
DO COMPRESSION GARMENTS ENHANCE THE ACTIVE RECOVERY PROCESS AFTER HIGH-INTENSITY RUNNING?

DALE I. LOVELL,¹ DALE G. MASON,¹ ELIAS M. DELPHINUS,¹ AND CHRISTOPHER P. McLELLAN²

¹*School of Health and Sport Sciences, Faculty of Science, Health and Education, University of the Sunshine Coast, Maroochydore, Queensland, Australia;* and ²*Faculty of Health Sciences and Medicine, Bond University, Gold Coast, Queensland, Australia*

ABSTRACT

Lovell, DI, Mason, DG, Delphinus, EM, and McLellan, CP. Do compression garments enhance the active recovery process after high-intensity running? *J Strength Cond Res* 25(12): 3264–3268, 2011—This study examined the effect of wearing waist-to-ankle compression garments (CGs) on active recovery after moderate- and high-intensity submaximal treadmill running. Twenty-five male semiprofessional rugby league players performed two 30-minute treadmill runs comprising of six 5-minute stages at 6 km·h⁻¹, 10 km·h⁻¹, approximately 85% $\dot{V}O_{2max}$, 6 km·h⁻¹ as a recovery stage followed by approximately 85% $\dot{V}O_{2max}$ and 6 km·h⁻¹ wearing either CGs or regular running shorts in a randomized counterbalanced order with each person acting as his own control. All stages were followed by 30 seconds of rest during which a blood sample was collected to determine blood pH and blood lactate concentration [La⁻]. Expired gases and heart rate (HR) were measured during the submaximal treadmill tests to determine metabolic variables with the average of the last 2 minutes used for data analysis. The HR and [La⁻] were lower ($p \leq 0.05$) after the first and second 6 km·h⁻¹ recovery bouts when wearing CGs compared with when wearing running shorts. The respiratory exchange ratio (RER) was higher and [La⁻] lower ($p \leq 0.05$) after the 10 km·h⁻¹ stage, and only RER was higher after both 85% $\dot{V}O_{2max}$ stages when wearing CGs compared with when wearing running shorts. There was no difference in blood pH at any exercise stage when wearing the CGs and running shorts. The results of this study indicate that the wearing of CGs may augment the active recovery process in reducing [La⁻] and HR after high-intensity exercise but not effect blood pH. The ability to reduce [La⁻] and HR has important consequences for many sports that are intermittent in nature and consist of repeated

bouts of high-intensity exercise interspersed with periods of low-intensity exercise or recovery.

KEY WORDS compression stockings, lactate, intermittent exercise

INTRODUCTION

Many sports involve periods of high-intensity exercise interspersed with periods of low-intensity exercise or recovery. It is during the periods of low-intensity exercise that athletes look to maximize their recovery, in particular by reducing blood lactate concentration [La⁻] and blood pH, which has been shown to affect subsequent performance (8,16). Various methods have been implemented to facilitate the removal of lactate during recovery such as active and passive recoveries (15,23), massage (24), ergogenic aids (6), and cold water immersion therapy (31). More recently, the wearing of compression garments (CGs) has been suggested as a possible method that may aid in an athlete's recovery after high-intensity training and competition (11,22).

Although CGs have been used clinically for years in the treatment and therapy of a number of pathological conditions (26), it is only recently that the potential benefit of CGs in enhancing sports performance has been recognized (7,21,22). One possible benefit for enhancing performance is the increased venous return from the compression of superficial veins and improved capillary filtration, which may reduce venous pooling in the lower limbs during and after exercise (25,26). This is achieved by applying a pressure gradient which is the highest in the ankle region and lowest in the upper thigh. As a result, the increase in blood flow is thought to aid in the removal of waste products and allow a quicker return to blood gas homeostasis (11).

