Lower-body compression garments worn following exercise improves perceived recovery and sleep quality but not subsequent performance in basketball athletes

ABSTRACT

This study examined the effects of lower-body compression garments worn following exercise on perceived recovery and subsequent performance in basketball athletes. In a parallel-group design, 30 recreational, male basketball athletes were randomly allocated to either a control (CON, n = 15, loose-fitting clothing) or experimental group (COMP, n = 15, compression garments) for 15h following fatigue-inducing, basketball-specific exercise. The evening exercise bout (1600-1800 h) included performance of the Basketball Exercise Simulation Test, lunge jumps, and an isometric wall sit exercise. Perceptual measures of fatigue and muscle soreness as well as physical performance tests (sprints, jumps and agility) were performed pre-exercise, post-exercise, and post-recovery (15 h following exercise). Subjective and objective measures of sleep were recorded following the exercise trial. There were non-significant ($p > 0.05$), *unclear-trivial* differences between groups for all performance measures. Perceived post-recovery fatigue ($d = -1.27$, *large*) and muscle soreness ($d = -1.61$, *large*) were significantly lower in COMP compared to CON ($p < 0.05$). COMP exhibited better perceived sleep quality ($d = 0.42$, *small*, $p = 0.18$) than CON, with an *unclear* difference in sleep duration between groups ($p > 0.05$). Wearing lower-body compression garments overnight improved perceived fatigue and muscle soreness, but had negligible effects on subsequent physical performances in basketball athletes.

Keywords: *fatigue; sprint; vertical jump; agility; sleep*

INTRODUCTION

The use of compression garments to enhance athletic recovery has become one of the most popular recovery strategies among elite athletes (MacRae, Cotter & Laing, 2011, Driller & Brophy-Williams, 2016; Tavares, Healey, Smith, & Driller, 2017). Recreational athletes are also opting to use compression garments to aid recovery following exercise. Research suggests compression garments may optimise blood flow (Driller & Halson, 2013); decreasing blood lactate and creatine kinase concentrations, and subsequently reducing muscle soreness (Duffield, Cannon, & King, 2010; Marqués-Jiménez, Calleja-González, Arratibel, Delextrat, & Terrados, 2016; Pruscino, Halson, & Hargreaves, 2013) and the inflammatory response by restricting the space available for swelling (Marqués-Jiménez et al., 2016; Pruscino et al., 2013). These aspects may combine to increase the overall efficiency of recovery to optimise and restore muscle function more promptly following fatiguing exercise (Duffield et al., 2010; Pruscino et al., 2013). There is some evidence to suggest that wearing compression garments during exercise may also aid in subsequent physical performances (Brophy-Williams, Driller, Kitic, Fell & Halson, 2019).

Inflammatory markers of muscle damage and delayed onset of muscle soreness typically take from 72 hours up to 5 days before returning to baseline without use of any recovery interventions to expedite this process (French et al., 2008). Application of compression garments has been supported to provide some relief following muscle-damaging exercise (Gill, Beaven, & Cook, 2006; Kim, Kim & Lee, 2017); however, a meta-analysis revealed compression garments elicited greater benefits following resistance or plyometric exercise than after endurance exercise (Brown et al., 2017). Consequently, compression garments may provide benefit to team sports requiring frequent bouts of explosive activity.

Basketball is a team sport predicated on repeated expression of power-driven movements (Wen, Dalbo, Burgos, Pyne, & Scanlan, 2018), with basketball athletes performing various high-intensity, power-related movements encompassing frequent multi-directional acceleration, deceleration, and jumping manoeuvres (Stojanović et al., 2018). Consequently, muscle damage is inevitable for most basketball athletes following game-play (Brown et al., 2017; Montgomery, Pyne, Hopkins, et al., 2008).

Previous research documented substantial increases in muscle damage (creatine kinase and myoglobin) and inflammation (C-reactive protein, leukocytes, and cytokines) markers following elite (Chatzinikolaou et al., 2014) and sub-elite games (Montgomery, Pyne, Cox, et al., 2008). These responses associated with basketball game-play may contribute to increased perceptions of muscle soreness in athletes, which are further compounded when playing multiple games on successive days during tournament-style competitions (Montgomery, Pyne, Hopkins, et al., 2008). To our knowledge, there is only one study to examine the recovery effects of compression garments following basketball activity examined during tournament game-play in sub-elite athletes (Montgomery, Pyne, Hopkins, et al., 2008). This study compared three recovery groups including a control (n=9), cold-water immersion applied post-game (n=10), and lower-body compression garments worn for ~18 h post-game (n=10) over three days. While cold-water immersion was shown to be the superior recovery approach, compression garments resulted in a decrease in 20-m sprint performance (3.2 ± 1.6%) and vertical jump height (-6.7 ± 11.2%) which was more detrimental than the control condition (0.7 ± 1.3% and -2.6 ± 6.6%, respectively) (Montgomery, Pyne, Hopkins, et al., 2008).

