ORIGINAL ARTICLE

Influence of compression garments on perceived exertion during maximal isometric exercises

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ABSTRACT

Compression garments have gained popularity in the sports world as a means to enhance athletic performance and accelerate recovery. This study investigates the effectiveness of upper-body compression garments and their impact on the rate of perceived exertion (RPE) during maximal isometric contractions. Eight adult males, students of a Master's degree program in Sports Sciences, participated in the study, conducting tests in controlled conditions at the University of Salerno. The subjects performed maximal isometric contractions in three separate sessions, wearing compression garments (CG), traditional sportswear (noCG), and a tight-fitting garment without compression effect, to minimize the placebo effect (Placebo), respectively. Perceived exertion was assessed using the modified CR-10 scale. Statistical analysis revealed a significant reduction in RPE when athletes wore compression garments compared to other conditions, suggesting a benefit in the use of such clothing. The findings indicate that compression garments can attenuate the perception of exertion during intense physical activities, with potential implications for performance, comfort, and recovery. This study contributes to the existing literature by expanding the understanding of the effects of compression clothing and highlighting the importance of further research to optimize the use of these garments in enhancing athletic performance.

Keywords: Performance analysis, Compression garment, Maximal isometric contraction, Rated Perceived Exertion (RPE), Sports performance.

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INTRODUCTION

Compression garments are identified as a non-invasive therapeutic strategy used to apply mechanical pressure to body tissues. This pressure is designed to compress the underlying tissues and provide stability to limbs or targeted anatomical areas (Partsch, 2005). Initially devised for treating conditions such as lymphedema and edemas (Moseley, Carati & Piller, 2007; Partsch, Winiger & Lun, 2004; Brennan & Miller, 1998; Földi, 1998; Rinehart-Ayres, 1998), they have also proven effective in other clinical contexts such as pulmonary embolism (Asano et al., 2001) and venous ulcers (O'Meara et al., 2012; Blair et al., 1988). Compression garments are widely used to treat clinical pathologies like deep vein thrombosis, chronic venous insufficiency, and other circulatory disorders by improving compromised hemodynamic functionality (Galanaud, Laroche & Righini, 2013; Qaseem et al., 2011; Ibegbuna et al., 2003; Scurr et al., 2001; Amaragiri & Lees, 2000; Agu, Hamilton & Baker, 1999; Krijnen et al., 1997; Mayberry et al., 1991). Despite the traditional use of graduated compression garments in the treatment of vascular conditions, the sports apparel industry has played a significant role in promoting their non-medical adoption, incorporating them into a wide array of items such as socks, tops, and garments for the lower and upper body (Cotter et al., 2022). This trend has led to an increased interest in scientific research in the sports domain, with a growing number of coaches and athletes from various disciplines and competitive levels integrating these garments into their training regimens (Stickford et al., 2015; Gupta, Bryers & Clothier, 2015; Fu, Liu & Fang, 2013; Sperlich et al., 2013; Troynikov et al., 2013; Ali, Creasy & Edge, 2011; Dascombe et al., 2011; Ali, Creasy & Edge, 2011; Doan et al., 2003). The exerted pressure depends on the mechanical properties of the fabric determined by its characteristics and fit (MacRae, Cotter & Laing, 2011).