Despite the increased use of CGs as a method of recovery (2), previous studies have produced conflicting results regarding the potential benefit of CGs during exercise and recovery (1,4,5,11,13,14,21). One of the earliest studies (4) to compare the effect of CGs on postexercise [La⁻] found no difference in [La⁻] after 3 minutes of high-intensity treadmill running with and without CGs. However, technological advances in the

Address correspondence to Dale I. Lovell, dlovell@usc.edu.au
25(12)/3264–3268

Journal of Strength and Conditioning Research
© 2011 National Strength and Conditioning Association

3264 ^JJournal of Strength and Conditioning Research™

materials used in the manufacture of CGs may provide more optimal compression and more measurable positive benefits than earlier CGs (22). More recently, CGs worn during 40 minutes of treadmill running (80% maximal oxygen uptake) by elite runners also produced no change in $[La^-]$ compared with control values despite participants being blinded as to whether they were wearing the control (no pressure), low pressure, or high pressure CG (1). However, $[La^-]$ produced during the treadmill test only reached maximal values of 3.9 ± 1.4 mmol·L⁻¹, which may not have been sufficiently high for the CGs to have a positive effect on $[La^-]$. Other studies (5,10) that have found reduced $[La^-]$ postexercise have used a variety of recovery methods in conjunction with the CGs that may have confounded the results. The effect of wearing CGs on postexercise recovery and $[La^-]$ remains unclear. The use of CGs during recovery may assist in reducing edema and enhancing venous return during active recovery (22). This may in return help reduce $[La^-]$ and the heart rate (HR) during the recovery process. We therefore hypothesized that the use of CGs in conjunction with active recovery would enhance the “muscle pump” allowing blood to return to the heart for a greater removal of lactate and lower the HR after high-intensity exercise. Thus, the purpose of this study was to examine the effect of CGs on active postexercise recovery after a bout of high-intensity exercise.

METHODS

Experimental Approach to the Problem

The use of CGs as an aid to sporting performance has become increasingly popular in recent years. However, despite their widespread use, there is little evidence regarding the ability of CGs to reduce $[La^-]$ and blood pH during active recovery and enhance subsequent performance between bouts of high-intensity running. This study examined the physiological effects of wearing CGs and a control condition in which regular running shorts were worn on moderate- and high-intensity treadmill running before and after active (walking) recovery. Elite semiprofessional rugby players who encounter similar high-intensity exercise and recovery periods during competitive match play were used in this study. Selected physiologically dependent measures that included HR, $\dot{V}O_2$, respiratory exchange ratio (RER), $[La^-]$, and blood pH were recorded and analyzed to determine the effect of wearing CGs. These results were then compared with those of the control condition of wearing regular running shorts. Based on the findings of previous studies (5,10), it was hypothesized that wearing CGs would enhance the active recovery process and result in lower HR, $[La^-]$, and blood pH during recovery.

Subjects

Twenty-six semiprofessional rugby league players with a mean \pm SD age 21.6 ± 2.5 years, height 182.2 ± 6.1 cm, and weight 92.6 ± 7.7 kg had the experimental risks of the study explained to them and subsequently gave written

informed consent to participate. Ethics approval was granted by The University of the Sunshine Coast Ethics Committee. The players had participated in rugby league for 13.3 ± 3.3 years and regularly performed 3–5 training sessions per week consisting of aerobic interval, anaerobic interval, resistance training, and team skills training. Testing took place after preseason training and before the commencement of regular match competition.

Procedures

Participants attended 3 testing sessions separated by 7 days and were advised to avoid exercise and the consumption of alcohol 24 hours before testing and to avoid food and caffeine 3 hours before testing. A food and training log was kept by participants 24 hours before testing for compliance and to ensure a similar routine before the subsequent testing session. The study comprised a randomized counterbalanced within-study design with each participant acting as his control, and involving a test session with regular running shorts and with lower body CGs during exercise and recovery.