While not in the sport of basketball specifically, Duffield et al. (2010) investigated the use of lower-body compression garments following an exercise bout of 10 x 20-m sprints and 10 x plyometric bounds every minute for 10 min, where 20-m sprint performance was measured pre, 2 h and 24 h after the first exercise bout. Participants (11 team-sport athletes) wore compression garments during the first bout of exercise and for the subsequent 24 h until the final testing was completed. No significant differences ($p = 0.70$) and *small* effects ($d < 0.3$) between control and compression groups were evident across all time points throughout recovery.

While the initial studies by Montgomery et al. (2008) and Duffield et al. (2010) offers useful insights, a wider evidence-base is needed for definitive recommendations regarding the use of compression garments as an efficacious recovery option for basketball athletes to be made. In particular, given the strong popularity of basketball among the general population in many countries, including the United States of America and Australia (Scanlan, Dascombe, Kidcaff, Peucker, & Dalbo, 2015), research examining compression garments in recreational athletes is needed. Such data would inform potential recovery strategies that may allow more frequent participation in basketball activity and thus bring greater associated health benefits such as improvements in aerobic fitness, lean body mass, bone mineral density, and arterial blood pressure (Randers et al., 2018), for the general population. Therefore, the aim of the current study was to evaluate the effect of wearing lower-body compression garments following basketball-specific, fatigue-inducing exercise (overnight) on perceptual ratings of recovery and physical performance in recreational, male basketball athletes.

METHODS

Participants

Thirty trained male basketball athletes (mean age: 22.5 ± 4.1 years, height: 179.3 ± 4.0 cm, body mass: 71.7 ± 6.3 kg, years of basketball experience: 6.2 ± 3.8 years) volunteered to take part in the study. Inclusion criteria required the participants to be free from lower-limb injury for the previous 6 months prior to participation, aged 18-35 years, be playing competitive basketball at the club level, and pass a Physical Activity Readiness Questionnaire (PAR-Q) and medical clearance. The study took place during the pre-season phase of the basketball competition. Written informed consent was obtained from each participant, and ethical approval was approved by an institutional Human Research Ethics Committee.

Experimental Design

Using a parallel-groups study design, participants were randomly allocated to either a compression group (COMP, n = 15) wearing a lower-body compression garment for ~15 hours (overnight) following exercise or a control group (CON, n = 15) wearing loose-fitting clothing for ~15 hours (overnight) following exercise (Figure 1). Participants were to refrain from performing any vigorous exercise in the 48 hours leading up to the testing session. On arrival at the laboratory at 16:00, participants performed a standardised warm-up and a familiarisation of the Basketball Exercise Simulation Test (BEST) protocol (Scanlan et al., 2014). Participants then completed baseline (pre-test) measurement of perceptual ratings and a performance testing battery, followed by a full trial of the BEST, jumping lunges, and an isometric wall sit (Broderick et al., 2019). Following the basketball-specific, fatigue-inducing exercise, the second testing session (post-test) was conducted with perceptual ratings taken again and the performance testing repeated. Participants were then given loose-fitting clothing or full-length, lower-body compression garments (Li-Ning, PowerShell AULM043-I, Beijing, China) and a wrist-worn sleep monitor (Xiaomi, MI band 2, Beijing, China) to wear following a 5-min warm shower. The size of compression garments was selected based on the height and body mass of each individual, according to the manufacturers sizing guidelines. The garment pressures were recorded immediately after they were put on. Each participant then received a standardised dinner at 18:30 and was placed in an environmentally-controlled (temperature and light) sleep laboratory (temperature: 21.8 ± 0.9°C; humidity: 49 ± 4%) until the next morning. Participants were only allowed to leave their rooms to go to the bathroom. Electronic devices (e.g. mobile phones) were not permitted after 21:00, and at this time all lights were turned off. At 07:30 the following morning, lights were turned on with garment pressures and perceptual ratings measured between 07:30-07:40. Participants gave ratings of sleep quality, which were recorded alongside objective sleep measures. Participants then completed the standardised warm-up before completing the performance testing battery again at 08.00.

Testing was completed at the same time each day for both groups to account for diurnal variations in performance. Participants were not permitted to use any additional recovery strategies (e.g. active recovery, stretching, cold-water immersion) or take anti-inflammatory/pain medications or other supplements to aid their recovery.

