Does Intermittent Pneumatic Leg Compression Enhance Muscle Recovery after Strenuous Eccentric Exercise?

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Key words

- recovery
- cuff compression
- creatine kinase
- muscle strength

Abstract

Intermittent pneumatic compression (IPC) has gained rapid popularity as a post-exercise recovery modality. Despite its widespread use and anecdotal claims for enhancing muscle recovery there is no scientific evidence to support its use. 10 healthy, active males performed a strenuous bout of eccentric exercise (3 sets of 100 repetitions) followed by IPC treatment or control performed immediately after exercise and at 24 and 48 h post-exercise. Muscular performance measurements were taken prior to exercise and 24, 48 and 72 h post-exercise and included single-leg vertical jump (VJ) and peak and average isometric [knee angle 75°] (ISO), concentric (CON) and eccentric (ECC) contractions performed at slow ($30°\cdot s^{-1}$) and fast ($180°\cdot s^{-1}$) velocities. Plasma creatine kinase (CK) samples were taken at pre- and post-exercise 24, 48 and 72 h. Strenuous eccentric exercise resulted in a significant decrease in peak ISO, peak and average CON ($30°\cdot s^{-1}$) at 24 h compared to pre-exercise for both IPC and control, however VJ performance remained unchanged. There were no significant differences between conditions (IPC and control) or condition-time interactions for any of the contraction types (ISO, CON, ECC) or velocities (CON, ECC $30°\cdot s^{-1}$ and $180°\cdot s^{-1}$).However, CK was significantly elevated at 24 h compared to pre-exercise in both conditions (IPC and control). IPC did not attenuate muscle force loss following a bout of strenuous eccentric exercise in comparison to a control. While IPC has been used in the clinical setting to treat pathologic conditions, the parameters used to treat muscle damage following strenuous exercise in healthy participants are likely to be very different than those used to treat pathologic conditions.

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Introduction

Commercially manufactured intermittent pneumatic compression (IPC) has recently gained popularity as a post-exercise recovery modality, with various athletes having anecdotally supported its use for enhancing post-exercise recovery. IPC is advantageous as it does not require muscle tone to create the appropriate pressure to increase venous and lymphatic return to reduce swelling, [33] where historically it has been used during the post-surgery recovery phase and to treat venous thromboembolism, [19] deep vein thrombosis [16] and prevent venous stasis [36]. Additionally, IPC has been reported to improve limb haemodynamics, [14] limb ischemia [25] and ulcer healing [30].

Recovery after strenuous exercise often relies on alleviating the effects of impaired muscle function and soreness. Therefore, to expedite the recovery process it is common practice for recovery strategies to be implemented between training and/or competition bouts [7]. Consequently, training and/or competition loads (volume, intensity or frequency) can be maintained and tolerated, without incurring possible injury or performance decrements [5, 7]. To ameliorate the symptoms of strenuous exercise a number of recovery modalities have been studied including, but not limited to cryotherapy, non-steroidal anti-inflammatory medication, hyperbaric oxygen therapy, massage, stretching and contrast temperature water immersion [5, 7, 10, 38].

Additionally, compression garments have received considerable attention as a recovery agent, where possible benefits to aiding performance may include reducing swelling and muscle soreness and eliciting changes to local haemodynamics, which may increase blood flow to accelerate the removal of metabolic waste [27]. Furthermore, compression garments may act as a mechanical support to keep muscle structures in place and reduce the amount of movement, thus mitigating the magnitude of the inflammatory response and attenuating soft tissue damage [26,28]. However, findings on the efficacy of compression garments for enhancing recovery remain equivocal [12,15,23,26–29], which may reflect the type and level of compression used and the under-reporting of the garment pressure gradients [29].

To overcome these difficulties in compression garment application, IPC can precisely control the application of pulse pressure, pulse time and duration. Commercially manufactured IPC units consist of inflatable lower and upper limb sleeves, which are connected by a tube to a programmable computerised compressor. The inflatable sleeves have multiple cells that allow for independent cell control of pulse pressure, pulse time and duration. These cells are pneumatically inflated and deflated using peristaltic pulse compression where the sequence is continued along the limb until the treatment time elapses.