Waist-to-ankle CGs (Body Science, Gold Coast, Australia) with decreasing pressure from the ankle to the hips were individually fitted to each participant to ensure that the correct pressure was applied to the lower body in accordance with the manufacturer’s recommendations (Figure 1). A pressure bladder (Kikuhime BG3792, Advancis Medical, Nottingham, United Kingdom) was placed beneath the skin and the CG at the ankle and calf with the pressure measurement taken in



Figure 1. Waist-to-ankle compression garments used by participants in the study.

TABLE 1. Heart rate (HR), $\dot{V}O_2$, \dot{V}_E , RER and $[La^-]$ measured during each 5-minute stage at different exercise intensities.*†

	Exercise intensity					
	6 km·h ⁻¹	10 km·h ⁻¹	85% $\dot{V}O_2$ max	6 km·h ⁻¹	85% $\dot{V}O_2$ max	6 km·h ⁻¹
Heart rate (b·min ⁻¹)						
CG	99 ± 9	145 ± 12	170 ± 10	112 ± 8‡	174 ± 12	114 ± 7‡
Running shorts	99 ± 9	146 ± 13	170 ± 9	116 ± 8	176 ± 10	119 ± 8
$\dot{V}O_2$ (L·min ⁻¹)						
CG	15.84 ± 0.94	33.47 ± 2.95	42.72 ± 3.64	16.69 ± 2.15	43.92 ± 4.12	17.02 ± 2.35
Running shorts	15.83 ± 1.19	33.66 ± 2.67	42.37 ± 3.26	16.20 ± 1.18	43.65 ± 3.84	16.67 ± 2.23
\dot{V}_E (L·min ⁻¹)						
CG	32.06 ± 4.45	72.70 ± 11.86	104.91 ± 15.79	39.45 ± 6.22	107.63 ± 16.42	41.32 ± 6.88
Running shorts	32.59 ± 4.94	74.35 ± 13.78	105.83 ± 20.23	39.48 ± 6.23	108.25 ± 18.95	40.54 ± 6.54
RER						
CG	0.90 ± 0.04	0.98 ± 0.03§	1.05 ± 0.04§	0.95 ± 0.04	1.07 ± 0.04§	0.97 ± 0.05
Running shorts	0.87 ± 0.04	0.96 ± 0.03	1.03 ± 0.04	0.95 ± 0.05	1.04 ± 0.03	0.96 ± 0.04
$[La^-]$ (mmol·L ⁻¹)						
CG	1.5 ± 0.5	2.7 ± 0.7‡	6.0 ± 1.4	3.0 ± 1.0‡	6.8 ± 1.5	3.2 ± 1.2‡
Running shorts	1.7 ± 0.6	3.0 ± 0.7	6.0 ± 1.4	3.6 ± 0.9	6.6 ± 1.6	3.9 ± 1.0
Blood pH						
CG	7.401 ± 0.003	7.366 ± 0.004	7.255 ± 0.005	7.164 ± 0.006	7.194 ± 0.007	7.114 ± 0.007
Running shorts	7.397 ± 0.004	7.352 ± 0.007	7.268 ± 0.006	7.152 ± 0.006	7.201 ± 0.005	7.125 ± 0.005

*CG = compression garment; RER = respiratory exchange ratio; $\dot{V}O_2$ = oxygen uptake; \dot{V}_E = ventilation; $[La^-]$ = lactate concentration.

†Values are mean ± SD.

‡p < 0.05, lower than when wearing running shorts.

§p < 0.05, higher than when wearing running shorts.

the standing position. This procedure was repeated at the end of the submaximal treadmill testing to ensure that no change in pressure occurred during the exercise bout.

Physiological Testing

The first session involved participants performing a graded exercise test on a treadmill (Woodway, Waukesha, WI, USA) to determine their cardiovascular fitness ($\dot{V}O_2$ max). The initial speed was set at 8 km·h⁻¹, and the speed increased by 1 km·h⁻¹ every 1 minute until 14 km·h⁻¹ with the grade increasing thereafter until exhaustion.