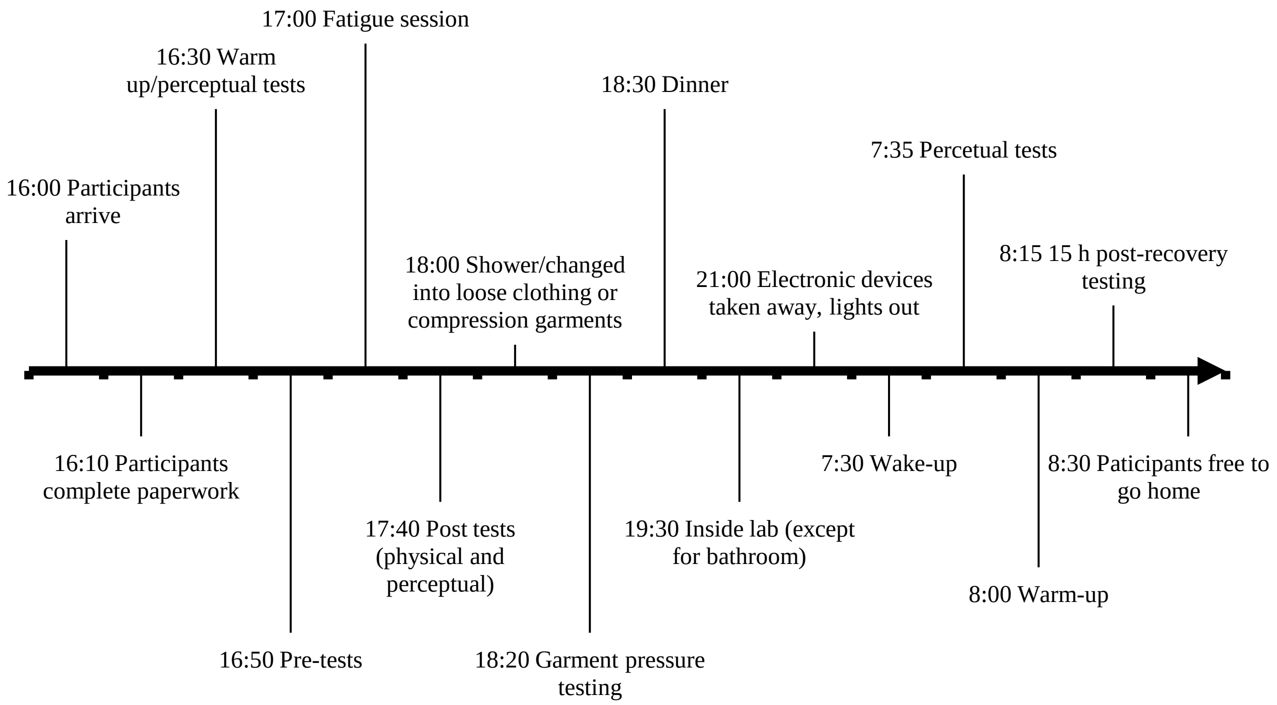

Figure 1. Timeline of events

Procedures

The standardised warm-up consisted of moderate-intensity jogging, a range of dynamic stretches, and then running efforts of increasing intensity across the length of the basketball court. Furthermore, three submaximal- and one maximal-effort circuits of the BEST were completed as part of the warm-up. Immediately following the warm-up, perceptual ratings were recorded and a standardised testing battery of basketball-relevant performance tests was administered.

Perceptual measures

The 10-point Mattacola scale (Mattacola, Perrin, Gansneder, Allen, & Mickey, 1997) was used to measure muscle soreness following the warm-up, after the fatigue-inducing exercise session, and the following morning after waking (~15 h post-exercise). The scale included ratings from 1 = no soreness to 10 = extremely sore. Similarly, fatigue was rated using a 5-point Likert scale (Pruscino et al., 2013) at the same time points (ratings ranged from 1 = not physically tired at all to 5 = very physically tired).

Countermovement jump

A countermovement vertical jump was used to assess lower-body power. Outcome measures gathered included jump height using a Vertec apparatus (Sports Imports, Columbus, OH, USA) as well as vertical jump impulse (N·s) using a force plate sampling at 1000 Hz (AMTI, Watertown, NY, USA). Five countermovement jumps were performed involving participants initially standing with feet shoulder-width apart on the force plate. Participants were asked to jump as high as possible following a self-selected depth countermovement. Participants jumped from both feet and were permitted to use a swinging arm movement. Prior to the first jump trial, the hand reach height (baseline) was measured when the participant displaced the vanes of the Vertec apparatus with their fingertips. At the peak of the jump, participants had to displace the Vertec vanes lightly with their fingertips to indicate jump height. Jump height was then calculated by subtracting the participant's baseline reach height from the maximum jump height, as validated previously. Five jumps were performed with 2 s between each jump. The highest jump of the five trials was used forfurther analysis.

