of muscle hypertrophy, or for muscle strength gain in rehabilitation programs, may or may not interfere in postural control of women with PFPS, since the practice of vascular occlusion decreases blood flow and, consequently, oxygen supply in the activating muscle. It is believed that if there is a decrease in postural control, exercises could be developed with less security, which could cause changes in performance of rehabilitation protocols. It is important to consider that vascular occlusion is widely used in training and rehabilitation, but little is known about the quality of exercises and whether they can cause some damage associated with postural control. Therefore, the objective of the present study was to evaluate whether the use of an OVP device in the quadriceps muscle may or may not alter the postural control of women with PFPS.

2 Material and Methods

The research was conducted in accordance with Resolution 466/2012 of the National Health Council and approved by the Ethics in Research Committee of the institution (Opinion n° 4.062.833). The participants, after being invited to participate in the study, were informed about the objectives and methodology of the research and signed the informed consent term. It was a cross-sectional (observational) study, with a convenience sample and composed of four sedentary women who met the inclusion criteria: age between 18 and 50 years, sedentary or physically active, minimum pain onset time in 8 weeks, exacerbated pain in at least three of the activities of sitting, squat, kneeling, climbing and down stairs, running and staying long in the sitting position.

The exclusion criteria were determined by: acute lower limb injury, chronic inflammatory joint diseases (rheumatoid arthritis) or signs and symptoms of other knee pathologies (coexistent), anterior knee surgery (in anterior cruciate ligament, menisks or patellar tendon), local knee injection (corticosteroid) in the previous month, and changes in plantar sensitivity due to any pathology or dysfunction.

The Analogue Visual scale (EVA) was used for instrumentation, which consists of a scale of 10 cm, being 0 signifying “no pain” and 10[11] the “maximum pain possible”. The participant marked on the scale her pain before collection. And the Anterior Knee Pain Scale (AKPS)[12], a translated and validated scale for the portuguese language, composed of 13 questions about the involvement of patellofemoral pain during functional activities. Each alternative corresponds to a score, the higher the final score the smaller the knee injury will be.

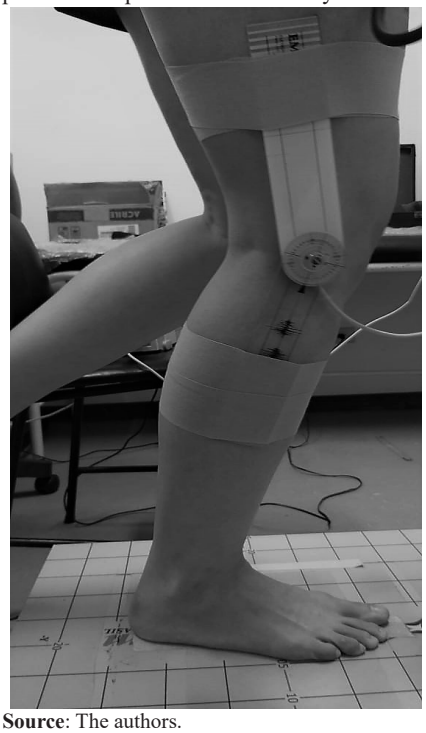
All participants were evaluated on the BIOMEC411 strength platform (Serial number: NS_BIO1470, EMG System do Brasil®, SP Ltda.), which has four load cells in a rectangular position and quantifies the distribution of vertical strength in these four points. The channels configured for the power platform have frequency band filters between 0 and 35Hz within scientific standards. Programmable sampling frequency – maximum 50KHz. All these parameters were

calculated at specific intervals for dynamic tasks (unipodal squat exercise with approximately 45 th knee flexion, in three consecutive repetitions, three tests were performed, with one minute of rest between each.

The participants were evaluated and after the diagnosis of patellofemoral pain syndrome (PFPS) they were referred to the evaluation protocols composed of a questionnaire for the characterization of the sample (age, weight, height, dominant lower limb, limb with pain, Pain history) and by the EVA and AKPS scales. Data collection was performed at the Research and Graduate Studies Center of the Health Sciences Center - Londrina State University (CEPOS-CCS/UEL). After completing the questionnaire and initial scales, the participants were submitted to assessment of the dynamic postural control over the strength platform.

The participants were previously familiar with the tests and equipment to be used, as well as the single-leg squat exercise. In the sequence, the participants performed three consecutive repetitions of single-leg squat exercise of the lower limb with PFPS (Figure 1), controlled up to 45° of knee flexion, with the contralateral limb in suspension and flexed at 90°[13], performed three times, with rhythm determined by sound stimulation by means of metronome, with one minute of rest sitting between each repetition. The participants were oriented to keep the trunk aligned and erect during the test and remain as much as possible with most of the plantar region touching the soil. After the one-leg squat was performed, the participants performed the same exercise with the vascular occlusion device with a pressure of 220mmHg. If the participants complained or reported pain the tests were interrupted.

Figure 1 – One-leg squat over the strength platform for postural control analysis



Source: The authors.

The main postural control parameters based on the pressure center (COP) were computed: the COP ellipse area (A-COP in cm2), the mean speed of COP oscillations (VEL in cm/s) in the directions of anteroposterior movement (A/P) and mid-lateral movement (M/L), COP oscillation amplitude (cm) in anteroposterior (A/P) and mid-lateral (M/L) directions and COP oscillation frequency (Hz) in anteroposterior (A/P) and mid-lateral (M/L) directions[14].