Cardiorespiratory-metabolic variables were measured using open circuit spirometry (Parvo-Medics TrueOne® 2400 Metabolic Measurement System, Sandy, UT, USA). The HR was measured via an HR monitor (Polar S610 HR Monitor, Polar Electro Oy, Kempele, Finland) strapped against the participant’s chest. During the progressive exercise test, each participant was encouraged to give a maximal effort. Maximal values for oxygen consumption were calculated from the average of the last minute of exercise before volitional fatigue. $\dot{V}O_2$ max was confirmed when 3 or more of the following criteria were met: (a) a plateau in $\dot{V}O_2$ despite an increase in running intensity; (b) an RER > 1.20; (c) an HR within 10 b·min⁻¹ of its predicted maximum; (d) a lactate concentration >10 m·mol·L⁻¹.

The second and third tests involved participants completing a 6-stage submaximal treadmill test, which consisted of 5-minute stages at 6 km·h⁻¹, 10 km·h⁻¹, approximately 85% of $\dot{V}O_2$ max, and 6 km·h⁻¹ as a recovery stage followed by approximately 85% $\dot{V}O_2$ max and 6 km·h⁻¹. All stages were followed by 30 seconds of rest during which 80 µL of blood was taken from the fingertip for subsequent analysis. The first 75 µL of blood was used to determine blood pH (Radiometer ABL 80, Melbourne, Australia) with the remainder of the blood used to determine $[La^-]$ (Lactate Pro, Arkray, Japan). Expired gases and HR were measured during the submaximal treadmill tests to determine metabolic variables with the average of the last 2 minutes of the 5-minute stages averaged and used for data analysis. Participants completed 1 test wearing the CGs and the other test wearing their normal playing shorts.

Statistical Analyses

The Statistical Package for the Social Sciences (SPSS Version 17.0) was used for all analyses. Based on previous research (1,11,22) and data from our laboratory involving CGs and exercise, a minimum sample size of 22 was established to achieve a statistical power of 90%. For dependent variables used in this study, the intraclass correlation coefficient was $R \geq 0.89$. A paired t-test was used to determine differences in physiological variables between the conditions (CGs vs. no CGs) at each stage

of the treadmill exercise with the significance level set at $p \leq 0.05$. Data are reported as means and *SDs* ($M \pm SD$).

RESULTS

Of the 26 participants who began the study, 1 withdrew because of injury occurring during match play unrelated to this study. The participants were individually fitted with CGs to ensure that the level of compression was within the manufacturer's recommendations. The average compression was 20 ± 2 mm Hg at the ankle and 15 ± 2 mm Hg at the calf.

There was no difference between CGs and running shorts for any physiological measures after the first 5 minutes of treadmill walking at $6 \text{ km}\cdot\text{h}^{-1}$. After the next 5 minutes of treadmill running at $10 \text{ km}\cdot\text{h}^{-1}$, RER values were higher and $[\text{La}^-]$ lower ($p < 0.05$) when wearing CGs compared with when wearing running shorts. After both 5-minute treadmill runs at 85% of $\dot{V}\text{O}_2\text{max}$, RER values were higher ($p < 0.05$) when wearing CGs compared with when wearing running shorts. At the completion of the first and second recovery stages at $6 \text{ km}\cdot\text{h}^{-1}$, HR ($p < 0.05$) and $[\text{La}^-]$ ($p < 0.05$) were lower when wearing CGs compared with when wearing running shorts (Table 1). There was no difference in blood pH when wearing CGs compared with when wearing running shorts, at any stage of the treadmill exercise.

DISCUSSION

The main finding of this study was that $[\text{La}^-]$ and HR were lower when wearing CGs during active recovery after a bout of high-intensity running compared with values obtained when wearing regular running shorts. Additionally, CGs reduced $[\text{La}^-]$ at $10 \text{ km}\cdot\text{h}^{-1}$ during submaximal treadmill running compared with when wearing running shorts. The ability to reduce $[\text{La}^-]$ has important consequences for many sports that are intermittent in nature and consist of repeated bouts of high-intensity exercise interspersed with periods of low-intensity exercise or recovery.