Repeated-sprint test

A repeated-sprint test was used to evaluate maximum speed and anaerobic capacity. Participants began the repeated-sprint test positioned 10 cm behind the first timing gate (Smart Speed Timing Gates, Coopers Plains, Australia). The repeated-sprint test consisted of 6 x 20-m sprints, each completed every 20 s and interspersed with passive standing rest. Each sprint was recorded to the nearest 0.001 s and the fastest sprint as well as the total of all sprints were taken as outcome measures. Sprint decrement (%) was also calculated as total time/ideal time × 100where total time was the sum of all sprint times and ideal time was the best sprint time multiplied by six (Spencer, Fitzsimons, Dawson, Bishop, & Goodman, 2006).

5-0-5 Agility test

To assess change-of-direction speed, participants completed two trials of the 5-0-5 Agility test. Participants commenced each trial positioned in a starting position at the 0 m mark and initiated a straight-line sprint for 15 m where they performed a 180˚ turn on a marked point and sprinted in the opposite direction for 5 m back towards the starting line. The timing lights (Smart Speed Timing Gates, Coopers Plains, Australia) were placed at the 10 m mark so they could capture the start and stop times for the 5-0-5 test. Participants completed a trial with each foot as the plant foot when initiating the turn and 30 s of passive standing rest was applied between trials. The faster of the two trials was taken as the outcome measure.

Fatiguing-inducing session

The BEST (Scanlan, Dascombe, Reaburn, Tucker, & Dalbo, 2014) was used to induce fatigue using a basketball-specific stimulus given the test replicates the movement patterns performed during basketball game-play (Figure 1). Participants completed 2 x 12-min trials of the BEST, with 2 min rest between each trial to represent the average playing time of basketball athletes during game-play (Sampaio, Drinkwater, & Leite, 2010). During the test, participants were required to complete repeated circuits of basketball-specific activity, with each circuit being allotted a 30-s timeframe.

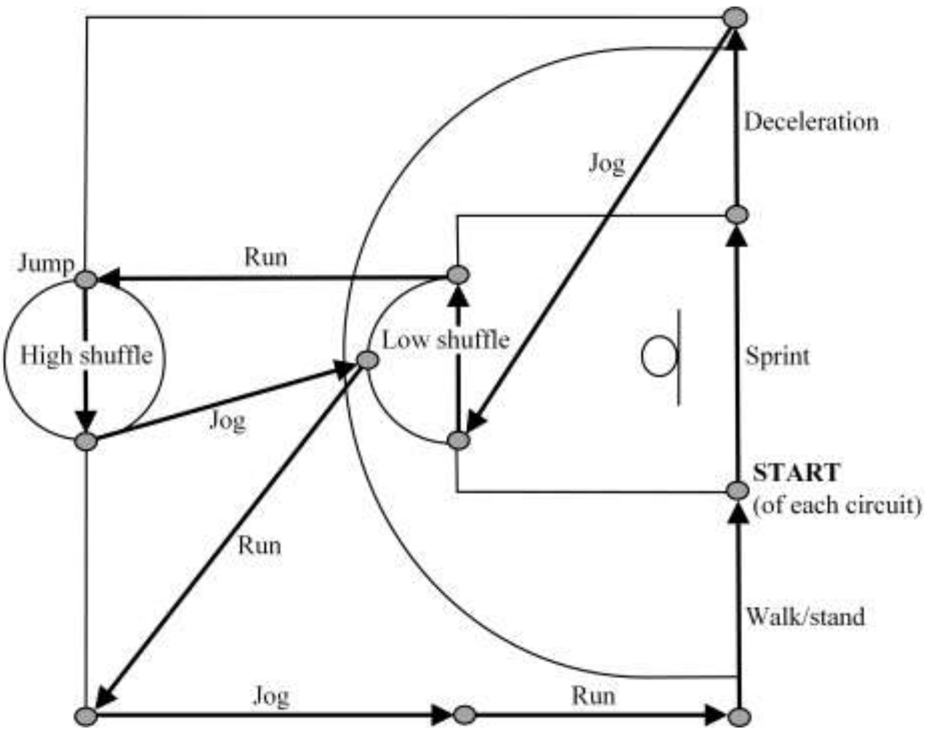

Figure 2. The Basketball Exercise Simulation Test (BEST), adapted from Scanlan et al. (2014).

On completion of the BEST, participants performed four sets of 10 lunge jumps, with a 30-s rest between each set. Finally, participants performed a 2-min isometric wall sit, involving sitting with their backs against a wall, feet flat on the ground, and knees bent at 90°. This protocol including the BEST, lunge jumps and wall sit has been used previously and has been shown to ensure fatigue and muscle soreness (Broderick, Uiga, & Driller, 2019).