The beneficial effects of wearing compression garments during exercise and recovery have been the subject of numerous scientific studies (Broatch, Bishop & Halson, 2018; Wannop et al., 2016; Driller & Halson, 2013). Meta-analyses by Brown et al. (2017), and Marqués-Jiménez et al. (2016), have highlighted that the use of such garments can facilitate recovery of strength and power performance after resistance training sessions, in addition to aiding recovery during cycling exercise. These findings are further supported by the meta-analyses of Machado et al. (2018), and Hill et al. (2014), which also identified a significant reduction in creatine kinase (CK) levels associated with the use of compression garments, suggesting an acceleration in muscle recovery process and a reduction in delayed onset muscle soreness (DOMS). It has been found that the use of compression garments enhances the economy of sports movements, promotes better management of soft tissues, reduces post-exercise limb swelling, and tends to lower blood lactate levels during physical activity (Leabeater, James & Driller, 2022; Engel, Holmberg & Sperlich, 2016). While not showing a significant impact on overall endurance performance, the use of compression garments has shown positive effects on specific sports variables, such as counter-movement jump height (Leabeater, James & Driller, 2022). Several studies on the use of compression garments have focused on perceived exertion, revealing, albeit modestly, a positive impact (Miyamoto & Kawakami, 2014; Rugg & Sternlicht, 2013), while others have shown no appreciable effect (Rider et al., 2014; Venckūnas et al., 2014). Despite evidence of positive effects in many studies, the use of compression garments presents a still inconsistent picture in the scientific literature, with some studies reporting conflicting results regarding certain benefits, highlighting the need for further research for a comprehensive evaluation (Cotter et al., 2022; Da Silva et al., 2018; Dascombe et al., 2013). A critical analysis of the literature on the subject has highlighted how discrepancies in the obtained results can be attributed to various variables, including the characteristics of the subjects involved in the studies, the exercise modalities adopted, the application of strategies to minimize the placebo effect, the types of compression garments used, and the duration of the treatment employed (Brophy-Williams et al., 2021; Wannop et al., 2016; Hill et al., 2015; MacRae, Cotter & Laing, 2011). In particular, discrepancies in results between studies could be attributed to a lack of standardization of the pressure exerted by compression garments, underscoring the need for further understanding of optimal parameters to achieve significant benefits in athletic performance (Brophy-Williams et al., 2021; Driller & Halson, 2013).

Given that research has mainly focused on the positive effects of wearing compression garments on the lower limbs, with particular emphasis on the analysis of perceived exertion, this study aims to observe the effects of using compression garments on the upper body during maximal isometric contractions. The goal is to analyse perceived exertion (RPE) in relation to the use of such garments, taking into account the subjects' intrinsic ability to perceive physiological load during physical activity. The hypothesis is that participants should indicate a lower RPE when using compression garments.

MATERIALS AND METHODS

Participants

The sample consists of eight adult males with an average age of 26.4 years (± 2.6 years), an average height of 172.88 cm (± 4.5 cm), a body mass of 72.03 kg (± 8.19 kg), and a brachial bicep diameter of 30.56 cm (± 0.90 cm), all enrolled in a Master's degree program in Sports Sciences (LM-68) at the University of Salerno (Unisa). The sample was selected based on the following inclusion criteria: students who engage in sports activities, with a similar brachial bicep diameter (≃30 cm). Exclusion criteria included a history or reported presence of any cardiovascular diseases, traumas that could influence the test, and current use of medications.

Procedures and measures

Participants were asked to refrain from alcohol consumption and intense workouts, and to maintain their normal dietary and hydration habits 24 hours before the experimental session. All participants were informed of potential risks and provided written informed consent for participation in this study, which was conducted in accordance with the Declaration of Helsinki. This study has been approved by the Ethical Committee of the Department at the University (Protocol Number: 0186309). The study was designed and coordinated by the research staff of the Laboratory for Innovative Teaching and Sports Performance Analysis at the University of Salerno (Unisa).

Evaluations were conducted in the gym of the University Sports Center (CUS) under controlled environmental conditions (room temperature, 22 ± 2°C; relative humidity, 60% ± 2%) and at a fixed time (from 9:00 to 14:00). Each participant performed the test 48 hours apart, under controlled environmental conditions and at a fixed time.

To analyse the differences in perceived exertion related to the use of garments, sessions were conducted with compression garments (CG), traditional sportswear (noCG), and tight-fitting non-compressive clothing (Placebo), used to minimize the placebo effect.

