Intermittent Pneumatic Compression Technology for Sports Recovery

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Abstract. Intermittent pneumatic compression (IPC) technologies are widely used in clinical populations to aid the reduction of limb oedema and for the prophylaxis of deep vein thromboses (DVT). IPC application within athletic populations is not however widespread. The main mechanism for the effectiveness of IPC is that it augments venous and arterial blood flow via the periodic inflation of external cuffs. We believe that this may be beneficial to the warm-down activities of athletes. The removal of waste products may help to reduce injury risk and the phenomenon of delayed onset muscle soreness (DOMS). A new implementation of the technology has been developed to test the extent of any potential warm-down effects induced by IPC treatment in athletes. This paper presents a pilot study in which male participants were exposed to IPC following intensive exercise. The specific treatment comprised 60sec inflation and 60sec deflation of a calf-thigh three compartment sequential compression garment (ratio 70:65:60mmHg) on each leg. This cycle was implemented by an electric pump with the participants in the partially supine position. The recovery protocol was designed to assess the ability of IPC to reduce the symptoms of delayed onset muscle soreness (DOMS) elicited by a high intensity repeated shuttle run. A 1 hour IPC treatment was implemented in this case. Vertical jump was used to identify any change in performance pre and post trial. Visual analogue scales were used +1, +24 and +48 hours after the tests to assess the presence of DOMS. During these tests, heart rate and blood pressure measurements were recorded.

1 Introduction

Intermittent Pneumatic Compression (IPC) has been used as a mechanical method of deep vein thrombosis prophylaxis for a number of years. These systems comprise the pumped inflation and deflation of air bladders within cuffs that can cover the foot, calf or whole leg. The inflation can be applied uniformly or sequentially with a variety of pressures at rapid or moderate rates. The core mechanism for the efficacy of these systems is the prevention of stasis by augmenting venous and arterial blood flow (Morris and Woodcock 2002 and 2004). Similarly this technology has been used for the reduction of lymphedema (Pappas and O'Donnell 1992) and to enhance localised muscle recovery (Wiener, Mizrahi and Verbitsky 2001).

Given these anti-inflammatory and muscle recovery mechanisms it is believed that IPC may have application in the treatment of delayed onset muscle soreness (DOMS). DOMS is a phenomena often associated with eccentric muscle contractions whereby damage to muscle fibres from periods of exercise causes muscle pain that can persist for several days. This has disruptive effects upon the training schedules of athletes and therefore solutions to reduce the duration of soreness are of great benefit.

One such condition that is often associated with the occurrence of DOMS is high intensity shuttle running (Thompson, Nicholas and Williams 1999). This paper therefore describes a pilot study to investigate the influence of IPC upon the occurrence of DOMS after a period shuttle running.

2 Methods

Nine healthy male participants mean SD (age 25.2±1.72yrs, height 184.8±9.94m, body mass 87±10.46kg, body fat 14.9±3.61% and VO_{2max} of $53.1 \pm 2.69 ml \cdot kg^{-1} \cdot min^{-1}$) attended the High Performance Athletics Centre at Loughborough University on four separate occasions. It was requested that participants did not consume any food for 2 hours prior to arriving and refrained from alcohol, caffeine and rigorous exercise for at least 24 hours prior to the tests.

The first of these sessions was a test to estimate maximal oxygen uptake (VO_{2max}). This was done using a progressive shuttle run (Ramsbottom, Brewer and Williams 1988) and permitted the grouping of participants during a modified Loughborough Intermittent Shuttle Test (LIST, Nicholas, Nuttall and Williams 2000) tailored to exacerbate delayed onset muscle soreness. All participants were also habituated with the segmented bladder, Intermittent Pneumatic Compression (IPC) and vertical jump equipment (Jump Meter, Just Jump). Body mass and composition were measured using a set of electronic scales (BF Scales, Tanita) and a 4 site skinfold calliper method (Jackson and Pollock 1985) respectively.

Each participant was then assigned to a group (n>1) comprising others with similar progressive shuttle run scores for completion of the following tailored LIST test:

- 12 x 20m at jogging speed (4 x 3 sequential bouts interspersed with the sprint)
- 12 x 20m at maximal running speed (sprint) (4 x 3 sequential bouts interspersed with the jog)
- 18 x 20m at walking pace
- Repeat (approximately 12 times, equivalent 1hr total duration)

The shuttle runs were repeated on three separate occasions by each participant (at least 3 days apart) and preceded a treatment session that comprised either: a rest for one hour; a one hour low-pressure IPC treatment (20:15:10mmHg) or; a one hour high-pressure IPC treatment (70:65:60mmHg). All treatments were carried out in the partially supine position and the order of application was randomized.