Although some studies (5,10) have reported lower $[\text{La}^-]$ when comparing CGs with running shorts after exercise, most have reported no change in $[\text{La}^-]$ immediately after high-intensity treadmill running (1,30), simulated game conditions (19), and high-intensity shuttle tests (20). Equally, we found no significant difference in $[\text{La}^-]$ immediately after high-intensity treadmill running ($\sim 85\% \dot{V}\text{O}_2\text{max}$) but did find lower $[\text{La}^-]$ after active recovery when wearing CGs. However, the lower $[\text{La}^-]$ was not associated with any difference in blood pH between wearing CGs and running shorts (Table 1). Although traditionally lactate was thought to be the primary cause of metabolic acidosis, recent evidence has suggested that changes in blood pH are because of other metabolic by-products and not because of changes in $[\text{La}^-]$ (27). The lack of association between blood pH and $[\text{La}^-]$ may explain the differences found in this study.

The results of this study indicate that the wearing of CGs may assist the active recovery process in reducing $[\text{La}^-]$ after high-intensity exercise. The skeletal muscle pump during active

recovery has been shown to facilitate the return of blood from the lower extremities by rhythmic muscle contractions creating intramuscular pressure oscillations, which increase blood flow and venous return (28). The specific design of the CGs used in this study may have also assisted in the pushing of edema from the damaged muscle tissue back into circulation, increasing the returning blood flow (22). The increased blood flow is believed to enhance the removal of lactate from the exercising muscle allowing a faster redistribution to alternative metabolism sites such as the liver, heart, and nonworking muscles (3) and increase CO_2 delivery to the lungs (12). The high-intensity exercise bout in this study produced RER values > 1.0 indicating a greater contribution of lactate buffering to the CO_2 being expelled from the lungs. This view is supported by the $[\text{La}^-]$ measured during the high-intensity bout ($> 6.0 \text{ mmol}\cdot\text{L}^{-1}$). Interestingly, RER values measured during the $10 \text{ km}\cdot\text{h}^{-1}$ and 85% $\dot{V}\text{O}_2\text{max}$ treadmill run were higher in participants wearing CGs compared with in those wearing running shorts, suggesting a greater release of CO_2 from the buffering of lactate while wearing CGs. Although there was no difference in $[\text{La}^-]$ at 85% $\dot{V}\text{O}_2\text{max}$ between wearing CGs and wearing running shorts, during the $10 \text{ km}\cdot\text{h}^{-1}$ treadmill run, participants wearing the CGs had lower $[\text{La}^-]$. Plasma $[\text{La}^-]$ has been shown to be the most significant determinant of RER at submaximal workloads similar to the $10 \text{ km}\cdot\text{h}^{-1}$ used in this study (17). Possibly, the lack of difference in $[\text{La}^-]$ at 85% $\dot{V}\text{O}_2\text{max}$ may have been because of the higher concentration of lactate masking the effectiveness of CGs at the higher intensity. However, there was no difference in RER during the active recovery despite there being lower $[\text{La}^-]$ in participants wearing the CGs, indicating a delay in the relationship between $[\text{La}^-]$ and metabolic measurements from expired gases. Previous studies (18,29) have also reported a delay in the adjustments in CO_2 balance, which may in turn take the RER several minutes to reach baseline values during recovery. Therefore, the higher RER values found for the participants wearing CGs in this study during the high-intensity treadmill run may have influenced their lower $[\text{La}^-]$ during the recovery process.

The HR was also lower when wearing CGs during active recovery compared with that when wearing running shorts. This may have been because of the augmented skeletal muscle pump and increased venous return previously mentioned, lowering HR during the active recovery. The changes in HR and subsequent cardiac output seen during recovery from exercise have been shown to be primarily because of the muscle pump maintaining central blood volume and not because of central command (9). Therefore, the combined effect of lower limb compression and the skeletal pump during active recovery appears to result in a lower HR during recovery when wearing CGs.