Despite widespread use of IPC and claims for hastening recovery, to our knowledge there is no scientific evidence to support its efficacy to enhance post-exercise recovery. Therefore, we chose a bout of strenuous eccentric exercise because many sporting movements involve eccentric contractions of jumping, landing, and deceleration. Furthermore, eccentric exercise is recognised as a research modality that can induce significant alterations to, and/or decrements in muscle performance with associated symptoms of soreness and loss in range of movement [9,10]. Therefore, the aim of this study was to investigate the effectiveness of IPC as a lower limb recovery modality after strenuous eccentric exercise. We hypothesised that IPC would expedite the recovery process, where leg muscle performance would be significantly accelerated compared to a control of no IPC.

Materials & Methods

▼

Participants

10 males (mean age (±S.D.) 21.0±1.7 yr.; body mass 79.2±12.8 kg, height 178.6±6.5 cm), who were healthy and involved in physical activity at least 3 times a week, volunteered to participate in the study. Written informed consent was obtained from the participants and ethical approval was granted by the University Human Ethics Committee. This study meets the ethical standards of the journal [21].

Study design

For the first trial participants were randomly assigned to either intermittent pneumatic compression (IPC) or No IPC (control) and to use either their dominant or non-dominant leg, which was allocated in a counter-balanced, cross-over approach (◉ **Fig. 1**). The sample size estimation for this study was based upon results from previous studies [4,8]. In healthy active males, strenuous eccentric exercise has been shown to reduce peak quadriceps isometric tension by 40±44 Nm [4]. We considered a decrease by 10% or more in muscle dynamometry to be a noteworthy difference. Further, exercise-induced muscle damage has been reported to decrease countermovement vertical jump by 95.2±1.3% of pre-exercise values [8]. Therefore, a reduction of 5% or more was considered to be a notable difference. From this the power analysis revealed that 10 participants were necessary to achieve a power of 0.80 with $\alpha=0.05$.

Participants were not blinded to the intervention and were instructed to refrain from any form of exercise and to maintain their usual diet during the course of the study. Dietary control was achieved by having participants record their normal diet throughout the duration of the first trial. The principal investigator then followed up with participants to ensure that the diet was replicated before the second trial.

All participants performed a strenuous bout of eccentric exercise (3 sets of 100 repetitions) followed by IPC or control performed immediately after exercise and at 24 and 48 h post-exercise. Measures of muscular performance and venous blood samples were taken prior to exercise and 24, 48 and 72 h post-exercise. 2 weeks after the first trial, participants returned to the laboratory to complete an equivalent eccentric exercise bout using the contralateral leg and the other condition. To minimise any circadian influence the participants performed all trials at the same time of day.

Muscular performance

Dynamometry

At least 1 week before their first trial, participants were familiarised with the exercise, performance measurements and IPC. Having been familiarised with the protocol, participants returned to the laboratory for testing and warmed up on a cycle ergometer (Monark, Varberg, Sweden) for 5 min at 100 W. Following the warm-up participants were seated on an isokinetic dynamometer (Biodex Medical Systems, New York, USA) and were secured with straps across the chest, hips and exercising leg to isolate movement of the quadriceps. Measures of maximum quadriceps isometric tension (ISO) and concentric (CON) and eccentric (ECC) torque was performed. 3 maximum repetitions were separated by 10 s rest and a 2-min rest was enforced between the 3 modes of muscle contractions.

ISO was measured at a knee angle of 75°, which has been known to produce maximum torque [6] and CON and ECC torques were measured at an angular velocity of $30°\cdot s^{-1}$ and $180°\cdot s^{-1}$ over a comfortable, full range of motion. The $30°\cdot s^{-1}$ and $180°\cdot s^{-1}$ were selected to provide 2 distinctive velocities of isokinetic strength. The absolute peak torque and average peak torque over 3 repetitions were recorded and the range of motion was noted and used for subsequent performance measurements. Follow-up measures of muscular performance were conducted 24, 48 and 72 h post-exercise.