Compression garment pressure measurement

The applied pressure of the compression garments was tested using the Kikuhime device (MediGroup, Melbourne, Australia) at the medial malleolus of the ankle, maximal circumference of the calf, and maximal circumference of the thigh (Figure 3). These three landmarks selected have been used previously when measuring the pressure of full-length compression garments (Brophy-Williams, Driller, Halson, Fell, & Shing, 2014). Garment pressure measurements were taken when the garments were first worn and immediately prior to their removal, ~15 hours later. The Kikuhime pressure monitor has been shown to be a valid (ICC = 0.99, CV = 1.1%) and reliable (CV = 4.9%) tool for compression measurement in sports settings (Brophy-Williams, Driller, Halson, Fell, & Shing, 2014).

INSERT FIGURE 3 AROUND HERE

Figure 3. The applied pressure of the compression garments was tested using the Kikuhime device (MediGroup, Melbourne, Australia) at three landmarks: A) the maximal circumference of the thigh, B) the maximal circumference of the calf, and C) the medial malleolus of the ankle.

Sleep monitoring

Sleep duration was monitored using the Mi-band 2 actigraphy device (Foxconn, Xiaomi, China). At 07:30, participants were woken if not already awake, and total sleep duration was recorded. The Mi-Band 2 has been validated previously, with a mean absolute percentage error accuracy of 0.12% reported for sleep duration (Xie et al., 2018). Sleep quality was also recorded in the morning on a 1-5 scale (1 = very poor, 5 = excellent) by each participant.

Statistical analysis

Descriptive statistics are shown as means ± standard deviations. To examine the efficacy of the fatigue protocol, and subsequent performance and perceptual measures, a two-way between-subjects ANOVA with 2 (condition: CON, COMP) x 3 (time: pre-exercise, post-exercise, post-recovery) factors was performed. Bonferroni post hoc tests were applied if significant effects were detected. Analysis of the studentised residuals was verified visually with histograms and also by the Shapiro-Wilk test of normality. Separate unpaired samples *t*-tests were used to compare both CON and COMP groups for each of the sleep measures. Effect size statistics were also calculated to determine pairwise differences between COMP and CON groups between post-exercise and post-recovery time points. Specifically, the standardised change in mean between time points was calculated and expressed as standardised effects (Cohen's *d*) with 95% confidence intervals. The magnitude of each effect size was interpreted using thresholds of 0.2, 0.6, 1.2 and 2.0 for *small*, *moderate*, *large*, and *very large (REFERENCE).* An effect size of <0.2 was considered *trivial*. Where the 95% confidence limits overlapped the thresholds for *small* positive and *small* negative values, the effect was considered *unclear.* Statistical analyses were performed using IBM SPSS statistics (Version 22, IBM Corporation, Armonk, NY) and effect sizes were calculated using Microsoft Excel. Statistical significance was set at $p < 0.05$ for all analyses.

RESULTS

Significant main effects of time from pre-exercise to post-exercise were found for all performance measures and perceptual ratings ($p \leq 0.05$), demonstrating increased fatigue and muscle soreness (Figure 3) and reduced physical performance (Table 1) following the exercise protocol.

INSERT FIGURE 4 AROUND HERE

INSERT TABLE 1 AROUND HERE

There was a statistically significant interaction between condition and time (post-exercise to post-recovery) for muscle soreness ($F(2, 28) = 184.67$, $p = 0.04$) and perceived fatigue ($F(2,28) = 3.65$, $p = 0.04$). Muscle soreness and perceived fatigue showed *large* differences post-recovery (in the change from post-exercise values) between groups (*d* = -1.27 and *d* =-1.61, respectively) in favour of COMP (Figure 3).

No significant interaction between condition and time (post-exercise to post-recovery) were found ($p > 0.05$) for any of the performance measures, suggesting there were negligible differences in performance recovery between COMP and CON. Furthermore, *trivial* or *unclear* differences in performance were evident between groups at all time points (Table 2).

INSERT TABLE 2 AROUND HERE

Table 3 presents the pressure measurements of the compression garments post-exercise and post-recovery. There were no significant differences in garment pressure across the experimental protocol ($p > 0.05$). Perceived sleep quality as well as measured sleep duration are reported in Table 4. *Small* differences in perceived sleep quality (*d* = -0.42, *p* = 0.18) were shown in favour of the COMP group. *Unclear* differences between conditions were found for measured sleep duration (*d* = -0.70, *p* = 0.10).

INSERT TABLE 3 AROUND HERE

Table 1. Mean ± SD for pre-exercise, post-exercise, and post-recovery performance measures for control (CON) and compression (COMP) conditions.