In conclusion $[\text{La}^-]$ and HR are lower when wearing CGs during active recovery after a bout of high-intensity treadmill running compared with when wearing regular running shorts. This is thought to be because of CGs assisting the muscle pump associated with active recovery and enhancing blood

flow and venous return. The RER values measured during the 10 km·h⁻¹ and 85% $\dot{V}O_2$ max treadmill run were higher in participants wearing CGs compared with when wearing running shorts, suggesting a greater release of CO₂ from the buffering of lactate while wearing CGs.

PRACTICAL APPLICATIONS

The practical applications of this study demonstrate the efficacy of wearing a waist-to-ankle CG during active recovery between bouts of high-intensity running. Reductions in blood lactate and HR during active recovery may assist in the recovery of an athlete in the preparation for their next bout of high-intensity exercise. Coaches and athletes associated with sports that involve high-intensity intermittent exercise may use CGs to assist in their recovery process and therefore improve subsequent performance.

ACKNOWLEDGMENTS

The authors would like to thank Body Science (Gold Coast, Australia) for providing the CGs used by the participants. They would also like to thank the Sunshine Coast Sea Eagles Rugby League Team and their players for their participation. The authors declare that they have no conflicts of interest.

REFERENCES

1. Ali, A, Creasy, RH, and Edge, JA. Physiological effects of wearing graduated compression stockings during running. *Eur J Appl Physiol* 109: 1017–1025, 2010.
2. Barnett, A. Using recovery modalities between training sessions in elite athletes: Does it help? *Sports Med* 36: 781–796, 2006.
3. Belcastro, AN and Bonen, A. Lactic acid removal rates during controlled and uncontrolled recovery exercise. *J Appl Physiol* 39: 932–936, 1975.
4. Berry, MJ, Bailey, SP, Simpkins, LS, and TeWinkle, JA. The effects of elastic tights on the post-exercise response. *Can J Sport Sci* 15: 244–248, 1990.
5. Berry, MJ and McMurray, RG. Effects of graduated compression stockings on blood lactate following an exhaustive bout of exercise. *Am J Phys Med* 66: 121–132, 1987.
6. Bishop, D, Edge, J, Davis, C, and Goodman, C. Induced metabolic alkalosis affects muscle metabolism and repeated-sprint ability. *Med Sci Sports Exerc* 36: 807–813, 2004.
7. Bringard, A, Perrey, S, and Belluye, N. Aerobic energy cost and sensation responses during submaximal running exercise—Positive effects of wearing compression tights. *Int J Sports Med* 27: 373–378, 2006.
8. Cairns, SP. Lactic acid and exercise performance: Culprit or friend? *Sports Med* 36: 279–291, 2006.
9. Carter, R III, Watenpaugh, DE, Wasmund, WL, Wasmund, SL and Smith, ML. Muscle pump and central command during recovery from exercise in humans. *J Appl Physiol* 87: 1463–1469, 1999.
10. Chatard, JC, Atlaoui, D, Farjanel, J, Louisy, F, Rastel, D, and Guezennec, CY. Elastic stockings, performance and leg pain recovery in 63-year-old sportsmen. *Eur J Appl Physiol* 93: 347–352, 2004.
11. Davies, V, Thompson, KG, and Cooper, SM. The effects of compression garments on recovery. *J Strength Cond Res* 23: 1786–1794, 2009.
12. Del Coso, J, Hamouti, N, Aguado-Jimenez, R, and Mora-Rodriguez, R. Restoration of blood pH between repeated bouts of high-intensity exercise: Effects of various active-recovery protocols. *Eur J Appl Physiol* 108: 523–532, 2010.