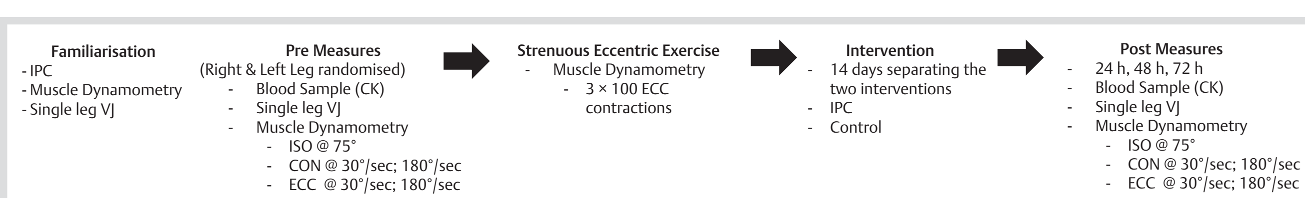

Fig. 1 Schematic representation of the study design. IPC – intermittent pneumatic compression; VJ – vertical jump; CK – creatine kinase; ISO – isometric; CON – concentric; ECC – eccentric.

Vertical jump

Following the muscle dynamometry, 3 repetitions of single-leg vertical jumps (VJ), separated by 10 s of rest were performed on a strain gauge ground reaction force platform (Bertec Corp, Columbus, OH) linked to a desktop computer using an integrated analogue-digital board and software system (Kistler BioWare, New York). Participants were instructed to remove their shoes, stand on one leg (that had undergone strenuous exercise), position their hands on hips to negate any influence of the upper body, and to keep their head still during the flight of the jump. The maximum jump height was calculated as the highest displacement of the centre of mass and the relative peak power was calculated from the product of force and velocity. The 3 VJ values were averaged for mean height and mean peak power, and the maximum values for jump height and maximum peak power were used for further analysis.

Strenuous eccentric exercise bout

After the measurement of muscular performance, participants completed 3 sets of 100 maximum eccentric contractions of the quadriceps on the isokinetic dynamometer. A 60° range of motion, from full flexion (0°), at an angular velocity of $30° \cdot s^{-1}$ was used and 5 min of passive recovery separated each set. This protocol has previously been used to bring about significant reductions in muscular performance and elevate creatine kinase (CK).[2, 3] Work completed during the 3 sets was recorded via the dynamometer software (System 3 v3, Biodex Medical Systems, NY, USA) and was later analysed.

Conditions

Immediately after the completion of the strenuous eccentric exercise bout participants underwent 30 min of IPC (Normatec MVP®, MA) and following performance measures, IPC was further administered 24 and 48 h post-exercise. Participants were seated on a reclined examination table where the leg was enclosed in an inflatable sleeve that covered the whole limb from distal toes to the proximal inguinal region and was connected by an inflation tube to a programmable computerised compressor. The leg sleeve had 5 cells that allowed for independent cell control of pulse pressure, pulse time and rest time. The peristaltic pulse compression started by inflating the most distal cell to a pre-set peak compression pressure, whereupon reaching this level it inflated and deflated in a pulsing manner. This was followed by a period of static pressure, which was pre-set at 10 mm greater than the cell's pulse pressure. The pulsing and holding cycle continued along the limb until the treatment time elapsed. Using the manufacturer's guidelines for post-work out, the pulse pressure in cell 1 (distal) was set at 70 mmHg, cells 2–4 80 mmHg, cell 5 (proximal) 60 mmHg. The pulse time and rest time was pre-set at 30 s.

For the control, participants were seated in the exact same position with the leg enclosed in the sleeve but the compressor unit was switched off. To standardise the energy intake after the completion of both conditions (IPC, control), participants consumed a small snack (4 066 kJ; protein 28.6 g, fat 28.6 g, carbohydrate 132.4 g).

