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The influence of below-knee compression garments on knee-joint proprioception

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ABSTRACT

Objective: The purpose of the study was to assess the influence of below-knee compression garments on proprioception accuracy under, information processing constraints designed to cause high or low conscious attention to the task.

Methods: In a counterbalanced, single-blinded, crossover trial, 44 healthy participants (26 male/18 female) with a mean age of 22.7 ± 6.9 years performed an active joint repositioning task using their nondominant and their dominant leg, with and without below-knee compression and with and without conducting a secondary task.

Results: Analysis of variance revealed no main effect of leg dominance and no interactions (p's > 0.05). However, a main effect was evident for both compression ($F_{1, 43} = 84.23$, $p < 0.001$, $\eta p^2 = 0.665$) and secondary task ($F_{1, 43} = 4.391$, $p = 0.04$, $\eta p^2 = 0.093$).

Conclusions: The study is the first to evaluate the effects of a belowknee compression garment on knee proprioception under differential information processing constraints. We conclude that proprioception accuracy of the knee joint is significantly enhanced post application of below-knee compression garments and when a secondary task is conducted concurrently with active joint repositioning. The findings suggest that below-knee compression garments may improve proprioception of the knee, regardless of leg dominance, and that secondary tasks that direct attention away from proprioceptive judgments may also improve proprioception, regardless of the presence of compression. Clinical implications are discussed with respect to proprioception in modern.sports and rehabilitation settings.

1. Introduction

Studies suggest that compression garments may be beneficial in modern sports [1–3] and rehabilitation settings [4–6]. These studies have shown that compression garments enhance performance [1], aid recovery [2,3], and prevent injuries [1,6]. The physiological mechanisms underlying such benefits are likely to be multi-factorial. The garments promote stable muscle alignment [3], increase skin stretch [7], enhance cutaneous afferent inputs [5,6,8] and encourage nerve fiber recruitment in muscles [9], thereby improving proprioceptive feedback and joint position awareness [5,6].

Typically, knee compression garments cover the knee joint completely, extending approximately four cm above and below the patella. However, recently below-knee compression garments have become popular in active sports [10–12], with speculation that such garments provide less support/stabilization compared to their predecessors (i.e., complete knee compression garments). However, to the best of our knowledge, no research has examined the effects of below-knee compression garments on knee-joint proprioception. Therefore, we assessed active joint repositioning accuracy in participants with and without below-knee compression.

Active joint repositioning performed in a clinical environment is likely to be subject to high levels of conscious awareness [13], given that participants are instructed to be as accurate as possible. It has been argued that high conscious awareness adversely impacts proprioception [14], possibly as a consequence of movement specific reinvestment [15]. The theory of reinvestment suggests that directing attention internally to control movements that are normally automatic can disrupt their performance [15,16]. We therefore asked participants to complete the active joint repositioning task with and without a secondary task. Secondary tasks are often used to 'soak up' information processing resources that otherwise would be available for the primary task, thus limiting conscious attention to the repositioning task [15,17].

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The present study is the first to investigate the effects of below-knee compression garments on knee joint proprioception under conditions of high and low conscious attention. We hypothesized that wearing a below-knee compression garment would benefit knee joint proprioception accuracy and that accuracy would be better when accompanied by a secondary task.

2. Methods

2.1. Participants

Forty-four recreational athletes (26 male/18 female; mean ± SD: age (y) 22.7 ± 6.9, height (cm) 174 ± 9, weight (kg) 72.2 ± 13) volunteered to participate in the study. All participants self-reported as healthy with no history of significant hip, knee or back injury. Written informed consent was obtained from each participant, and ethical approval was obtained from the Human Research Ethics Committee of the Institution.

2.2. Experimental design

Participants were randomly allocated in equal numbers to wear the compression garment on the dominant leg (CompDom group), or to wear the compression garment on the non-dominant leg (CompNon-Dom group). In each group, and for both the dominant and the non-dominant leg, participants carried out the active (knee-joint) repositioning task while conducting or not conducting a concurrent secondary task (SecTask or No-secTask, respectively). The secondary task (random word generation) was designed to direct conscious attention away from the repositioning task and its presence or absence was counterbalanced within leg in each group [18]. The target angle for the repositioning task was 30° and 60° for the dominant and non-dominant leg, respectively [19], to reduce learning effects.

