

# COMPARATIVE STUDY OF TWO PROTOCOLS OF ECCENTRIC EXERCISE ON KNEE PAIN AND FUNCTION IN ATHLETES WITH PATELLAR TENDINOPATHY: RANDOMIZED CONTROLLED STUDY

LOCOMOTOR APPARATUS IN EXERCISE AND SPORTS



ORIGINAL ARTICLE

Ronaldo Alves da Cunha<sup>1</sup>  
 Andreia Natacha Dias<sup>1</sup>  
 Marcelo Bannwart Santos<sup>1</sup>  
 Alexandre Dias Lopes<sup>2</sup>

1. Center of Sports Traumatology-Orthopedics (CETE) of the Federal University of São Paulo (Unifesp), São Paulo, SP, Brazil.

2. Master's Program in Physiotherapy of the University São Paulo City (UNICID), São Paulo, SP, Brazil.

## Mailing address:

Rua Santa Clara, 215  
 12900-470 – Centro  
 Bragança Paulista, SP, Brasil  
 E-mail: [ronaldoalvesdacunha@yahoo.com.br](mailto:ronaldoalvesdacunha@yahoo.com.br)

## ABSTRACT

**Introduction:** The eccentric squat on a slope has been proved effective in conservative treatment of patellar tendinopathy, especially in the athletic population. However, several aspects such as intensity and pain during therapy still differ among authors. **Objectives:** To compare the effectiveness of two protocols of eccentric exercise (performed with and without pain), in the improvement of knee function and pain intensity in athletes with patellar tendinopathy. **Methods:** 7 athletes of both genders with diagnosis of patellar tendinopathy were selected and randomly assigned to two treatment groups. The first group of volunteers performed eccentric squat exercises on a slope with pain in the patellar tendon. The second group of volunteers was instructed to perform the same exercise, but without presenting pain in the patellar tendon during performance. The treatment lasted 12 weeks and the evaluation of pain and function was performed by the VISA-P and VAS before starting treatment, at eight weeks of intervention, and at treatment completion. **Results:** There was improvement in both groups when results of evaluations carried out after eight and 12 weeks of beginning of the treatment were compared with the initial evaluation; however, no significant difference between the group that performed exercise with pain and the group that performed exercises without pain was found. Analysis of the probability of obtaining clinical improvement for VISA and VAS scores at eight and 12 weeks, there was no difference between the two groups. **Conclusion:** A program of eccentric exercise on an inclined plane using squat, performed with or without the presence of pain, was effective in improving pain and function in athletes with patellar tendinopathy.

**Keywords:** patellar tendon, rehabilitation, sports.

## INTRODUCTION

The patellar tendinopathy (PT) is an overload injury, common in elite athletes<sup>1</sup>, being much more frequent and recurrent in sports involving jumps<sup>2</sup>. The prevalence of unilateral and bilateral PT is different between genders; bilateral tendinopathy is twice commonly men than in women; however, unilateral tendinopathy presents equivalent prevalence<sup>3</sup>.

Firstly described by Blazina *et al.* in 1973<sup>4</sup>, it still presents an obscure etiology. In the literature, there are two hypotheses about the tendon injury: a mechanical and a vascular theory, but the two are not mutually exclusive<sup>5</sup>. In the mechanical theory, great part of injuries on the tendon is related to the microtrauma of repetition, frequently described as overuse disease<sup>6</sup>. Many tendon injuries are also associated with the reduced vascular perfusion on the tendons<sup>7</sup>. Many theories on the circulation decrease have been described; however, in contradiction to this theory, chronic tendon's injury many times present increase in vascularization<sup>8</sup>. Studies with ultrasound have shown increase in vascularization in the areas with structural alteration<sup>1,7,9</sup>. Nevertheless, the same alterations are seen in asymptomatic individuals<sup>8</sup>.

The pain origin in PT is obscure<sup>10</sup>. Microdialysis studies observed the absence of inflammatory cells discarding the hypoth-

esis that there is an inflammatory process originating pain<sup>11</sup>. The alterations observed in the region close to the tendon were suggested as a biomechanical adaptation hypothesis to the compression forces where the peripheral tissues would be responsible for pain, since they are not adapted and would stimulate nociceptors<sup>12</sup>. There is also a biochemical model which considers the alterations of chemical substances as the cause for pain<sup>10</sup>.

