

## The ‘piston’ effect of the calf muscle pump in region of Achilles tendon

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### ABSTRACT

**Aim:** The aim of the current study was to highlight the ‘piston’ effect of the calf muscle pump using constriction mechanisms.

**Method:** Working pressure variations of 27 lower limbs of 14 volunteers wearing 20/30 mmHg elastic stockings were evaluated using a balloon catheter. The balloon catheter was 4 x 5 cm in size, placed between the skin and the material of the stockings and connected to a DTX Plus <sup>TM</sup> sensor; a portable device that collects and stores pressure readings at half-second intervals. One catheter was placed in the medial region of the calf muscle and another at the insertion point of the Achilles tendon in this muscle. The volunteers were asked to walk. The paired Student t-test was utilized for statistical analysis with an alpha error of 5% considered acceptable.

**Result:** The pressure variations were greater in the region where the Achilles tendon is inserted into the muscle than in the medial region of the calf muscle (Student t-test; p-value = 0.0006).

**Conclusion:** At the insertion point of the Achilles tendon in the calf muscle there is a ‘piston’ effect during exercising, causing working pressure variations when contention mechanisms are used.

**Key words:** Elastic stockings–working pressure–mechanism–piston effect

### 1 INTRODUCTION

Compression is a physical method of treatment using elastic or inelastic materials that, when applied around a limb, exerts a pressure on the structures it encircles. Resting pressure is that which is caused due to compression under contention and working pressure is produced by muscle activity against the structures of the limb [1].

With differences in working pressures the musculature works as a ‘propulsion pump’ producing contractions similar to the heart and because of this it is considered the venous heart that pumps the blood during walking as well as acting

as a segmentation mechanism of the venous pressure [2].

The propulsion mechanism of the calf muscle pump is exerted with muscle contractions in the deep posterior compartment of the legs, increasing the pressure inside and around all the structures enveloped by the deep fascia [3–5]

These pressure variations are transmitted towards the contention mechanism, thereby generating working pressure. The objective of the current study is to highlight the ‘piston’ effect with the use of contention at the Achilles tendon-muscle insertion point.

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## 2 METHOD

Working pressure variations in 27 lower limbs of 12 female and two male volunteers using elastic stockings with 20/30 mmHg of compression were evaluated. Their ages ranged between 27 and 46 years old with a mean of 34.6 years. A 4 x 5-cm balloon catheter connected to a DTX Plus <sup>TM</sup> sensor Plus was utilized. This portable equipment, developed by Braile Biomédica in São José do Rio Preto, Brazil, collects and stores the data in a numeric form at half-second intervals. To evaluate variations in working pressure of the stockings, one balloon catheter was positioned in the medial region of the calf musculature and another at the point of insertion of the Achilles tendon in this muscle. The volunteers were asked to perform walking activities at their normal speed. After data collection, the pressure differences in half-second intervals were evaluated for the different catheters. The paired t test was utilized for statistical analysis with an alpha error of 5% considered acceptable (p-value < 0.05). This study was approved Ethical Committee of Medicine School of Sao José do Rio Preto- FAMERP CAAE 0018.0.140.000-08 # 069/2008.

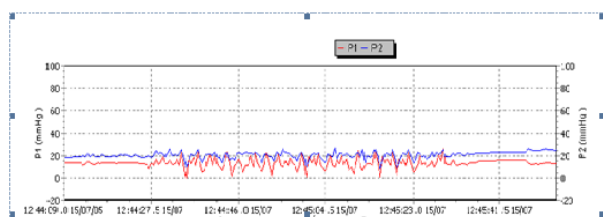
## 3 RESULTS

The pressure variations were greater in the region of the insertion of the Achilles tendon in the muscle than in the calf muscle region (p-value = 0.0006).

Table 1 shows the mean, median, standard deviation, standard error and minimum and maximum pressure variations. Figure 1 shows the pressure variations during one of the evaluations.

**Table 1. Mean, median, standard deviation, standard error, minimum and maximum pressure variations**

Parameter	Muscle insertion	Calf muscle
Mean	5.148	2.333
Number of evaluations	27	27
Standard deviation	2.783	1.776
Standard error	0.5356	0.3418
Minimum	0.000	0.000
Maximum	11.000	6.000
Median	5.000	2.000



**Figure 1. Resting and working pressure variations of elastic stockings during walking. In red, the sensor was placed at the insertion point of the Achilles tendon in the muscle and in blue, in the medial calf muscle region.**

## 4 DISCUSSION

The current study shows working pressure differences generated by elastic stockings in the region of the calf muscle and at the insertion of the Achilles tendon in this muscle. This constitutes, together with a contention mechanism, the ‘piston’ effect of the calf muscle pump.

Note that the musculature develops a radial force both in the medial region of the calf muscle and at the insertion of the Achilles tendon however, at the Achilles tendon there is longitudinal muscle displacement. This variation allows increases in the differences of working pressure due to the elastic stockings, causing the ‘piston’ effect.

Another important datum observed in this study was that the resting pressures were higher in the calf muscle region than at the point of insertion of the Achilles tendon, thus questioning the system of decreasing pressure gradients used with elastic stockings. This fact suggests that stockings need to be checked during their use so that the patient does not fold the top of the stocking or allow creases to form as this may affect the efficacy of the contention.

On the other hand, this fact shows the importance of this mechanism of elastic stockings and questions whether the pressure differences between the calf muscle region and the point of insertion of the Achilles tendon are not more important than the proposed mechanism of decreasing pressure gradient. No studies discussing this characteristic were found in the Medline Electronic Database and so it is important to further discuss the mechanism of elastic stockings and about the necessity of greater precautions in their use.

Stockings may exert an additional venous propulsion mechanism during walking, dependent of the material used to restrain the muscle structures.

## 5 CONCLUSION

There is an evident ‘piston’ effect at the insertion point of the Achilles tendon in the muscle and so using a contention mechanism intensifies differences in working pressures.

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