Blood sample

Creatine Kinase (CK)

A venous blood sample was obtained from an antecubital vein of participants at pre-, and post-exercise 24, 48 and 72 h. Blood was collected into a 4-mL, EDTA-containing vacutainer, placed on ice for 10 min and centrifuged at 4 °C for 10 min at 805 g. Plasma was aspirated into 300 µL aliquots and frozen at −80 °C for later analysis. CK activity was determined using a Vitalab Flexor clinical chemistry analyser (Vital Scientific NV, Netherlands) and a Roche CK-NAC liquid assay kit (Roche Diagnostics GmbH, Mannheim, Germany), with average intra-assay CV of <5 %.

Statistical analyses

VJ average height and average peak power, and maximum height and maximum peak power and quadriceps average and peak tension for ISO, torque for CON ($30° \cdot s^{-1}$ and $180° \cdot s^{-1}$) and ECC ($30° \cdot s^{-1}$ and $180° \cdot s^{-1}$) were analysed using SPSS for Windows (version 20.0, IBM, New York). A 2-factor [condition (IPC, control) and time (Pre-, Post 24, 48, 72 h)] repeated measures ANOVA was performed to examine the magnitude of the condition effect over time for each measurement. A general linear-model 2-way repeated-measures ANOVA (condition × set) was used to compare the total work performed during the strenuous eccentric exercise bout (3 sets of 100 repetitions). Where there was significance, post-hoc pairwise comparisons were performed using Bonferroni adjustment to investigate changes in performance over time within each condition. Due to the high physiological variability and to achieve a normal distribution, CK values were log transformed before statistical analysis. To assess the effect size the partial eta-squared (η_p^2) coefficient was calculated. The effect size magnitude of 0.01, 0.06 and 0.14 were interpreted as small, medium and large worthwhile changes. All values are reported as mean ± standard deviation and level of statistical significance was set at $p<0.05$.

Results

There was no significant difference in the total work completed during the strenuous eccentric exercise bouts between conditions (IPC 13.3 ± 3.5 kJ; control 12.5 ± 2.5 kJ; $p=0.65$, $\eta_p^2=0.024$). There was less total work performed in sets 2 and 3 compared to set 1 for both IPC and control, while there was no difference in work between set 2 and 3. Repeated-measures ANOVA of trial one vs. trial 2 and dominant vs. non-dominant leg found no significant effect of order or leg for any of the muscular performance measures (both $p>0.1$).

For both conditions strenuous eccentric exercise resulted in a decrease in muscular force development. However, only peak ISO ($p=0.000$, $\eta_p^2=0.583$), peak CON at $30° \cdot s^{-1}$ ($p=0.000$, $\eta_p^2=0.968$) and average CON at $30° \cdot s^{-1}$ ($p=0.000$, $\eta_p^2=0.980$), (**Table 1, 2**) decreased significantly over time. There were no other significant reductions in torque measures for other muscle contraction types and velocities. However, peak ECC at $30° \cdot s^{-1}$ ($p=0.02$, $\eta_p^2=0.509$), $180° \cdot s^{-1}$ ($p=0.015$, $\eta_p^2=0.375$) and average ECC at $30° \cdot s^{-1}$ ($p=0.02$, $\eta_p^2=0.508$), $180° \cdot s^{-1}$ ($p=0.034$, $\eta_p^2=0.312$) were significantly greater at 48 and 72 h compared to 24 h (**Table 1, 2**). There were no significant differences in dynamometry measures (ISO, CON, ECC; $30° \cdot s^{-1}$ and $180° \cdot s^{-1}$) between conditions and no interaction effects (**Table 1, 2**) were evident. There were no significant changes in VJ maximum and average height between conditions ($p=0.578$, $\eta_p^2=0.036$;), time ($p=0.138$, $\eta_p^2=0.227$), or interaction effect ($p=0.432$, $\eta_p^2=0.045$). Likewise, for VJ maximum and average peak power no significant changes were evident between conditions ($p=0.531$, $\eta_p^2=0.045$;), time ($p=0.221$, $\eta_p^2=0.148$) or interac-