The difficulty in the PT treatment has been described by some authors<sup>2,9</sup>, and there is not a gold standard for its treatment<sup>2,13</sup>. Many interventions have been used, such as rest, alteration in the lifestyle, weight reduction, medication, surgery and specific skills, such as physiotherapy and physical exercises<sup>14</sup>. Therapeutic exercises recommended as a way of decreasing pain and improving function have proved their efficiency through systematic reviews<sup>15</sup>.

Performance of eccentric exercises (EE) is accepted as an important part of the conservative treatment<sup>2,16</sup>, and the squat exercise performed on a slope is one of the most recommended exercises for PT<sup>17,18</sup>. The efficiency of the EE has been demonstrated<sup>19</sup>; however, different explanations are proposed to elucidate these good results<sup>10,20</sup>.

The concept of eccentric training in the tendon rehabilitation

was firstly proposed by Stanish *et al.*<sup>21</sup>, and has become popular afterwards<sup>9</sup>. Nevertheless, there is divergence among these authors: while some recommend that the patients perform eccentric squat exercise without pain, others suggest that it should be performed even in the presence of moderate or intense pain<sup>16</sup>. The lack of consensus about which would be the best way to perform the EE protocol (exercise performance with or without pain), justifies the performance of controlled and randomized studies comparing these two kinds of intervention.

The present study had as main aim to compare the efficiency of two EE protocols, one performed without pain and the other with pain, in the improvement of the knee function and pain intensity in athletes with PT.

## METHOD

This research is a random controlled and prospective study, in which subjects were selected by medical recommendation provided to the Physiotherapy Sector of the Center of Sports Traumatology-Orthopedics (CETE) of the Federal University of São Paulo (Unifesp), with PT diagnosis.

Individuals of both genders, aged over 18 years, who practiced any sport activity, with medical PT diagnosis guided by ultrasound exam (US) and/or nuclear magnetic resonance (NMR) were included. The participants who underwent through a surgery on the knee in the last 12 months, made use of corticosteroid injections on the patellar tendon, performed physiotherapy in the last month for knee problems or used medication such as hormonal or non-hormonal anti-inflammatory, were not included in the study<sup>18</sup>.

All volunteers received clarification on the performed procedures and signed a Free and Clarified Consent Form carried out according to the National Health Board, resolution 196/96. This study was approved by the Ethics in Research Committee of the Federal University of São Paulo.

After inclusion of the athletes in the study, they were divided in two groups. Pain Group (PG), which performed the EE with maximal tolerated pain, and the group named Without Pain (WP), which performed the exercises without causing any discomfort or pain. All athletes were treated by treatment intention. The subjects were distributed in these two groups through a random draw, with a sealed matte bag which had two pieces of paper inside it with the names of the two groups (PG or WP). The patients were blind since they were not informed there were two groups in the study.

### Intervention

The PG and the WP groups were submitted to three physiotherapy sessions per week, during 12 weeks, with a total of 36 sessions. The patients of both groups performed squat exercises up to 60° of knee flexion on a slope of 25°, in which the eccentric part of the exercise was performed with the injured limb and the concentric part with the contralateral limb. Three sets of 15 repetitions with a one-minute interval between each set were performed. A squat instrument with a guided bar was used for load increment in the exercise, which allowed the addition of plates from five to five kilos. The load used in the EE varied for each patient concerning the tolerance to pain group and the group he was in. The PG subjects were told to perform the exercise with the most pain as possible on the tendon, but which

did not cause alteration in the exercise performance standard. The WP subjects performed the exercise without causing any discomfort or pain. When the subjects from the WP group, even without load addition, presented pain during the exercise, they were told to rest the upper limbs on a bar with the purpose to decrease overload on the patellar tendon.