Before each experimental trial, all subjects underwent a standardized warm-up consisting of three sets of unilateral bicep curls, with six repetitions at 50% of their 1RM (Zhao, Nishioka & Okada, 2022). There was a 1-minute recovery period between sets. In each experimental session, subjects performed 3 trials of isometric curl with both arms, maintaining a 90° elbow flexion angle, at 100% of maximum voluntary contraction for a duration of 10 seconds (Muthalib et al., 2010). The recovery between trials consisted of a passive rest period lasting 180 seconds (Peixoto et al., 2010). In the first session, subjects performed the trials wearing traditional sportswear (noCG). In the second session, they performed the trials wearing a compression garment (CG) from LB9 (®LB9 BRAND S.R.L.).

The characteristics of the worn garment are: 60% Nylon, 40% Spandex, size M. The pressure at the wrist measurement point corresponds to $\simeq$24 mmHg, from which the pressure decreases before increasing at the level of the brachial biceps with a pressure of $\simeq$22.7 mmHg.

In the third session, subjects performed the trial wearing tight-fitting but non-compressive clothing (Placebo). At the end of each trial, subjects were asked to indicate the RPE value of the trial using the validated Italian translation of the modified CR-10 scale (Foster et al., 2001; Foster et al.,1996; Borg, 1998). This scale is a category-ratio scale ranging from 0 to 10, where each number has a verbal anchor indicating the level of perceived exertion, ranging from "*rest*" (0) to "*maximum*" (10) (Table 1).

Table 1. Modified CR-10 Scale (Foster et al., 1996).

Rating	Description
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Maximal

Analysis

From the collected data, the mean RPE values for each of the three trials were calculated for each participant. Subsequently, the group average for each of the three conditions was determined. The statistical analysis was conducted in MATLAB (The MathWorks, Inc., 2024). The Shapiro-Wilk test for normality was performed for each condition to verify the distribution of the data. Depending on the nature of the data, the Friedman test was used, being the most suitable choice for analysing differences in RPE among the three conditions. To determine which specific pairs of conditions differed significantly, the Wilcoxon Signed-Rank test with Bonferroni correction for multiple comparisons was utilized.

RESULTS

The RPE data, including means and standard deviations for each condition, are presented in Table 2. The Placebo group shows the highest values, followed by the noCG group, and finally, the CG group ranks third with the lowest values.

Table 2. RPE Means and Standard Deviation for each tested condition.

Condition	RPE Means	Std. Dev.
noCG	5.7	1.3
CG	4.9	1.3
Placebo	6	1.6

The Friedman test revealed significant differences in RPE between at least two of the three conditions. Subsequently, the Wilcoxon Signed-Rank test with Bonferroni correction for multiple comparisons, the results of which are reported in Table 3, indicates a significant difference in RPE between the noCG and CG conditions and between the CG and Placebo conditions. No significant difference was found between the noCG and Placebo conditions after correction for multiple comparisons.

Table 3. Wilcoxon Signed-Rank Test results with Bonferroni correction.

Comparison	Raw *p*-Value	Bonferroni *p*-Value	Significance
noCG vs CG	.0014	.0043	Yes
noCG vs Placebo	.1006	.3019	No
CG vs Placebo	.0001	.0004	Yes

DISCUSSION

The results of this study indicate that the participants reported significantly lower levels of perceived exertion during the performance of maximal isometric contractions while wearing compression garments (CG) compared to the noCG and Placebo conditions. The comparison between noCG and Placebo conditions did not show significant differences, suggesting that, from the perspective of perceived exertion (RPE), wearing tight-fitting garments to eliminate the placebo effect does not result in a significant change compared to performing with traditional sportswear. The presence of significant differences in the comparisons between noCG vs. CG and CG vs. Placebo suggests the effectiveness of compression garments in mitigating the subjective perception of exertion during maximal isometric contractions, as assessed by the Rating of Perceived Exertion (RPE). This observation can be interpreted through a series of physiological and psychological mechanisms that presumably contribute to this improvement.

