Deep Friction Massage and the Minimum Skin Pressure Required to Promote a Macroscopic Deformation of the Patellar Tendon

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ABSTRACT

Objective: The purpose of this study was to determine the skin pressure needed to promote the macroscopic deformation of the asymptomatic patellar tendon and to verify if the pressure is associated with the individual's characteristics.

Methods: A descriptive laboratory study was performed with a convenience sample of 18 young, voluntary, and asymptomatic individuals of both sexes. A progressively increasing pressure was applied on the skin over the patellar tendon, through an instrument designed to perform and control the pressure upon an ultrasound probe; data were recorded and analyzed by 2 blind investigators. All statistical analyses were conducted considering $\alpha = 0.05$.

Results: The average pressure needed to promote a macroscopic deformation of the patellar tendon was 1.12 ± 0.37 kg/cm². Female sex and age were inversely but not significantly associated with the pressure performed. Sports practice, weight, height, body mass index, muscle mass, and subcutaneous thickness were positively but not significantly associated with the pressure executed.

Conclusion: The average pressure needed to promote the macroscopic deformation of the patellar tendon was 1.12 ± 0.37 kg/cm², which was not influenced by the characteristics of the participants. (J Chiropr Med 2018;17:226-230)

Key Indexing Terms: Tendons; Massage; Stress, Mechanical; Elastic Modulus

INTRODUCTION

Deep friction massage (DFM) is a widely used intervention aiming to promote the regeneration process, through the passive mobilization of soft tissues,¹⁻⁶ by

inducing an increase in fibroblastic activity, breaking disorganized intermolecular cross-links, and favoring the realignment and elongation of the collagen fibers.^{1-4,7-12} Its relevance in the treatment of tendinopathy is not clear, and so far, the real morphological and histological effects of its application in the tendinous structure are not known.^{2,11}

The pressure performed seems to be crucial to elicit the advocated morphological and histological effects,^{1,4,9,10,13,14} and this fundamental parameter of the technique only has been described qualitatively as “deep enough” to mobilize the tendinous fibers,^{2,4,6,14} which may account for the lack of control over DFM application procedures reported in the literature.^{2,3} Considering the importance of pressure in the technique's execution, there is a need to define the pressure required during DFM to ensure that the tendon is in fact reached, assisting the physiotherapist in the quantitative management of this parameter, constituting a fundamental basis for the study of the mechanical effects of the technique.

Hence, the purpose of this observational, cross-sectional, and analytical study was to determine the skin pressure needed to promote the macroscopic deformation of the asymptomatic patellar tendon and to verify if the pressure

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needed to deform the tendon is influenced by the individual's characteristics.

METHODS

Sample Recruitment

A convenience sample of 18 young and healthy individuals from both sexes was recruited through printed advertisements on notice boards at various sites of our institution. Inclusion criteria included age between 18 and 30 years and asymptomatic patellar tendon. Exclusion criteria included history of previous injury of the lower limbs. Ethical approval was guaranteed by the ethics committee of the Faculty of Sports, University of Porto (ref. 15.2017). All participants signed an informed consent according to the Declaration of Helsinki.

Procedures

After the anthropometric measurements, in a laboratory with the temperature controlled and set at 24°C, the skin pressure needed to promote the macroscopic deformation of the patellar tendon was determined. To guarantee the standardization of the assessment procedure, we used a system composed of 4 major components: the ultrasonography fixation ring, the sensors, a stepper motor, and a structure where all the parts come together. It was 3D-printed, a special component where the ultrasonography

probe was fixed in the center and the 2 sensors attached in opposite directions. Those 2 sensors, each composed by a bar (50-kg-max) load cell, then were attached to the structure (Fig 1).

Each participant was in a seated position, with the knee positioned at 45° of flexion and in the center of the developed mainframe; the ultrasonography probe was positioned to contact the skin over the patellar tendon at 1 cm below the patellar apex (Fig 2). Next, the pressure was applied progressively over the tendon at a constant speed (0.5 mm/s), and the ultrasound images and the values from the pressure device were recorded (Fig 2).

Once data were collected, 2 blind investigators analyzed the video images and identified and recorded the moment when the tendon was macroscopically deformed by changing its position in relation to the adjacent structures, with the pressure applied over the skin for that specific moment recorded. In addition, the distance between the skin and the tendon (subcutaneous thickness) also was evaluated through the ultrasound image. The assessment procedure was repeated 3 consecutive times in each lower limb (dominant and nondominant), and the average of these was used.

Statistical Analysis

Descriptive statistics comprised absolute and relative frequencies for categorical variables, and mean with standard deviation for numeric variables. The normality

Fig 1. Pressure measurement system: (A) constitution parts, and (B) superior view of the assessment procedure.