### Evaluations

The subjects of the two groups were evaluated in three moments: an initial evaluation (pre-treatment), which consisted in the application of specific questionnaire to evaluate the knee function with athletes with PT; VISA-P (*Victorian Institute of Sport Assessment – Patellar*)<sup>22</sup>; and the visual analog scale (VAS), with the aim to measure the pain intensity caused by the PT on the knee<sup>23</sup>. Two other evaluations were done after eight and 12 weeks from the beginning of the treatment. The application of the VISA-P questionnaire and the VAS for pain was filled out with not any intervention from the evaluator. It is worth mentioning that in the evaluations through the VISA-P questionnaire, higher final values represent better therapeutic result, while in the VAS evaluations higher final values represent worse therapeutic results.

### STATISTICAL ANALYSIS

A mean comparison test was used to evaluate the differences between groups before the beginning of the intervention. The values obtained from the VISA-P and the VAS were compared between groups with analysis of variance with two repeated measures, for group and time interaction. The data analysis of the two groups was performed with descriptive statistics with one measure of central tendency (mean) and one measure of dispersion (standard deviation). The significance adopted was  $\alpha = 0.05$ . The statistical program used was the SPSS (*Statistical Package for Social Sciences*), version 17.0 for data analysis.

In order to determine the probability to obtain clinically useful results, a specific analysis was performed to detect the lowest clinically important alteration in the VISA-P and VAS<sup>18</sup>. An alteration above 20 points in both scales was considered a clinically important alteration, probably reflecting a significant alteration in the clinical functional capacity<sup>23</sup>. When alterations between 20 and 10 points occurred, they were considered moderate clinical alterations, and when alterations with values lower than 10 points occurred in the scales, they were considered without clinical significance.

### RESULTS

All the 17 participants (14 men and three women) completed the eight-week evaluation and 14 (11 men and three women), completed the 12-week follow-up evaluation (three individuals were excluded from the study due to lack of periodicity in the treatment), as can be observed in figure 1. There was not statistically significant difference for any of the variables of the results in the initial evaluations before the intervention. Table 1 illustrates the general characteristics of the population.

Improvement in both groups was observed when the results of the evaluations performed after eight and 12 weeks from the beginning of the treatment and the initial evaluation were compared; however, there was no significant difference between the group which performed exercise with pain (PG) and the one

which performed the exercises without pain (WP) (figure 2). In the probability analysis of clinical improvement for the VISA and VAS scores in eight and 12 weeks, there was not any difference between the two groups (figure 3).

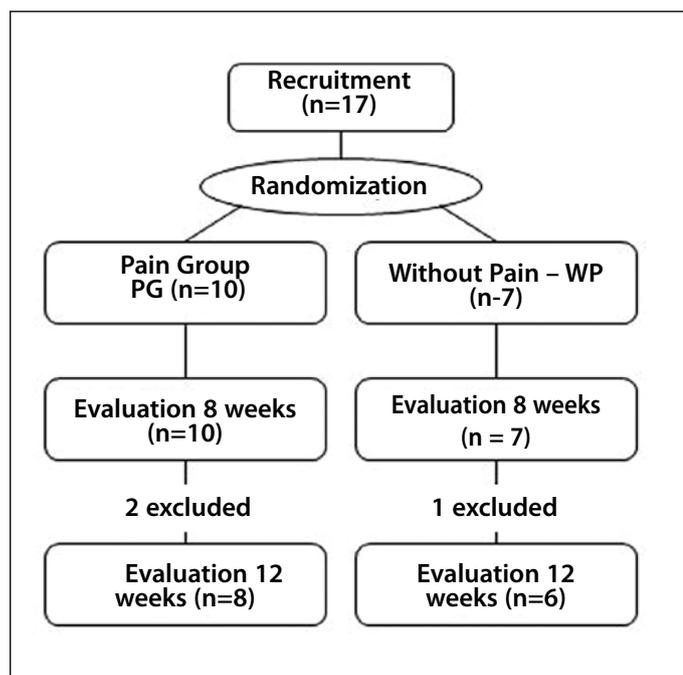


Figure 1. Chart illustrating the volunteers' participation in the study.

Table 1. General characteristics of the participants.