From a physiological perspective, compression garments may reduce muscle oscillations during exercise, promoting greater stability and control, reducing the sensation of fatigue, perceived exertion, and structural damage to the muscles (Valle et al., 2014; Duffield, Cannon & King, 2010; Kraemer et al., 2010; Bringard, Perrey & Belluye, 2006; Doan et al., 2003). Additionally, it is plausible to consider that the positive effect of compression garments on RPE could be mediated by improved lymphatic drainage, which reduces muscle swelling, and by improvements in blood flow to the limbs, leading to greater muscle oxygenation (Faulkner et al., 2013; Kraemer et al., 2010; Kraemer et al., 2001). These physiological aspects provide a solid foundation for understanding the relationship between the use of compression garments and the perception of exertion during physical exercise.

From a psychological viewpoint, it is reasonable to hypothesize that the comfort derived from the use of compression garments may have a significant impact on athletes' perception of exertion (Rugg & Sternlicht, 2013), contributing to performance improvement (Wannop et al., 2016). This aspect could be crucial in understanding the perceptual improvements observed in our study. The combination of these factors might contribute to reducing the perception of exertion during physical exercise, allowing athletes to maintain higher activity intensities or complete a greater volume of work during training (Loturco et al., 2016). It is important to consider that the results obtained in this study are consistent with other studies in the scientific literature that have reported improvements in muscle pain perception, RPE, and/or fatigue with the use of compression garments during physical exercise (Engel, Holmberg & Sperlich, 2016; Rugg & Sternlicht, 2013; MacRae, Cotter & Laing, 2011). However, there are also studies that report contrasting results (Mizuno et al., 2017; Venckūnas et al., 2014; Del Coso et al., 2014; Houghton, Dawson & Maloney, 2009; Bringard, Perrey & Belluye, 2006).

The potential role of the placebo effect in research on compression garments should also be considered, as knowledge of the purported benefits can influence individuals' expectations and thus the outcomes. The nature of compression garments, which involves a perceivable pressure on the body, makes them inherently difficult to test under blind experimental conditions (Driller & Halson, 2013; MacRae, Cotter & Laing, 2011). However, it is important to note that in the present study, a tight-fitting sports shirt was used as a control to minimize the placebo effect, which may have contributed to the robustness of the results obtained.

CONCLUSIONS

The perception of one's state of comfort and well-being during physical activity might play a significant role in determining athletic performance. Therefore, in addition to physiological aspects, the perception of exertion during exercise emerges as one of the factors that could impact sports performance (Duffield & Portus, 2007).

This study highlighted how the attire worn during the execution of a maximal isometric curl can significantly influence athletes' perception of exertion. Specifically, the use of a compression garment appears to reduce the RPE compared to other conditions, suggesting a potential beneficial effect on the perceived exertion experience during exercise. These findings provide important insights for athletes and coaches regarding the choice of clothing during training and competition, with potential implications for comfort, exertion perception, and performance.

As suggested by MacRae, Cotter & Laing (2011), the fundamental characterization of the garment and fabric provides useful information that allows for comparison between different studies.

In this study, it was possible to identify both the composition of the compression garment through the analysis of the materials used, and the pressure exerted by the garment on the affected body area, through specific measurements.

In conclusion, it is widely recognized in the scientific literature that any variation in the perception of exertion during physical activity can act as an ergogenic mechanism contributing to improved performance, regardless of the presence of direct physiological effects (Born, Sperlich & Holmberg, 2013). Therefore, the observed reduction in RPE with the use of compression garments could have significant implications for enhancing athletic performance.

AUTHOR CONTRIBUTIONS

The article is the result of collaborative work by all the authors. Rodolfo Vastola is the Scientific Coordinator of the entire contribution.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICAL APPROVAL

The present study has been approved by DISUFF Ethical Committee of University of Salerno (protocol N. 0186309).

DATA AVAILABILITY STATEMENT

Data available on request.

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