








# Effects of eccentric exercise in pressure pain threshold in subjects with functional ankle equinus condition

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## SUMMARY

Stretching exercises are widely used by the population before sporting activities. One of the most common technique is eccentric exercise. Here, we made a clinical examination of 98 subjects with equinus condition before activity and after 30 min of running (49 participants with previous eccentric exercise and 49 with no previously eccentric exercise). The clinical assessment of the Achilles tendon was based on the pressure pain threshold (PPT). We identified significant PPT changes between the previous eccentric stretching and the non-previous eccentric stretching group in the Achilles tendon evaluations. Based on our findings, we propose that subjects with equinus condition could use eccentric stretching in order to improve the Achilles tendon status.

**KEYWORDS:** Ankle. Foot. Sports. Equinus Deformity.

## INTRODUCTION

Equinus is a clinical ankle condition that limits the dorsiflexion range of movement. Equinus could be explained as the “limitation of the ankle for dorsiflexion with the knee extended and/or flexed (excluding osseous-restriction)”<sup>1,2</sup>. Although Equinus is a non-symptomatic pathologic pattern, it may promote a clinical alteration in the Achilles tendon (AT) and triceps surae muscle. Equinus condition is deep-

ly related to lower limb injuries (as anterior cruciate ligament rupture), hip pain, ankle sprain, asymmetric load patterns, and changes in muscle activity for the triceps surae<sup>3-6</sup>.

Equinus condition could promote a higher basal activation for triceps surae and hamstring muscles. This clinical condition has been investigated using force-pressure platforms<sup>7-10</sup> and its relationships be-

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tween muscle activity patterns have been studied by electromyography<sup>11-13</sup>. Equinus condition is deeply related to gait, posture<sup>9,10</sup> and injuries. The activation of the triceps surae musculature could modify the mechanosensitivity of the Achilles tendon and promote other alterations<sup>14-17</sup>. Human posture is actively supported by the contraction of muscles as gluteus, hamstrings and triceps surae.

We aimed to assess with an algometer the PPT values for the Achilles tendon. The main aim of the study was to check PPT values between eccentric and non-eccentric stretching in subjects with Equinus before and after running exercise.

## METHODS

This was an observational study; 98 healthy male subjects were recruited. A consecutive sampling method was used to select participants. A total of 49 subjects with eccentric stretching and 49 with non-eccentric stretching were recruited. All participants completed the study. The exclusion criteria were the presence of sprains, infection, bone alteration, musculoskeletal disorders, tendon injuries, low back and pelvic pain, scoliosis, and use of drugs in the week preceding the test.

The studied variable was PPT. The pain pressure threshold was measured with an algometer. Twenty eccentric stretching exercises were carried out before the activity. Subjects then ran for 30 minutes on a treadmill at a speed of 10 km/h, and the PPT assessment was repeated.

### Sample size calculation

The sample size calculation was carried out by the difference between two independent groups with the G\*Power statistic tool and based on the right-Achilles tendon PPT of a case-control pilot study with 2-groups [mean (SD)], n = 10 subjects with Equinus condition [1.60 (0.57) kg/cm<sup>2</sup>] and n = 10 subjects without Equinus condition [1.98 (0.57) kg/cm]. Indeed, 1 tail hypothesis, an effect size of 0.67, an  $\alpha$ -error of 0.05, and a power of 0.95 were used for the sample size calculation. Therefore, a total sample size of 98 subjects, 49 for each group, was obtained.

### Ethical considerations

The Ethics Committee of the HULP (Madrid, Spain; record number: CE 2828A) approved the study. All participants provided signed informed con-

sent before the beginning of the study. The ethical standards for human experimentation of the Declaration of Helsinki and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were applied.

### Clinical exploration

First, subjects lay in a supine position, and their Equinus condition was assessed with the knee extended/ flexed. The range of movement was checked using a goniometer to evaluate the angle between the plantar line of the foot and the tibia bone axis. The PPT was checked using an algometer before and after activity. The Equinus assessment and PPT was carried out by the same Podiatry Doctor (D.R.S) in order to ensure the reliability of measurements.



**FIGURE 1**

## STATISTICAL ANALYSIS

Statistical analyses were carried out with SPSS (version 22.0 for Windows, IBM SPSS Statistics for Windows, Armonk, NY, IBM Corp) with an  $\alpha$  error of 0.05 (95% confidence interval [CI]), with the desired power of 80% ( $\beta$  error of 0.2).