	Pain Group (n = 10)	Without Pain Group (n = 7)
<b>Gender (men/women)</b>	8/2	6/1
<b>Age (years)</b>	24.1 (8.3)	26 (5.9)
<b>Weight (kg)</b>	76.7 (9.4)	75.5 (10.8)
<b>Height (cm)</b>	176 (10)	175 (8)
<b>Injured knee</b>		
Right	3	4
Left	7	3
<b>Type of diagnosis (exam)</b>		
NMR + US	7	3
US	3	3
NMR		1
<b>Time of sports practice (years)</b>	8.2 (5.8)	7.8 (6)
<b>Sports modality</b>		
Track and Field	3	1
Basketball		1
Capoeira		1
Soccer	2	
Handball	1	
Fights		2
Skateboarding	1	
Triatlton		1
Volleyball	3	1

The variables age, weight, height and time of practice are presented as mean and standard deviation.

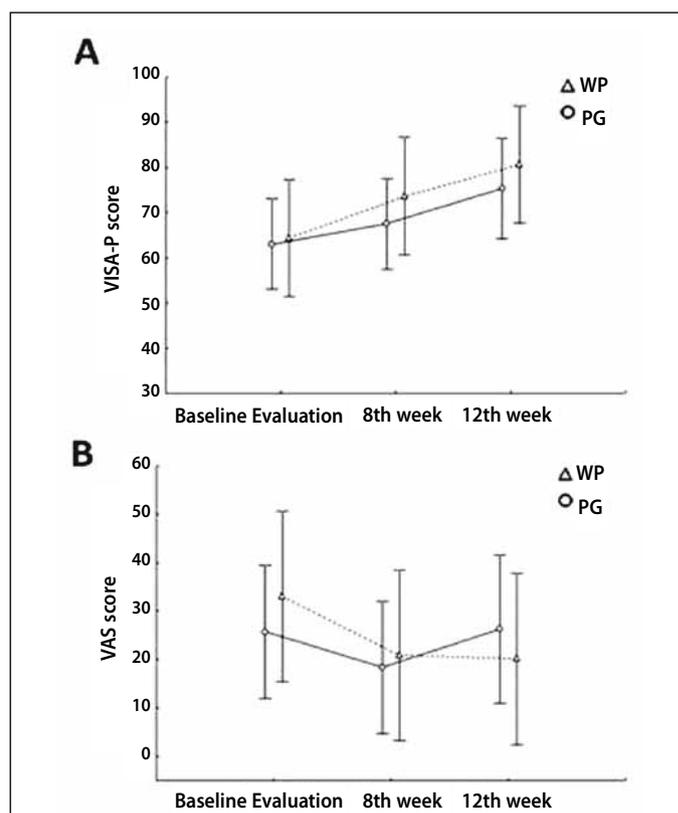


Figure 2. Variations of the mean (SDP) in (A) results of the VISA-P and (B) VAS in 12 weeks.

## DISCUSSION

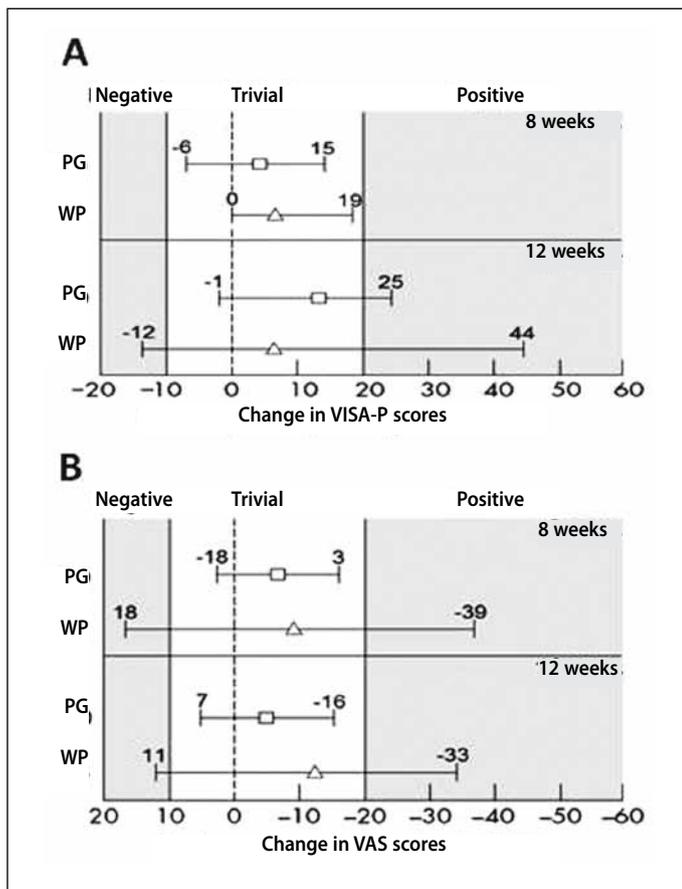
The results of this controlled and randomized clinical essay conducted with athletes with PT diagnosis, demonstrated that a 12-week intervention with eccentric squat exercises on a slope can be performed with and without pain, since both groups presented pain decrease and function improvement.