Measure	**Condition**	**Pre-exercise**	**Post-exercise**	**Post-recovery**
Vertical jump height (cm)	CON	69.8 ± 7.8	68.6 ± 9.1	67.2 ± 8.1
	COMP	67.9 ± 11.8	66.1 ± 11.5	65.1 ± 12.1

Vertical jump impulse (N·s)	CON	1.56 ± 0.29	1.44 ± 0.34	1.57 ± 0.37
	COMP	1.55 ± 0.36	1.35 ± 0.27	1.53 ± 0.40
20-m sprint time (s)	CON	3.25 ± 0.27	3.32 ± 0.39	3.39 ± 0.16
	COMP	3.47 ±0.29	3.59 ± 0.36	3.55 ± 0.30
Repeated-sprint time (s)	CON	20.41 ±0.99	21.37 ±1.77	20.79 ±0.97
	COMP	21.77 ±1.55	22.61 ± 2.52	21.77 ±1.88
Sprint decrement (%)	CON	-4.6 ± 5.3	-6.9 ± 8.0	-2.1 ± 1.0
	COMP	-4.2 ± 4.2	-4.6 ± 2.8	-2.2 ± 1.3
5-0-5 Agility time (s)	CON	2.63 ± 0.22	2.67 ± 0.20	2.60 ± 0.18
	COMP	2.72 ± 0.23	2.74 ± 0.26	2.64 ± 0.19

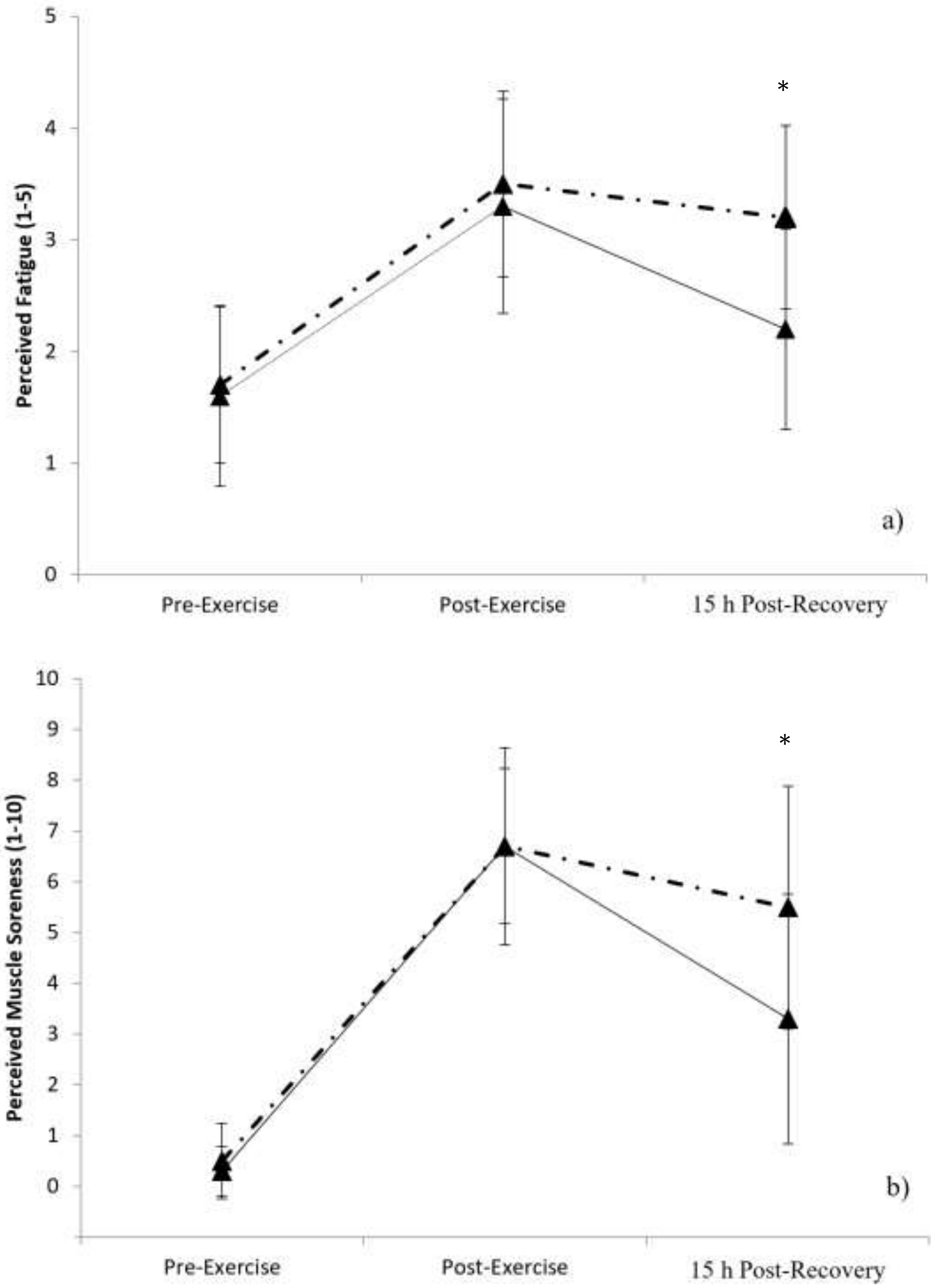

Figure 4. Mean ± SD a) perceived fatigue (1 = not physically tired at all to 5 = very physically tired) and; b) perceived muscle soreness (1 = no soreness to 10 = extremely sore) pre-exercise, post-exercise, and post-recovery in control (CON – dashed line) and compression (COMP - solid line) conditions. * Represents significant difference between groups ($p < 0.05$).