Body mass, vertical jump and calf / thigh circumference were recorded prior to and immediately following the completed treatment session. Heart rate was recorded during the tests (Polar Team System, Polar Electro). A vital signs monitor (Smartsigns Assist, Huntleigh Healthcare) was used to record heart rate and blood pressure during the treatment sessions. Following completion of the sessions, participants completed a soreness diagram (Fig. 1) with the aid of a 10 point scale with anchors ranging from 1 (Not sore) to 10 (Very, very sore). Participants were prompted to rate their perceived level of soreness and identify the location by marking the diagram accordingly. This was repeated without supervision +24 and +48 hours post-testing.

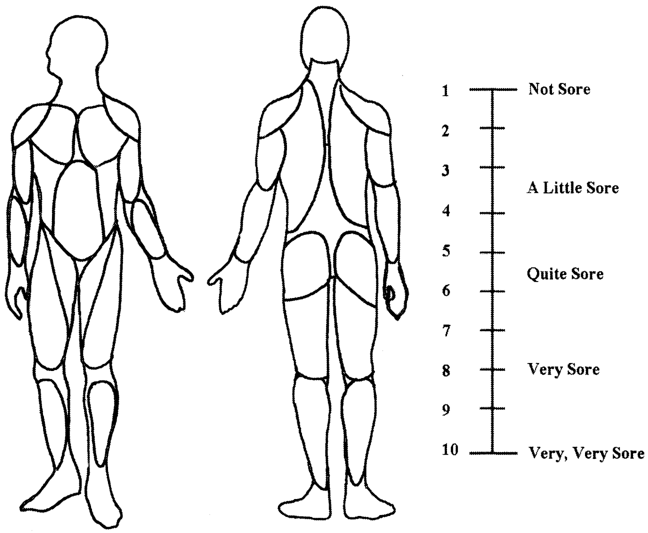

Fig. 1. Soreness diagram and accompanying visual analogue scale

Repeated measures t-tests were used to investigate any differences in data between the high pressure, low pressure and no pressure treatments. Significance was taken at $p<0.05$. All results are presented as mean values ± 1 standard deviation.

3 Results

3.1 Shuttle Session

Consistent heart rate plots were recorded by all subjects across each of the shuttle run sessions. The heart rates observed during all trials ranged from a minimum of 118.9±12.3bpm to a maximum of 181.8±9.1bpm. These heart traces were also used to check consistency of the shuttle run sets and sprint component durations. The plots show that both the set and sprints were consistent for all subjects with 6.8±0.7 and 3.0±0.3min for the set and sprint times respectively.

3.2 Treatment Session

Over the hour of treatment, hart rate gradually approached resting values from elevated rates immediately post-shuttle run. During this time both the high and low pressure treatments produced significantly lower mean heart rate values than the no treatment condition (83±6.9 and 82.4±9.1 vs. 87.3±8.1bpm respectively). Incidentally the high and low pressure treatments were not significantly different. Diastolic blood pressure was also significantly higher without any leg compression (76±2.4 vs. 71.7±2.0 and 71.5±1.9mmHg for the high and low pressure treatments respectively). As per the heart rate plots, there was no significant difference between high and low pressures.

3.3 Performance Measures

There was no significant or consistent change in the measured calf and thigh circumferences. Vertical jump performance was reduced on all occasions however the magnitude of the reduction was smaller following high and low pressure IPC treatments. The high pressure treatment produced a significantly smaller mean reduction than both the low pressure treatment and no treatment (1.9±1.4 vs. 4.4±3.8 and 5.9±3.4cm respectively).

