EFFECTS OF LOWER BODY COMPRESSION GARMENT IN MUSCLE OSCILLATION AND TISSULAR INJURY DURING INTENSE EXERCISE

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This study meant to evaluate if compression garments have a protector effect on muscular injury. Nine active males participated in the study ([mean ± SD] age 27.7 ± 10.9 years; height 176.8 ± 3.6 cm; weight 76.1 ± 6.1 kg). Subjects performed a 40 min running test at the velocity of their anaerobic threshold with a negative steep of –10% wearing shorts with compression in one leg and no compression in the other leg using a balanced, randomised design. Muscular displacement was evaluated using a 3D analysis. Tissue damage was assessed by a muscular biopsy performed 48h after the running test. Results indicate a significantly higher muscular displacement in the leg with no compression and an increased muscular damage. This indicates that compression shorts have a protective effect on muscle.

KEYWORDS: running, performance, videography 3D, kinematics, biopsy.

INTRODUCTION: Compression garments are of common use in sport and fitness activities. They are used because of style but also because there is the belief that they bring comfort and protection against injuries. In fact, it has been observed that the use of compression shorts increase skin temperature under the garment which is considered to be beneficial for the muscle, decreasing warm-up time and reducing the potential for injury, especially in cold environments (Doan et al, 2003; Duffield & Portus, 2007). It has also been observed that compression enhances proprioception and joint position sense (Kraemer et al, 1998) which may cause a prophylactic effect in joints movement and that reduces muscle oscillation upon landing from a maximal vertical jump, which may reduce muscular fatigue and tissue injuries (Doan et al, 2003; Kraemer et al, 1998). These ideas are supported by the subjective information of reduced self-reported muscular soreness and pain when compression is used during intense exercise, although there is no scientific evidence (Bernhardt & Anderson, 2005; Duffield & Portus, 2007 Duffield et al 2008).
The aims of this investigation were to determine if the custom-fit compression reduces muscle oscillation and muscular tissue injuries after a moderate eccentric activity.

METHODS: Nine active males participated in the study ([mean $\pm$ SD] age 27.7 $\pm$ 10.9 years; height 176.8 $\pm$ 3.6 cm; weight 76.1 $\pm$ 6.1 kg). Inclusive criteria were to be sane without any muscular-skeletal pathology in the lower extremity at least during the 6 months previous to the testing, to have a maximum oxygen intake (VO2max) at least of 40 ml/kg and to be non-smoking. All research practices were granted approval by the Ethical Committee of the Catalan Sports Council. Subjects were fully informed of the purposes and risks of participating in this investigation and signed informed consent document prior to testing.
Conventional compression garments are composed by a simple fabric structure that controls elasticity only in two directions (Figure 1A). In this study we used a developed compression shorts (Colibri®, Puntiblond, Spain) that are composed by warp knitted fabric 57% Pa (polyamide) and 43% Elastan. The

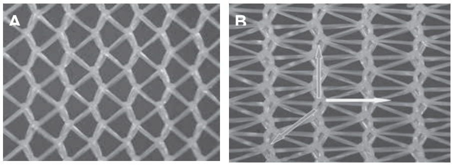

Figure 1: Structure of garment. (A) simple structure, (B) warp knitted structure.

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structure of this garment controls the elasticity and absorbs shocks in three directions as showed in the microscopic image (Figure 1B).
In order to assess muscular damage and muscle oscillation, subjects performed a running test with a redesigned shorts that produced compression (C) in one leg and no compression (NC) in the other leg using a balanced, randomised design.
A week previous to the induced damage subjects were functionally evaluated with an effort test. It consisted on a progressive incremental loads test with an initial velocity of 6km/h and a steep of 3% with increases in velocity of 1km/h every minute until maximal effort (Buchfuhrer et al, 1983).
The induced damaging exercise consisted of a 10 min warm-up running at a desired velocity and a 40 min running at the velocity of their anaerobic threshold with a negative steep of -10% (Nurenberg et al., 1992).
In order to evaluate muscular displacement four markers were placed on the skin or the textile on the rectus femoris, vastus lateralis and vastus medialis of the quadriceps femoris as indicated in Figure 2. Ten seconds of running were captured using two synchronised high-speed cameras (Bastler) at a frequency of 200Hz (Vicon Motus, Peak Performance). A calibration procedure was performed each day of data collection. The average 3D residual error for the motion capture system was 2.6mm ± 1.1mm. Data was processed using a low-pass Butterworth filter at a cut-off frequency of 6Hz (Doan et al, 2003). In order to compare the two conditions, muscle displacement between 0.1s prior and 0.15s after the impact of the feet on the floor was used in each axis of movement. A 2D sagital recording with a high-speed camera (Bastler) at a frequency of 200Hz was used for the assessment of stride frequency and stride length.

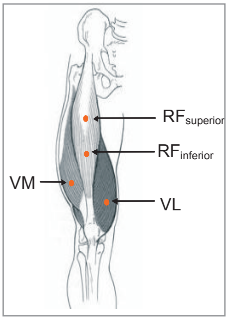

Figure 2: Markers position on the thigh.

Statistical analysis was performed using SPSS 14.0 (SPSS Inc, Chicago, Ill). A pared T-Student was used to compare data. Significant level ($p<0.05$) was corrected with the Everet method (Curran-Everet, 2009).
A muscular biopsy was performed 48h after the running test. A sample from the vastus lateralis of quadriceps femoris, at the same level on the two legs, was extracted following Ramírez-Sarmiento et al (2002) procedure. Samples were processed by an independent laboratory following a double-blind study design. Injury indicators compared were intracellular albumin, anti-MPO and anti-CD3.