For data analysis, Shapiro-Wilk's test was used to determine data normality and, as a function of normality, paired Student's T-Test was used to compare intra-group values, described in mean and standard deviation. The level of statistical significance was set at $p \leq 0.05$ and the statistical software was SPSS® 20.0.

3 Results and Discussion

Sample characterization data showed that they were young women, with pathofemoral pain above 3 points in EVA, with knee-related disability greater than 72 points in the AKPS (Table 1).

Table 1 - Sample characterization

Participant	1	2	3	4
Age	20	24	28	21
Height	1.58	1.72	1.63	1.56
Weight	57	64	89	56
BMI	22.8	21.6	33.5	23.0
Member with pain	Right	Right	Right	Left
Visual Analog Pain Scale	4	3	4	4
AKPS	75	86	72	80

AKPS: Anterior Knee Pain Scale.
Source: Research data.

The results of postural control in the women evaluated did not establish differences for one-leg squat performed with and without vascular occlusion (Chart 2).

Table 2 - Results of postural Control in one-leg squat with and without Partial Vascular Occlusion

	Without OVP	With OVP	P
Amplitude AP	7.58 (0.99)	7.28 (1.48)	0.617
Amplitude ML	3.93 (0.10)	3.87 (0.49)	0.767
A-COP	23.37 (4.21)	24.09 (8.83)	0.833
AP Speed	5.77 (0.86)	5.39 (0.59)	0.195
ML Speed	4.99 (1.00)	4.41 (0.82)	0.082

OVP: Partial Vascular Occlusion. The data were described as mean (DP), by paired Student's T-test.
Source: Research data.

The present study investigated the effect of partial vascular occlusion (PVP) on quadriceps muscle during a single-leg squad activity on postural control of women with PFPS. It was observed that there were no significant differences in the postural control of the participants when performing one-leg squat with and without PPO. It is known that dynamic postural balance may be influenced by several kinematic changes related to lower extremities, such as pelvis, hip, knee and ankle positioning, as well as muscle imbalances

that are directly related to postural changes[15]. Postural control of individuals with PFPS has an important relationship with muscle stabilization, especially of knee joint that has as its main stabilizer, the quadriceps muscle. Quadriceps muscle weakness, especially during eccentric contractions, is present in most patients with knee anterior pain. Although pain and/or instability are the main complaints, hypotrophy and reduced muscle activity of the vastus medialis oblique in relation to the vastus lateralis are often found and one of the most important causes of dysfunction. Local muscle instability in the knee may lead to changes in all positioning of the lower limbs and trunk, and consequently postural control deficits, which justifies the importance of quadriceps muscle training in these patients[16].

Quadriceps muscle strengthening, among other muscle groups, is already well defined in the literature as indicated and essential approaches in the treatment of patients with PFPS[17]. However, one of the greatest difficulties in the progression of exercises and strength gain of these patients is the exacerbation of pain with the increase in exercise volume. Recently, studies have begun to explore the use of muscle training with blood flow restriction, also called PVP, for the muscle in training, with low intensity loads (30% of 1 RM) in individuals who cannot tolerate high training loads. Many investigations show positive results of PVP in healthy participants, athletes and elderly people. Several hypotheses for the efficacy of PVP in increased muscle strength and hypertrophy have been proposed[18], mainly related to low-load training, however, the vast majority of studies occurred with healthy and pain-free individuals. The number of studies carried out with different knee pathologies, specifically in PFPS, is still small.

It is noteworthy that training with PPO in lower limb muscles can be used with the objective of muscle strength gain in patients with discomfort or PFPS, since studies have shown positive effects with low-load training on pain improvement, discomfort and hypertrophy of patients with some knee pathology. Initially, it was questioned whether the oxygen deficit caused by vascular occlusion could in some way impair the muscle activation of the restricted muscle at the time of the test, that is, in real time of movement, with consequent worsening of the postural control. It is known that the method recommends that with reduced oxygen availability during vascular occlusion, there is an increase in metabolic accumulation with higher recruitment of additional motor units. Previous studies have shown significant increases in the rate of motor units associated with vascular occlusion, and suggest that the recruitment of high levels of motor units is not affected only by the strength and rate of contraction, but also by the availability of oxygen[3].

In general, the positive results obtained with vascular occlusion are consequences of a training protocol with several sessions, for many weeks, however, the studies do not assess the possible negative effects in the short term, or more specifically, at the time of this muscle flow restriction. In the present study, it was observed that even with the decrease in partial muscular oxygenation and blood flow restriction, it was not possible to identify a difference in the participants' postural control at the moments evaluated, with and without vascular occlusion, which suggests that exercises performed with vascular occlusion do not alter the postural control of patients with PFPS when compared to patients who perform without occlusion, and that the method can be used for training these patients, without damages related to the postural control.

This study presents limitations that may have an influence on the results found, such as the small number of participants evaluated and the non-randomization of the execution of the exercises. It is suggested that more studies with this research line be performed with a larger sample, besides controlling other variables that may have a direct relationship with postural control, such as quadriceps muscle activation during movement with and without vascular occlusion, confirming the hypothesis of deficit or non-deficit of this muscle at the moment of occlusion, and not only the results after weeks training protocol.

4 Conclusion

It was concluded that one-leg squad with vascular occlusion does not alter the postural control of patients with PFPS when compared to patients who perform without vascular occlusion, and that the method can be used for the training of these patients, without damages related to postural control.

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