In order to verify improvement in the knee function a questionnaire specific to PT was used (VISA-P). Other studies evaluated the efficiency of the EE in the PT, and great part of these studies also used the VISA-P for evaluation of the knee function<sup>18,24</sup>. The results of our study could not be compared with other research since it is the first investigation concerning with the comparison of the efficiency of the EE performance with or without pain in individuals with PT.

Decrease in pain was observed in both groups of athletes of this investigation. The VAS was used here such as in many other studies. The pain improvement was evaluated after performance of EE for PT<sup>16-18</sup>. The same way it was not possible to compare the knee function due to existence of investigations which enabled us perform any kind of comparative analysis, the discussion on the pain aspect was also limited by the lack of reference which approached similar issues

The use of eccentric exercises for the treatment of PT has increased over the last years and it is based on few studies which demonstrated positive results in the pain and function improvement in athletes. Although the pain indication during exercise and high intensity of performance seem to be crucial pre-requisites for the good therapeutic result for some authors<sup>16,18,25</sup>, our study demonstrated that both groups benefited from the EE practice.

The results of the present study also questioned about the need for EE performance in an aggressive manner and in the



**Figure 3.** Probability of clinical results for (A) results of VISA-P and (B) VAS, in eight and 12 weeks (mean variation).

presence of pain on the knee extensor mechanism. As observed, regardless of the application choice (with or without pain), improvement in the severity of symptoms was reached, although it is not known for sure which mechanism would lead to the PT improvement after EE performance. From the practical point of view, it shows us that it is not necessary to submit the patient to a painful and uncomfortable intervention since even when performed in a less aggressive and painless manner, the EE presented positive results.

This study presented some limitations which should be avoided in future studies which involve PT in athletes. We believe that the low number of participants and the short follow-up period (12 weeks) may have influenced on the results of this study, as some other researchers have reported. Perhaps the difficulty in getting a population with a medical diagnosis and at least a complementary exam (US or NMR) may make it difficult to increase the number of participants in future investigations. A longer follow-up period is another difficulty factor with this kind of study, since the evolution of the clinical status of the athletes with PT is very fast, being hence very difficult to keep them under treatment for a longer period.

## CONCLUSION

The results of this study corroborate that an EE program using squatting on a slope performed with or without pain was efficient in improving the pain and function scenario in athletes with PT.

All authors have declared there is not any potential conflict of interests concerning this article.