Peak ISO	Pre	24h*	48h*	72h*
IPC	261.7 ± 49.1	234.5 ± 61.7	264.7 ± 58.8	269.3 ± 54.4
Control	264.3 ± 38.2	225.8 ± 28.7	246.5 ± 34.7	276.2 ± 40.9
Peak CON-Slow	Pre	24h*	48h	72h†
IPC	224.4 ± 36.4	189.6 ± 49.0	203.0 ± 55.7	215.9 ± 36.9
Control	224.5 ± 34.0	183.8 ± 31.2	205.2 ± 27.2	220.4 ± 37.1
Peak CON-Fast	Pre	24h	48h	72h
IPC	189.9 ± 30.4	163.9 ± 26.0	166.2 ± 29.3	175.4 ± 26.0
Control	181.6 ± 22.5	156.9 ± 16.6	158.0 ± 17.1	173.2 ± 25.0
Peak ECC-Slow	Pre	24h	48h†	72h†
IPC	277.3 ± 72.3	253.5 ± 87.1	293.0 ± 73.1	306.0 ± 65.5
Control	282.2 ± 51.7	236.1 ± 47.9	289.1 ± 45.1	301.2 ± 67.0
Peak ECC-Fast	Pre	24h	48h†	72h†
IPC	274.2 ± 70.3	258.5 ± 65.3	284.1 ± 81.3	303.1 ± 88.6
Control	271.0 ± 58.7	254.6 ± 62.4	280.1 ± 56.8	310.4 ± 74.3

Ave ISO: Peak isometric torque; Ave CON-Slow: Peak concentric torque ($30°·s^{-1}$);
Ave CON-Fast: Peak concentric torque ($180°·s^{-1}$); Ave ECC-Slow: Peak eccentric torque ($30°·s^{-1}$); Ave ECC-Fast: Peak eccentric torque ($180°·s^{-1}$)
* Significant time effect, different from Pre $p<0.01$
† Significant time effect, different from 24h $p<0.01$

Table 1 Peak torque (Nm) of ISO, CON and ECC fast and slow contraction velocities over time following strenuous eccentric exercise.

Ave ISO	Pre	24h	48h†	72h†
IPC	245.3 ± 53.6	218.6 ± 59.8	247.7 ± 60.9	258.1 ± 52.0
Control	245.9 ± 38.8	214.2 ± 32.0	235.2 ± 34.9	261.5 ± 38.8
Ave CON-Slow	Pre	24h*	48h	72h†
IPC	213.2 ± 33.0	180.0 ± 46.4	192.2 ± 56.6	204.4 ± 36.8
Control	213.0 ± 34.6	174.0 ± 29.9	191.7 ± 27.1	211.8 ± 35.6
Ave CON-Fast	Pre	24h	48h	72h
IPC	181.0 ± 30.6	148.6 ± 32.1	157.4 ± 27.2	167.9 ± 24.8
Control	171.4 ± 26.7	145.0 ± 23.6	152.1 ± 16.8	167.6 ± 23.2
Ave ECC-Slow	Pre	24h	48h†	72h†
IPC	246.8 ± 63.5	236.7 ± 78.2	276.3 ± 67.4	289.6 ± 62.0
Control	267.5 ± 48.5	220.7 ± 50.1	271.5 ± 41.4	289.6 ± 60.5
Ave ECC-Fast	Pre	24h	48h†	72h†
IPC	256.5 ± 68.1	239.2 ± 69.1	266.2 ± 75.7	286.6 ± 79.2
Control	254.7 ± 54.1	226.1 ± 56.8	260.5 ± 50.2	295.6 ± 69.6

Ave ISO: Average isometric torque; Ave CON-Slow: Average concentric torque ($30°·s^{-1}$);
Ave CON-Fast: Average concentric torque ($180°·s^{-1}$); Ave ECC-Slow: Average eccentric torque ($30°·s^{-1}$); Ave ECC-Fast: Average eccentric torque ($180°·s^{-1}$)
*Significant time effect, different from Pre $p<0.01$
†Significant time effect, different from 24h $p<0.05$