Fig 2. Laboratory setting for data collection. Tissues thickness' in the initial position (without pressure) (A). Tissues thickness' in the final position (with pressure) (B). Pressure measurement system (C). Output of the pressure performed (D).

of data distribution was tested with the Shapiro-Wilk test, Q-plots, and histograms. All continuous data followed a normal distribution. To compare the mean pressure performed on the dominant versus nondominant limb, the paired sample *t* test was used. Crude beta (β) and respective 95% CIs were used to estimate the relation between pressure performed on the dominant limb and the participant's characteristics. All statistical analyses were conducted considering $\alpha = 0.05$ and were 2-tailed. Analyses were performed on IBM SPSS Statistics version 24.0 (IBM Corp, Armonk, New York).

RESULTS

The average participant age was 23.0 ± 4.56 years. Most of them were female ($n = 11$, 61.1%), and half of them were engaged in a sport ($n = 9$, 50.0%). Their body mass index was 22.5 ± 3.86 kg/m² (weight: 64.5 ± 11.28 kg, height: 1.7 ± 0.09 m, muscle mass: 45.2 ± 10.82 kg).

The average pressure needed to promote a macroscopic deformation of the patellar tendon was 1.12 ± 0.37 kg/cm². When comparing the dominant limb with the nondominant limb, no statistically significant differences were found ($P = .100$).

Table 1 shows the association between DFM pressure and participants' demographic, anthropometric, and body composition characteristics. Female sex and age were inversely but not significantly associated with DFM pressure. Sports practice, weight, height, body mass index, muscle mass, and

subcutaneous thickness were positively but not significantly associated with DFM pressure.

DISCUSSION

The aim of the present study was to characterize the skin pressure needed to promote macroscopic deformation of the asymptomatic patellar tendon and to verify if the characteristics of the participants were associated with the pressure. Our results have shown that on average, the minimum skin pressure needed to promote the macroscopic deformation of the patellar tendon was 1.12 ± 0.37 kg/cm² and also that there was no association between the required pressure and the characteristics of the participants.

To our best knowledge, this is the first study that objectively analyzed the pressure needed to macroscopically deform a tendinous structure through mechanical pressure mimicking a therapeutic procedure. This information may be useful as reference for therapeutic interventions based on mechanical deformation of the tendon, such as DFM.

The objective quantification of the pressure needed to promote the macroscopic deformation of the patellar tendon may help clarify the qualitative description of this parameter ("deep enough"), acting as a guide and allowing better control over the application procedures of DFM.

Taking this into account, this study may represent a basis for future research targeting the relevance of DFM

Table 1. Association Between the Skin Pressure Performed During DFM (kg/cm²) and Participant's Characteristics

Participants' Characteristics	Pressure Performed Dominant Side
	Crude β (95% CI)
Sex	
Female	-0.226 (-0.595 to 0.143)
Male	0
Sports practice	
Yes	0.105 (-0.269 to 0.479)
No	0
Age, y	-0.006 (-0.049 to 0.036)
Weight, kg	0.015 (-0.001 to 0.030)
Height, m	1.341 (-0.694 to 3.376)
BMI, kg/m ²	0.024 (-0.025 to 0.072)
Muscle mass, kg	0.011 (-0.006 to 0.028)
Subcutaneous thickness, mm	0.700 (-0.658 to 2.059)

BMI, body mass index; CI, confidence interval; DFM, deep friction massage.

application in the treatment of tendinopathy and further study of the histological and morphological effects attributed to the technique and found in the animal model. Our results establish an important clarification regarding the minimum pressure needed to promote deformation of the patellar tendon to provide a basis for the histological and morphological effects to occur. Thus, if the pressure applied during DFM is inferior to the pressure we have found, the physiotherapist should be aware that the mechanical effects attributed to the technique may not be elicited.

Limitations

This study was performed in asymptomatic individuals. In future studies, this variable could be limited or conditioned by pain if the participants presented a symptomatic patellar tendon. Moreover, there is no grounding to consider that symptomatic individuals may have alterations in the subcutaneous tissues. Although our sample is in the age group with the highest prevalence of patellar tendinopathy and even though our results have shown that there was no association between the individuals' characteristics and the pressure performed, the authors acknowledge that the sample size and its characteristics may constitute a limitation of the study.

CONCLUSION

The average skin pressure needed to promote the macroscopic deformation of the patellar tendon was 1.12 ± 0.37 kg/cm², and there was no association between the pressure needed and the characteristics of the participants.

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CONTRIBUTORSHIP INFORMATION

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Practical Applications

- This study found no association between the pressure needed to promote the macroscopic deformation of the patellar tendon and the characteristics of the individuals.
- The pressure needed to promote the macroscopic deformation of the patellar tendon seems suitable to be performed in clinical practice.

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