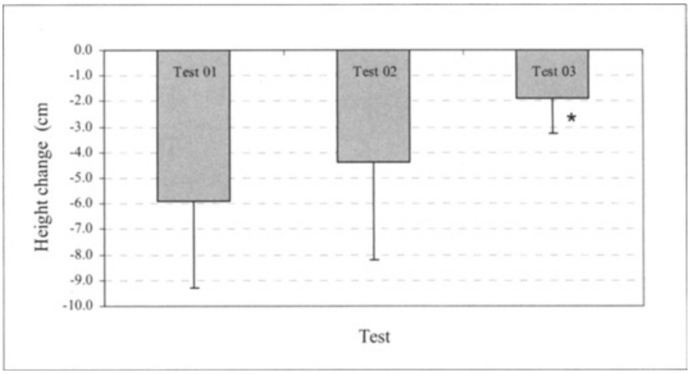

Fig. 2. Reduction in vertical jump performance (*significant, $p<0.05$)

3.4 Soreness Measures

Mean perceived soreness measured at the shins, calves, quadriceps and hamstrings was significantly reduced by high and low pressure IPC treatment +1 hour (2.1±1.2, 3±1.1 c.f. 4±1.5), +24 hours (1.3±0.2, 2±0.8 c.f. 3±1) and +48 hours (0.6±0.2, 1.1±0.3 c.f. 1.9±0.7) compared to no treatment after the shuttle runs. In each case the low pressure treatment produced significantly lower ratings than after no treatment, and the high pressure treatment produced significantly lower ratings than both the low pressure treatment and no treatment.

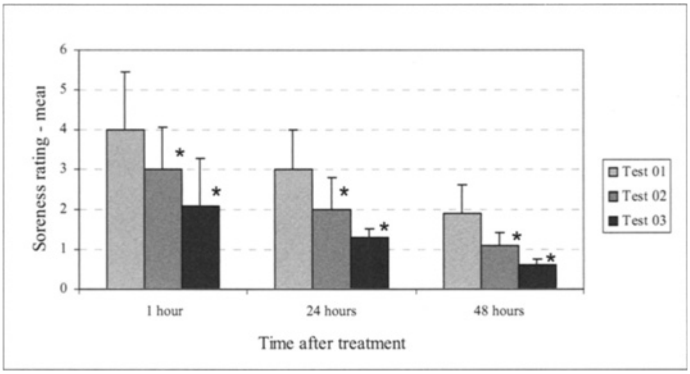

Fig. 3. Mean soreness rating for shin, calf, quadriceps and hamstring (*significant, $p<0.05$)

4 Discussion

Analysis of the shuttle run heart rate data shows that good consistency was maintained throughout the trials in terms of duration and effort of each shuttle component. The relative changes in the remaining data can therefore be considered reliable.

During the IPC treatment session, heart rate and blood pressure were both lower compared to the no treatment condition. It is interesting to note however that both the low and high pressure values are similar. This could suggest that only a low pressure is necessary to reduce cardiac work, however, further inspection of the equipment highlights a more likely explanation. The low pressure IPC pump applied pressure to both legs simultaneously whereas the high pressure pump compressed each leg in turn. This may have resulted in a lower net effect with the leg under high pressure and the leg receiving no pressure forming a lower equilibrium comparable to the lower pressure treatment. This factor does not seem to have had an effect on the performance and soreness data.

The vertical jump results clearly show a benefit of IPC given the reduction in the performance deficit. This improvement is greatest and reaches significance with the high pressure treatment suggesting that IPC is capable of maintaining performance levels even after high intensity work. The mechanism for this benefit may be explained by the soreness data given that the lowest soreness values were recorded following the high pressure IPC treatment. This reduced soreness may have permitted a more pain free muscle activation in the final vertical jump manoeuvre. Interestingly there is also a reduction in soreness with the lower pressure treatment. This suggests that there may be other mechanisms contributing to the reduced soreness such as the thermal insulation or supportive benefits. In addition to this it is clear that this treatment could be optimised. The pressures applied were in accordance with the manufacturer's instructions and chosen to produce a magnitude of effect in blood dynamics. A program of optimisation may be required to better understand the benefits of increasing pressure and perhaps the application of heat or cold.

We had expected to see some increase in calf or thigh circumference brought on by fluid collecting in the limbs during treatment. We hypothesized that the IPC treatment would abate this swelling. The data suggests however that there is no change. This could be due to insufficient muscle damage taking place, however, it is more likely that the results are due to postural differences. The first measurement was taken on arrival at the test session on a cold muscle whereas the second measurement was taken immediately following 1 hour in the supine position. It may therefore have been more appropriate to take a third measurement between the completion of the shuttle run and prior to the treatment session.

5 Conclusion

This study has shown that IPC provides benefits in terms of abating performance reduction following high intensity exercise and reduces soreness shortly after exercise as well as 48 hours later. This favourably suggests that athletes undertaking IPC as part of their training regime should be able to increase their training volume with a reduced risk of discomfort and injury. Further investigations will be useful in optimising the technology thus increasing the magnitude of these effects.

Acknowledgements

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