## REFERENCES

- Cook JL, Kiss ZS, Khan KM, Purdam CR, Webster KE. Anthropometry, physical performance, and ultrasound patellar tendon abnormality in elite junior basketball players: a cross-sectional study. *Br J Sports Med* 2004;38:206-9.
- Cook JL, Khan KM. What is the most appropriate treatment for patellar tendinopathy? *Br J Sports Med* 2001;35:291-4.
- Cook JL, Khan KM, Harcourt PR, Kiss ZS, Fehrmann MW, Griffiths L, et al. Patellar tendon ultrasonography in asymptomatic active athletes reveals hypoechoic regions: a study of 320 tendons. Victorian Institute of Sport Tendon Study Group. *Clin J Sport Med* 1998;8:73-7.
- Blazina ME, Kerlan RK, Jobe FW, Carter VS, Carlson GJ. Jumper's knee. *Orthop Clin North Am* 1973;4:665-78.
- Riley G. The pathogenesis of tendinopathy. A molecular perspective. *Rheumatology (Oxford)* 2004;43:131-42.
- Kjaer M. The treatment of overuse injuries in sports. *Scand J Med Sci Sports* 2001;11:195-6.
- Gisslen K, Alfredson H. Neovascularisation and pain in jumper's knee: a prospective clinical and sonographic study in elite junior volleyball players. *Br J Sports Med* 2005;39:423-8; discussion -8.
- Cook JL, Malliaras P, De Luca J, Ptasznik R, Morris M. Vascularity and pain in the patellar tendon of adult jumping athletes: a 5 month longitudinal study. *Br J Sports Med* 2005;39:458-61; discussion -61.
- Alfredson H. The chronic painful Achilles and patellar tendon: research on basic biology and treatment. *Scand J Med Sci Sports* 2005;15:252-9.
- Khan KM, Cook JL, Maffulli N, Kannus P. Where is the pain coming from in tendinopathy? It may be biochemical, not only structural, in origin. *Br J Sports Med* 2000;34:81-3.
- Alfredson H, Forsgren S, Thorsen K, Lorentzon R. In vivo microdialysis and immunohistochemical analyses of tendon tissue demonstrated high amounts of free glutamate and glutamate NMDAR1 receptors, but no signs of inflammation, in Jumper's knee. *J Orthop Res* 2001;19:881-6.
- Hamilton B, Purdam C. Patellar tendinosis as an adaptive process: a new hypothesis. *Br J Sports Med* 2004;38:758-61.
- Khan KM, Maffulli N, Coleman BD, Cook JL, Taunton JE. Patellar tendinopathy: some aspects of basic science and clinical management. *Br J Sports Med* 1998;32:346-55.
- Rees JD, Maffulli N, Cook J. Management of tendinopathy. *Am J Sports Med* 2009;37:1855-67.
- Wasielowski NJ, Kotsko KM. Does eccentric exercise reduce pain and improve strength in physically active adults with symptomatic lower extremity tendinosis? A systematic review. *J Athl Train* 2007;42:409-21.
- Purdam CR, Jonsson P, Alfredson H, Lorentzon R, Cook JL, Khan KM. A pilot study of the eccentric decline squat in the management of painful chronic patellar tendinopathy. *Br J Sports Med* 2004;38:395-7.
- Cannell LJ, Taunton JE, Clement DB, Smith C, Khan KM. A randomised clinical trial of the efficacy of drop squats or leg extension/leg curl exercises to treat clinically diagnosed jumper's knee in athletes: pilot study. *Br J Sports Med* 2001;35:60-4.
- Young MA, Cook JL, Purdam CR, Kiss ZS, Alfredson H. Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players. *Br J Sports Med* 2005;39:102-5.
- Alfredson H, Ohberg L. Sclerosing injections to areas of neo-vascularisation reduce pain in chronic Achilles tendinopathy: a double-blind randomised controlled trial. *Knee Surg Sports Traumatol Arthrosc* 2005;13:338-44.
- Rees JD, Wolman RL, Wilson A. Eccentric exercises; why do they work, what are the problems and how can we improve them? *Br J Sports Med* 2009;43:242-6.
- Stanish WD, Rubinovich RM, Curwin S. Eccentric exercise in chronic tendinitis. *Clin Orthop Relat Res* 1986;65-8.
- Visentin PJ, Khan KM, Cook JL, Kiss ZS, Harcourt PR, Wark JD. The VISA score: an index of severity of symptoms in patients with jumper's knee (patellar tendinosis). Victorian Institute of Sport Tendon Study Group. *J Sci Med Sport* 1998;1:22-8.
- Flandry F, Hunt JP, Terry GC, Hughston JC. Analysis of subjective knee complaints using visual analog scales. *Am J Sports Med* 1991;19:112-8.
- Visnes H, Hoksrud A, Cook J, Bahr R. No effect of eccentric training on jumper's knee in volleyball players during the competitive season: a randomized clinical trial. *Clin J Sport Med* 2005;15:227-34.
- Stasinopoulos D, Stasinopoulos I. Comparison of effects of exercise programme, pulsed ultrasound and transverse friction in the treatment of chronic patellar tendinopathy. *Clin Rehabil* 2004;18:347-52.