2.3. Compression garment

A standard below-knee unisex compression sleeve (BSX Insight®, USA) was worn by the participants. The compression garment extended from the superior aspect of the tibial tuberosity to the proximal two-thirds of the tibial shaft. The garment was allocated to each participant according to the manufacturer's size guidelines. While not measured in the current study, interface pressure measurements of these garments have been recorded in our laboratory, with average pressures ranging from 10 to 15 mmHg (unpublished observations).

2.4. Procedure

Participants were seated with their feet on the floor (knee-joint angle 90°). The chair backrest was adjusted to an 85° incline and the pelvis was stabilized [6]. Participants were blindfolded to eliminate visual cues. The experimenter passively moved the dominant or non-dominant leg to a previously identified target position (30° or 60°) in an open kinetic chain [6] for 10 s to allow the participant to memorize the position [19], and thereafter checked and rechecked the angle while using a handheld goniometer. The first experimenter is a trained physiotherapist familiar with such procedures. Additionally, a second experimenter monitored the process to ensure rigor. The leg was then returned to the initial position (90°) and following a 5 s interval the participant attempted to reposition the leg at the same joint angle. The participant was required to hold the leg at the perceived target angle for 4 s and then return it to the starting position. Repositioning error (RE) was assessed in each trial using a universal 360° manual goniometer (RBMS®, USA) to measure the knee-joint angle with ±0.2° precision. Repositioning error was calculated as the difference from target angle in magnitude but not direction [20]. Good reliability and validity of both the repositioning procedure and the manual goniometer have previously been reported [20,21].

3. Statistical analysis

Statistical analyses were performed using Statistical Package for Social Science (V. 22.0, SPSS Inc., Chicago, IL). We examined Repositioning Error (the dependent measure), by conducting a Group (CompDom/CompNon-Dom) × Secondary task (present/absent) × Compression (present/absent) RM-ANOVA with repeated measures on the last two factors. Effect sizes of the independent variables were expressed using partial eta squared (η_p^2), with effect sizes <0.01 considered to be small, effect sizes between 0.01 and 0.10 considered to be medium and effect sizes >0.10 considered to be large [22]. An alpha level of 0.05 was adopted.

4. Results

Descriptive statistics are summarized in (Table 1). Statistical analysis revealed no significant interactions (*p*'s > 0.05) and no main effect of group ($F_{1,43} = 0.505$, $p = 0.481$, $\eta_p^2 = 0.12$). However, a significant main effect was evident for both compression ($F_{1,43} = 84.23$, $p < 0.001$, $\eta_p^2 = 0.665$) and secondary task ($F_{1,43} = 4.391$, $p = 0.04$, $\eta_p^2 = 0.093$). For clarity, Fig. 1 illustrates these effects separately for the dominant and non-dominant legs.

5. Discussion

This study aimed to further our understanding of the effects of below-knee compression on proprioception under conditions of high and low conscious attention. In agreement with our hypothesis, enhanced proprioception accuracy was observed when active joint repositioning was performed with a below-knee compression garment and when participants were required to conduct a secondary task concurrently with repositioning. Despite the lack of an interaction between the secondary task and the compression conditions, repositioning accuracy was highest when both were present, resulting in average repositioning errors of 3.3° ± 3° and 4.1° ± 3.1° for the dominant and non-dominant leg, respectively.

Conventional knee compression garments are common in sports and rehabilitation settings [1]. These garments have demonstrated their capability for enhancing proprioception by increasing cerebral haemodynamics [23], cutaneous afferent feedback [5], musculoskeletal activation [24], and stability perception [25]. Improved proprioception has been reported in samples of sedentary and sports populations executing active repositioning tasks with complete knee compression garments [5,6]. However, with the influx of new types of compression garments and the range of materials used, we decided to use

Table 1
Mean (SD) and 95% confidence intervals (CI) for repositioning error (°) in the different treatment conditions for dominant (Dom, 30°) and non-dominant (Non-Dom, 60°).

	M ± SD		95% C.I	
Repositioning Task	Dom	Non-Dom	Dom	Non-Dom
Compression/sec task	3.3 ± 3	4.1 ± 3.1	2.4–4.1	3.1–5
No-compression/sec task	5.5 ± 3.3	5.5 ± 4.4	4.5–6.4	4.2–6.8
Compression/no sec task	9.3 ± 5.2	9.1 ± 4.6	7.7–10.8	7.7–10.4
No-compression/no sec task	10.6 ± 4.6	10.1 ± 4.6	9.2–11.9	8.7–11.4

Sec task: Secondary task, No sec task: No secondary task, Dom: Dominant, Non-dom: Non dominant.

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