Table 2. Post-recovery comparison of all performance measures and perceptual ratings compared to post-exercise. Data presented as raw difference in values (mean ±95% confidence intervals) with effect sizes for comparison between experimental (COMP) and control (CON) groups. * Represents significant difference between groups ($p < 0.05$).

Measure	**Post-recovery ΔCOMP-ΔCON**	
	Raw ±95% CI	***d* ±95% CI, *interpretation***
Vertical jump height (cm)	0.4 ±2.1	0.04 ±0.20, *trivial*
Vertical jump impulse (N·s)	0.05 ±0.31	0.16 ±0.99, *unclear*
20-m sprint time (s)	-0.12 ±0.19	-0.33 ±0.53, *unclear*
Repeated-sprint time (s)	-0.36 ±0.80	-0.19 ±0.43, *unclear*
Sprint decrement (%)	-2.3 ±3.8	-0.42 ±0.68, *unclear*
5-0-5 Agility time (s)	-0.03 ±0.09	-0.11 ±0.36, *unclear*
Fatigue	-1.0 ±0.7*	-1.27 ±0.85, *large*
Muscle soreness	-2.1 ±1.9*	-1.61 ±1.17, *large*

Table 3. Mean ± SD pressure measurements (mmHg) for the compression garments at post-exercise and post-recovery.

Time point	**Ankle**	**Calf**	**Thigh**
Post-exercise	7 ± 3	10 ± 3	8 ± 2
Post-recovery	8 ± 3	10 ± 2	8 ± 2

Table 4. Sleep quality and duration for the control (CON) and compression (COMP) groups, with effect sizes between groups ±95% confidence intervals.

Measure	**Group**	**Mean ± SD**	**CON-COMP** ***d*** **±95% CI,** ***interpretation***
Perceived sleep quality[#]	CON	3.4 ± 1.3	-0.42 ±0.49, *small*
	COMP	4.0 ± 0.9	
Sleep duration (h:min)	CON	9:50 ± 0:24	0.70 ±1.00, *unclear*
	COMP	9:25 ± 0:45	

[#]Perceived sleep quality measured using a 5-point Likert scale where1 = very poor and 5 = excellent.

DISCUSSION

This study examined the efficacy of lower-body compression garments worn overnight following basketball-specific, fatigue-inducing exercise on perceived recovery and subsequent performance in recreational basketball athletes. The main findings in this study were that compression garments aided perceptual ratings of fatigue and muscle soreness with *large,* significant improvements compared to the control group. Furthermore, non-significant, *trivial* or *unclear* effects were evident for all performance measures between compression garment and control groups, suggesting a negligible influence on physical performance.

Participants who wore compression garments felt less muscle soreness and fatigue compared to the control group post-recovery in the current study. These findings demonstrate a psychological benefit with compression garments, which has also been shown in other research (Duffield et al., 2010; Goto, Mizuno, & Mori, 2017; Montgomery, Pyne, Cox, et al., 2008; Pruscino et al., 2013). Collectively, these studies indicate the changes induced in psychological response may be greater than physiological responses when wearing compression garments. In this regard, Duffield et al. (2010) investigated perceived muscle soreness following fatiguing exercise (sprints and plyometric bounds), showing a significant improvement ($p = 0.01$) when wearing full-length, lower-body compression garments compared to a control condition. Likewise, Pruscino et al. (2013) showed a trend ($p = 0.053$) in favour of compression garments worn during recovery in reducing muscle soreness when worn for 24 h after exercise compared to a control condition. Montgomery et al. (2008) also reported *moderate* to *very large* differences in perceived muscle soreness (-0.9% ± 1.5%) and fatigue (-1.1% ± 2.0%) throughout a 3-day basketball tournament compared to a control group. These studies are comparable to the current study, which resulted in a *large* difference between groups for the post-exercise to post-recovery change in muscle soreness (d = -1.61) in favour of the compression group. Improvements in perceived muscle soreness may be underpinned by increases in circulation and decreases in inflammation with compression, increasing blood lactate removal and reducing space for swelling to occur (Pruscino et al., 2013). However, this mechanism is largely speculative in the current study, and even unlikely given the low levels of pressure in the garments, indicating a possible placebo effect might have occurred.