Table 2 Average torque (Nm) ISO, CON and ECC fast and slow contraction velocities over time following strenuous eccentric exercise.

tion effect ($p=0.405$, $\eta_p^2=0.100$) (**Table 3**). The CK logged values showed a significant increase at 24h compared to pre-exercise in both IPC ($p=0.000$, $\eta_p^2=0.867$) and control ($p=0.002$, $\eta_p^2=0.667$), but there were no other significant changes in time ($p=0.062$, $\eta_p^2=0.334$), condition ($p=0.188$, $\eta_p^2=0.187$) or interaction effect between condition and time ($p=0.475$, $\eta_p^2=0.079$) (**Table 3**).

Discussion

The current results failed to show that IPC can attenuate muscle force loss in ISO, CON, ECC contractions at slow ($30°·s^{-1}$) and fast ($180°·s^{-1}$) velocities following a bout of strenuous eccentric exercise. However, there was no change in VJ performance for both IPC and control following strenuous eccentric exercise. A likely explanation could be the joint and movement specificity of the eccentric exercise protocol, which specially targeted the quadriceps muscle group in producing a reduction in torque. However, VJ performance remained unchanged due to its use of multi-joint action and muscles. VJ requires a co-ordinated sequence that relies on hip and knee extensors and ankle plantar flexors [32]. Additionally, there is evidence to suggest that non-extensor muscles may also play a role in VJ performance [31]. Therefore, it is plausible that hamstrings, gluteal muscles, calf and non-extensors may have contributed to upholding jump performance [22,31].

Historically in the clinical setting, the primary purpose of IPC has been to improve recovery time by reducing oedema, [20] decreasing venous pressure, [13] increasing venous velocity, [17] and promoting skin blood flow [1]. From the aforementioned beneficial effects, the expectation was that IPC would alleviate post-exercise muscle trauma from a bout of strenuous exercise. However, the current findings refute our hypothesis such that IPC does not expedite leg muscle performance following strenuous eccentric exercise. The discrepancy between previous medical and the current findings may lie with specific factors. For instance, post-exercise recovery of muscle and performance are multifactorial and are likely to include tissue repair and adaptation as well as resynthesis of muscle glycogen. Con-

Ave VJ-Ht	Pre	24 h	48 h	72 h
IPC	33.9 ± 4.8	33.0 ± 4.7	34.2 ± 4.5	34.8 ± 4.3
Control	33.6 ± 5.2	32.4 ± 3.5	33.9 ± 4.1	33.3 ± 4.3
Ave VJ-PP	Pre	24 h	48 h	72 h
IPC	2486.4 ± 399.5	2466.0 ± 455.5	2451.1 ± 373.3	2431.2 ± 338.8
Control	2447.8 ± 278.7	2360.9 ± 268.3	2423.3 ± 260.7	2430.3 ± 324.1
Max VJ-Ht	Pre	24 h	48 h	72 h
IPC	35.1 ± 5.4	34.3 ± 3.7	35.4 ± 4.7	35.1 ± 4.5
Control	35.1 ± 4.3	34.6 ± 4.4	35.8 ± 4.8	35.6 ± 5.0
Max VJ-PP	Pre	24 h	48 h	72 h
IPC	2568.0 ± 319.1	2490.8 ± 287.8	2504.1 ± 316.4	2522.1 ± 331.2
Control	2556.6 ± 396.7	2527.7 ± 457.5	2546.2 ± 380.1	2496.5 ± 383.6
CK	Pre	24 h*	48 h	72 h
IPC	2.3 ± 0.3	2.7 ± 0.3	2.6 ± 0.3	2.5 ± 0.4
Control	2.4 ± 0.4	2.7 ± 0.4	2.7 ± 0.5	2.5 ± 0.6

VJ-Ht – Vertical jump height (cm); VJ-PP – Vertical jump peak power; CK – creatine kinase; Ave – average; Max – Maximum
*Significant time effect, different from Pre $p < 0.01$

Table 3 Single-leg vertical jump average and maximum height (cm), average and maximum peak power (W) and creatine kinase logged values over time following strenuous eccentric exercise.

versely, post-surgical recovery and various pathologies require specific and specialised treatment. In the present study healthy, active males were assessed, and it is therefore plausible that the physiologic responses to IPC could be vastly different in a healthy population, compared to patients suffering from a pathologic condition, which may be a requirement for IPC to be effective [37].