13. Duffield, R, Cannon, J, and King, M. The effects of compression garments on recovery of muscle performance following high-intensity sprint and plyometric exercise. *J Sci Med Sport* 13: 136–140, 2010.
14. Duffield, R, Edge, J, Merrells, R, Hawke, E, Barnes, M, Simcock, D, and Gill, N. The effects of compression garments on intermittent exercise performance and recovery on consecutive days. *Int J Sports Physiol Perform* 3: 454–468, 2008.
15. Franchini, E, Yuri Takito, M, Yuzo Nakamura, F, Ayumi Matsushigue, K, and Peduti Dal’Molin Kiss, MA. Effects of recovery type after a judo combat on blood lactate removal and on performance in an intermittent anaerobic task. *J Sports Med Phys Fitness* 43: 424–31, 2003.
16. Glaister, M. Multiple sprint work: Physiological responses, mechanisms of fatigue and the influence of aerobic fitness. *Sports Med* 35: 757–777, 2005.
17. Goedecke, JH, St Clair Gibson, A, Grobler, L, Collins, M, Noakes, TD, and Lambert, EV. Determinants of the variability in respiratory exchange ratio at rest and during exercise in trained athletes. *Am J Physiol Endocrinol Metab* 279: E1325–E1334, 2000.
18. Hagberg, JM, Hickson, RC, Ehsani, AA, and Holloszy, JO. Faster adjustment to and recovery from submaximal exercise in the trained state. *J Appl Physiol* 48: 218–224, 1980.
19. Higgins, T, Naughton, GA, and Burgess, D. Effects of wearing compression garments on physiological and performance measures in a simulated game-specific circuit for netball. *J Sci Med Sport* 12: 223–226, 2009.
20. Houghton, LA, Dawson, B, and Maloney, SK. Effects of wearing compression garments on thermoregulation during simulated team sport activity in temperate environmental conditions. *J Sci Med Sport* 12: 303–309, 2009.
21. Kemmler, W, von Stengel, S, Kockritz, C, Mayhew, J, Wassermann, A, and Zapf, J. Effect of compression stockings on running performance in men runners. *J Strength Cond Res* 23: 101–105, 2009.
22. Kraemer, WJ, Flanagan, SD, Comstock, BA, Fragala, MS, Earp, JE, Dunn-Lewis, C, Ho, JY, Thomas, GA, Solomon-Hill, G, Penwell, ZR, Powell, MD, Wolf, MR, Volek, JS, Denegar, CR, and Maresh, CM. Effects of a whole body compression garment on markers of recovery after a heavy resistance workout in men and women. *J Strength Cond Res* 24: 804–814, 2010.
23. Monedero, J and Donne, B. Effect of recovery interventions on lactate removal and subsequent performance. *Int J Sports Med* 21: 593–597, 2000.
24. Moraska, A. Sports massage. A comprehensive review. *J Sports Med Phys Fitness* 45: 370–380, 2005.
25. O’Donnell, TF Jr, Rosenthal, DA, Callow, AD, and Ledig, BL. Effect of elastic compression on venous hemodynamics in postphlebotic limbs. *J Am Med Assoc* 242: 2766–2768, 1979.
26. Partsch, H and Mosti, G. Thigh compression. *Phlebology* 23: 252–258, 2008.
27. Robergs, RA, Ghiasvand, F, and Parker, D. Biochemistry of exercise-induced metabolic acidosis. *Am J Physiol Regul Integr Comp Physiol* 287: R502–R516, 2004.
28. Rowland, TW. The circulatory response to exercise: Role of the peripheral pump. *Int J Sports Med* 22: 558–565, 2001.
29. Short, KR and Sedlock, DA. Excess postexercise oxygen consumption and recovery rate in trained and untrained subjects. *J Appl Physiol* 83: 153–159, 1997.
30. Sperlich, B, Haegele, M, Achtzehn, S, Linville, J, Holmberg, HC, and Mester, J. Different types of compression clothing do not increase sub-maximal and maximal endurance performance in well-trained athletes. *J Sports Sci* 28: 609–614, 2010.
31. Vaile, J, Halson, S, Gill, N, and Dawson, B. Effect of cold water immersion on repeat cycling performance and thermoregulation in the heat. *J Sports Sci* 26: 431–440, 2008.