RESULTS: With respect to the kinematic analysis, a mean of 6471 steps (±373 steps) were performed in 40 minutes running. No significant difference was observed neither for the stride frequency (C = 79.9s/min, NC = 79.7s/min) nor for the stride length (C = 1.88m, NC = 1.89m) between legs.
Muscular displacement was significantly higher in the leg with no compression (Figure 3). Results of inflammatory response and structural sarcomere injury are presented in figure 4. Non-dominant limb and no-compression values tended to be higher than dominant limb and compression. When joining the two conditions (Figure 4C) higher inflammation and injury are observed with no compression regardless of the laterality. Significant difference was observed in the sarcomere injury indicator (albumin) for the compression condition.

DISCUSSION: This study meant to evaluate if compression garments had a protector effect on muscular injury. Muscle oscillation was assessed by means of a 3D analysis with two high-speed cameras. The procedure allowed to make evident that muscle mass had a significant higher displacement, in the three axis of movement, when thigh was not protected with a compressor short. The results of the markers oscillation placed on the skin or the textile is presented in Figure 3. This represents the muscular distance covered during a range of time that the feet are impacting on the ground. If we consider 40 min running, then mount up displacement increases considerably (Table 1). The results of our research support the studies of Kraemer et al (1998) and Doan et al (2003) that observed an increased muscle oscillation upon landing from a maximal vertical jump when thigh was not protected by a compressive garment.

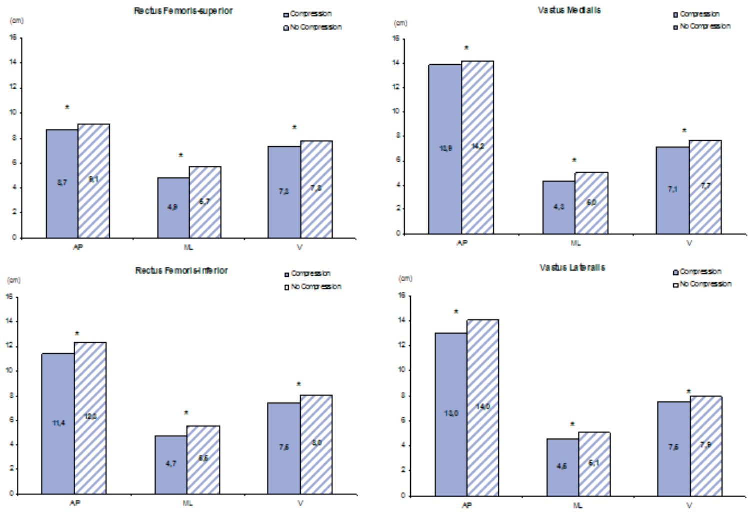

Figure 3: Mean displacement of markers during a single stride in the three axis of movement. (*) Indicates significant different, p<0.05.

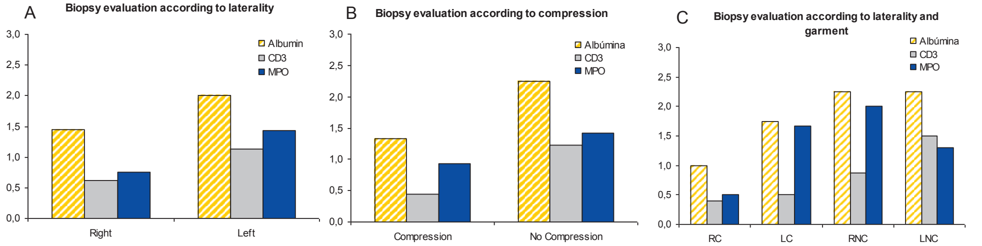

Figure 4: Results of biopsy indicators according to laterality (A), compression (B) and both conditions altogether (C).

Table 1
Approximate displacement (in m) of markers during a 40 min running in the three axis of movement.

	Compresion			No Compresion		
	AP	**ML**	**V**	**AP**	**ML**	**V**
RF-sup	280	157	236	294	185	251
RF-inf	370	151	241	398	179	260
VL	421	146	243	454	165	257
VM	449	139	231	459	161	249

Delayed onset muscle soreness (DOMS) is common after an eccentric exercise. DOMS goes from the mere adaptation process of muscular structure to a muscle breakdown, but in any case, athletes experience a loss of function and pain as a result. Injury process can cause disruption to skeletal muscle pH control and induce cellular metabolic changes consistent with inflammatory and repair processes (Trenell et al, 2006).
Researches observed a reduction of perceived muscle soreness and pain when compression is used during intense exercise, although any of the studies found scientific evidence (Kraemer et al, 2001; Bernhardt & Anderson, 2005; Duffield & Portus, 2007 Duffield et al

2008). Trenell et al (2006) suggested that the use of compression may alter the inflammatory response to damage and accelerate the repair processes inside muscle, while Kraemer et al (2001) found that compression promotes faster recovery of force production. Kraemer et al (2010) also observed a reduction of muscle soreness and muscular swelling when compressive garments were worn after a heavy resistance exercise, helping the recovery process.
The muscular biopsy performed after two days of the induced muscular damage demonstrated higher histological injury in the leg with no compression, which confirms the self-reported reduction of DOMS when compression garment is used during exercise.
It has also been hypothesized that a reduction of muscle oscillation may reduce muscular fatigue and tissue injuries (Doan et al, 2003; Kraemer et al, 1998). We observed a reduced muscular displacement and a reduced muscular damage when compression was used, which endorse the relation of both parameters.

CONCLUSION: Results from this study demonstrated that compression shorts have a protective effect on muscle tissue. The compression caused by the garment reduced muscle oscillation, thus reducing inflammatory response and structural sarcomere injury after a moderate eccentric exercise.

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