The advantage that IPC has over other recovery modalities (i.e., compression garments) is that the pulse pressure can be precisely controlled. In the current study, the pulse pressure was set according to manufacturer instructions of 70 mmHg at the ankle, 80 mmHg at the knee and 60 mmHg at the thigh, which is greater than any reported compression garment [18, 27, 35]. However, the dynamics of wearing a compression garment differs in its application to IPC. Nevertheless, the IPC pressure protocol used in the current study was comparable to the pressures (65–120 mmHg) that have been applied to the foot and calf to successfully treat medical conditions, such as peripheral arterial disease [14, 24, 34]. The disparity between current and medical findings may be explained by the different sample populations (healthy vs. medical conditions) and the different protocols of IPC. For medical ailments, multiple IPC treatments can occur daily up to a total duration of 3 h [24]. Although the benefits from using IPC appear to be statistically insignificant, we observed a small but unclear difference for the main outcome of condition and time interaction. Therefore, the practical significance on expediting recovery remains uncertain based on the sample population that performed the current protocol.

To date, there are no scientific recovery guidelines for optimal IPC pulse pressure. Therefore, in the present study the pulse time and the total duration may have been inadequate to elicit the required responses. The manufacturer suggests that higher pulse pressures and longer pulsing times may be required where the pathology is the greatest. In the current study, the pulse time was pre-set at 30 s, which may have been inadequate to initiate the desired peristalsis action to enhance the physiologic responses of reducing oedema and promoting blood flow to expedite the removal of waste products to accelerate recovery. While it was beyond the scope of this study to measure the physiologic factors, it has been reported that IPC causes changes in lower limb blood flow and skeletal muscle gene expression without, however, having any impact on endothelial function [37]. Therefore, further research is required to examine different IPC pulse pressures and compression rates following strenuous exercise. This will provide valuable insights to understanding its efficacy as a possible recovery strategy.

Strenuous or unaccustomed exercise is likely to disrupt the muscle membrane so that CK is released into circulation. As such, CK is often used as a common blood marker to detect muscle damage [11, 18, 27]. In the present study the strenuous eccentric bout of 3 sets of 100 repetitions reduced force development and significantly elevated CK at 24 h compared to baseline levels, indicating possible muscle damage and confirms previous reports that this strenuous eccentric protocol elicits muscle damage [4]. The observed increase in CK occurring in both IPC and control corresponded to performance decrements in peak and average torque in CON-slow (12 % and 17.5 %) and ISO torque (18 %), which are comparable to isokinetic torque losses documented by Barnes et al. [4]. Because the current study only investigated the functional components of performance, it would be of further interest if additional markers of inflammation were examined in future studies. Additionally, it is important to note that participants were instructed to maintain their usual diet during the course of the study. However, there is a possibility that the participants' macronutrient intake could have slightly deviated between the 2 trials, which may have influenced the performance and results of the study.

In conclusion, the current findings indicate that following a strenuous eccentric exercise bout, IPC was unable to hasten muscle recovery in healthy, active males. We hypothesised that IPC would accelerate lower limb muscle performance compared to a control of no IPC. However, IPC failed to attenuate muscle force loss in isokinetic dynamometry muscle contractions. Nevertheless, it is important to note that IPC may have an impact on different types of exercise. Therefore, further research is necessary to investigate the potential role of IPC to expedite muscle recovery by focusing on finding an optimal pulse pressure, pulse time, duration and frequency of its application as well as investigating the effect IPC has on other modes of strenuous activity.

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