Our findings for all performance measures, suggests a limited benefit of compression garments when worn overnight following basketball-specific exercise. These results are in line with previous basketball research (Montgomery, Pyne, Hopkins, et al., 2008) involving lower-body compression garments worn overnight for ~18 hours each day, across a 3-day basketball tournament in sub-elite athletes. Likewise,

Similarly, the effects of compression garments on other performance measures, including vertical jump and change-of-direction speed outcomes in the current study were also *unclear*, which aligns with previous research in team sport athletes (French et al., 2008; Goto et al., 2017; Montgomery, Pyne, Cox, et al., 2008; Duffield et al. 2010)). For instance, Goto et al. (2017) reported no significant differences between control and compression groups during countermovement and rebound jumps, with the authors concluding insufficient pressures may have been exerted by the compression garments (~8-12 mmHg) with high inter-individual variability (Goto et al., 2017). Similarly, Montgomery, Pyne, Hopkins, et al. (2008) reported negligible effects for compression garments, also suggesting the pressure applied by the garments was not high enough (~18 mmHg) to elicit physiological changes that may aid recovery for jump and change-of-direction performance. Consequently, the pressure levels exerted by the compression garments in our study may have also been insufficient to induce positive performance effects only reaching mean values of 7-10 mmHg across lower-body landmarks.

Sleep data showed an *unclear* effect for sleep duration between compression garment and control groups, and a *small* effect for perceived sleep quality in favour of compression garments. Previous research showed sleep quality was unaffected when wearing compression garments in male and female participants after a resistance exercise bout (Kraemer et al., 2010); however, the compression garments worn in their study were full-body suits, which may elicit greater discomfort than lower-body garments when worn overnight. In the current study, it is possible that the reduced muscle soreness in the compression group was related to the enhanced perceived sleep quality encountered. Indeed, previous research has shown that pain may interfere with sleep (Wittig, Zorick, Blumer, Heilbronn, & Roth, 1982). When it comes to muscle soreness or pain, there is potential for an increased activation of neurons that transmit nociceptive signals, and activate regions of the brain involved in the regulation of sleep (Mense, 1993). Further research on muscle soreness and sleep are warranted in the exercise recovery setting.

Despite the novel approach to examining the perceptual and performance effects of lower-body compression garments worn during recovery in basketball athletes, there were some important limitations that should be acknowledged. First, the use of a randomised, counter-balanced, cross-over design was preferable; however, this approach was not feasible in the present study due to logistical constraints. Second, the lack of a placebo group meant that psychological factors could potentially elicited a confounding effect on the results obtained. While it is difficult to design a placebo garment in compression studies, perhaps an alternative placebo recovery strategy could have been implemented. Indeed, it has been shown previously that belief in the benefit of compression garments may positively influence results (Brophy-Williams, Driller, Kitic, Fell, & Halson, 2017). Third, compression levels were lower than expected in the current study (~10 mmHg), as participants used the recommended sizing for garments provided by the manufacturer (based on body height and mass measures). Perhaps a smaller-sized garment than what is recommended should have been used to ensure a higher pressure was applied (ideally >20 mmHg). While the optimal pressure of compression garments is yet to be determined, Liu and colleagues (2008) suggested that pressure ≥18 mmHg was required to instigate positive responses in haemodynamics, with Hill and colleagues (2017) suggesting that >14 mmHg was more effective than <14 mmHg for strength and power measures and Bochmann and colleagues (2005) recommended pressures of ≥20 mmHg to increase limb blood flow. Conversely, a meta-analysis of 23 studies by Beliard et al. (2015) suggest there is no relationship between the effects of compression and the pressures applied. . Future research should consider the possible implications of long-term/chronic use of compression garments as a recovery tool. Given the trends towards improved sleep quality and lower muscle soreness in the compression group, it would be interesting to evaluate the use of compression over multiple weeks of use. Indeed, this would also allow for research to gain insights into the longer-term physiological adaptations that might occur and how these may influence physical performance measures.

In conclusion, wearing of lower-body compression garments overnight following basketball-specific fatiguing exercise improved perceived muscle soreness and fatigue, but did not restore various performance measures (jumps, sprints, repeated sprints or agility) more effectively than a control condition in recreational basketball athletes. There were *small* benefits to perceived sleep quality when wearing lower-body compression garments. Based on these results, we would recommend that recreational basketball athletes may benefit from the use of lower-body compression garments to reduce muscle soreness and fatigue, which may enhance subsequent sleep quality. These findings may have practical applications to recreational populations in promoting daily activity and exercise levels. Future research on the long-term use of compression garments and physical adaptations is warranted.

Acknowledgments

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