The Kolmogorov-Smirnov test was used to assess data normality. All data were normally distributed, and the parametric statistical tests were selected. The mean and standard deviation of the temperature data were obtained for the selected lower limb muscles Achilles tendon.

Unpaired sample Student's t-test were performed to test for statistically significant differences in height, weight, body mass index, and age between the two groups. Paired Student's t-tests were performed to determine differences between the groups (Eccentric and non-eccentric stretching) as well as between sessions (before and after running).

## RESULTS

We found no statistically significant differences between the eccentric and non-eccentric groups for participant height, weight, age, or body mass index (Table 1).

**TABLE 1.** PARTICIPANT CHARACTERISTICS (N = 49 ECCENTRIC STRETCHING AND 49 NON-ECCENTRIC STRETCHING)

	Eccentric exercise group	Non-eccentric group
Age (years)*	34.56 ± 3.7	36.2 ± 2.4
Height (cm)*	174.5 ± 5.3	168.1 ± 4.9
Weight (kg)*	71.8 ± 2.1	70.2 ± 1.9
Body mass index*	21.1 ± 1.2	20.8 ± 1.4

\* No statistically significant difference between groups ( $p \geq 0.05$ ).

We found significant differences for pressure pain threshold in the Achilles tendon between both groups (eccentric and non-eccentric stretching exercises) after the activity (Table 2).

## DISCUSSION

Here, we identified that the PPT values were also lower for the non-eccentric stretching group vs. the eccentric stretching participants.

The triceps surae requires stronger activation in subjects with Equinus condition, therefore, might

**TABLE 2.** PRESSURE PAIN THRESHOLD ASSESSMENT

	PPT Before Running	PPT After Running
	Mean (SD)	Mean (SD)
Eccentric stretching	2.7 (0.22)	3.5 (0.33)
Non-eccentric stretching	2.5 (0.14)	2.8 (0.13)
p-value	0.17*	0.01†

\*No statistically significant difference between groups before running. † Statistically significant difference between groups before running

be affected early by pain or fatigue, thus explaining why we observed an increase in PPT values for the eccentric stretching participants compared with the non-eccentric stretching participants. In the assessment before running, we did not find any significant differences in the PPT values. The running exercise may serve as a stimulus to increase PPT values in muscles and consequently differences between groups.

Eccentric stretching exercise may assist triceps surae extensibility during loading and running and promote venous return. Biomechanically, the maximum ankle dorsiflexion during the stance-phase of a normal gait occurs before heel lift with the knee completed extended.<sup>1</sup> The most deeply known range of movement values for ankle dorsiflexion in the reviewed literature for static evaluation is the minimum dorsiflexion movement of the ankle for normal gait, which is 10° of motion.<sup>3, 18-23</sup>

Further studies are necessary to improve our knowledge of muscle condition and establish the clinical relevance of the association between PPT in non-equinus subjects<sup>25,26</sup>. Based on our findings, we propose that eccentric stretching exercise be recommended for runners with GSE condition.

## CONCLUSIONS

The eccentric stretching group showed a higher PPT-value for the Achilles tendon after exercise than the non-eccentric group. Therefore, an algometer that measures pain pressure threshold could be promoted as a screening tool for prevention or therapeutic actions. Based on our findings, we propose that eccentric exercise be recommended for subjects with GSE condition

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## RESUMO

*Exercícios de alongamento são amplamente utilizados pela população antes da atividade esportiva. Uma das técnicas mais comuns é o exercício excêntrico. Aqui, fizemos um exame clínico de 98 indivíduos com condição de pé equino antes da atividade e após 30 minutos de corrida (49 corredores com exercício excêntrico anterior e 49 sem exercício excêntrico anterior). A avaliação clínica do tendão de Aquiles foi baseada no limiar de dor à pressão (PPT). Identificamos modificações significativas no PPT entre alongamentos prévios excêntricos e nenhum exercício anterior excêntrico de alongamento para as avaliações do tendão de Aquiles. Com base em nossos achados, propomos que sujeitos com condição de pé equino poderiam fazer alongamentos com exercícios excêntricos para melhorar o status do tendão de Aquiles.*

**PALAVRAS-CHAVE:** Tornozelo. Pé. Esportes. Pé equino.

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