ARE COMPRESSION GARMENTS BENEFICIAL FOR ENDURANCE RUNNERS?

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Learning Objective

To understand the efficacy of compression garments on endurance running performance and recovery.

Key words: Compression Stockings, Endurance Running, Performance, Recovery Modality, Marathon, Trail Running

INTRODUCTION

During the past few decades, ultraendurance events, particularly ultramarathons, have become increasingly more popular throughout the world (17,18). Ultramarathons are considered any race longer than the standard marathon distance of 42.2 km (4), including both trail and road events. The sheer volume of training and duration associated with ultramarathon events place significant physiological and mechanical stress on the body, ultimately resulting in neuromuscular fatigue (5,27). Thus, it seems advantageous for runners to use a strategy that helps limit neuromuscular fatigue and aids in recovery between training sessions to increase maximal performance capability. Compression garments (CGs) might be the answer runners are looking for because of cost-effectiveness and an easy-to-use approach. Some CG manufacturers claim that the garments improve performance, circulation, energy, and recovery, together with decreasing soreness and swelling (2,30). If CGs live up to manufacturer claims, the information could be used by endurance athletes, strength and conditioning specialists, and the health and fitness industry to construct training programs aimed at enhancing endurance running.

Photo courtesy of Rachel Dorie.

More and more runners are starting to use CGs not only to increase performance but also to decrease recovery time between exercise sessions (12,24,35,36). The rise in popularity of CGs among runners can be attributed in part to the numerous advertising claims. Claims made by manufacturers can be very appealing to endurance athletes, especially runners, who are constantly training and searching for ways to improve aerobic efficacy. If runners believe that CGs augment the ability to train, reduce recovery time, and may improve performance, runners will start adapting methodologies that incorporate the use of CGs. However, scientific research involving ultraendurance events, focusing on CGs and performance, is lacking and warrants further investigation.

Originally designed for treatment of populations suffering from deep vein thrombosis (29) and venous return insufficiency (34), CGs have now evolved from the medical setting into the recreation and athletic setting. CGs now come in all shapes and sizes and vary in functions — from keeping an individual warm to providing joint stability. Specifically, in running, lower-body CGs such as compression knee high socks, shorts, and tights are the most common types of CGs being used (6,33). CGs are designed to exert an external pressure on the body, either consistently, as with standard CGs, or gradually with varying levels of compression. Graduated CGs produce the greatest pressure at the ankle, dissipating pressure toward the calf. This graduated pressure helps with reducing blood pooling and enhances blood return toward the heart (28) and has been proposed as one of the main physiological adaptation mechanisms associated with CGs (1,8,23). The enhanced blood return may increase end-diastolic volume, resulting in an improved cardiac output (7,35). Using a CG could essentially increase the efficacy of the skeletal muscle pump, causing a decreased heart rate at the same intensity level.

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Clinical trials recommend compression starting at 20 mmHg at the ankle that decreases to 10 mmHg toward the knee (23). Considering that this is the recommendation for individuals with compromised skeletal muscle pumps, this pressure may not be appropriate for healthy individuals and caution is warranted. Ali et al. (2) compared various grades of CGs on running performance. The results of the study indicated that a high-grade (23 to 32 mmHg) CG was significantly tighter and more pain inducing than the control (0 mmHg) and the low (12 to 15 mmHg) CG.

It is important to note that CGs produce a localized effect on the musculature they are compressing. Although many different types of CGs are available, there is a dearth in the amount of research indicating one type of garment to be better than another, and the possible influences of greater body coverage seem unknown despite being of great importance (25).

EFFICACY OF COMPRESSION GARMENTS ON PERFORMANCE

Aerobic Exercise

As noted earlier, many runners use CGs during ultramarathon events (12,24,36), but the research involving CGs and running events of this duration is minimal. Therefore, extrapolating information on the efficacy of CGs and performance from studies involving shorter durations should be done with caution.

Kemmler et al. (19) conducted a randomized crossover study to determine the effect of CGs on running performance. Subjects completed a stepwise speed-incremented treadmill test to voluntary maximum termination with or without CGs for a time under load of more than 30 minutes. A second treadmill test was completed within 10 days of recovery. The researchers reported that the CGs significantly increased time under load and total work performed together with an increased running performance at anaerobic and aerobic threshold. No difference was seen between heart rate, $\dot{V}O_{2max}$, or pulmonary ventilation. The authors concluded that the increase in performance may be attributed to a higher mechanical efficiency possibly via the mechanism of a reduction in muscle oscillation brought on by the CGs. It has been suggested that the reduced muscle oscillation promoted by CGs may optimize the contraction direction of muscle fibers, producing an increased mechanical efficiency during exercise (8).

Varela-Sanz et al. (35) reported an increase of 13% in time to exhaustion while running at competition pace with CGs, together with a tendency for $\dot{V}O_{2peak}$ to be lower in the CG group; however, these results were nonsignificant. It should be noted that the relatively small sample size, six subjects in each group matched by $\dot{V}O_{2max}$, may partially explain the nonsignificant findings. In addition to the nonsignificant increase in run time and lowered $\dot{V}O_{2peak}$, the CG group experienced a significantly lower percentage of maximal heart rate during the test when compared with the control group. One explanation for the decreased heart rate for the CG group involves the Frank Starling mechanism, the ability of the heart to change stroke volume based on venous return (26), another potential mechanism by which CGs may be efficacious.

Conversely, numerous studies involving CGs have found little or no impact on performance measures for aerobic exercise.

TABLE: Published Research on the Efficacy of CGs on Running Performance

Author (Year)	CG Type	Applied Pressure, mmHg	Exercise Protocol	Performance Measure	Effect of CG
Ali et al. (2010)	CGS (knee length); 3 types: control, low, high pressure	Control: 4 ankle, 4 calf; low: 11 ankle, 8 calf; high: 26 ankle, 15 calf	40-minute run at 80% $\dot{V}O_{2max}$	$\dot{V}O_2$	↔
				HR	↔
				Blood lactate	↔
				RPE	↔
Ali et al. (2011)	CGS (knee length); 4 types: control, low, medium, high pressure	Control: 0 ankle, 0 knee; low: 15 ankle, 12 knee; medium: 21 ankle, 18 knee; high: 32 ankle, 23 knee	4 10km time trials	Run duration	↔
				CMJ	
				-Low	↑
				-Medium	↑
				-High	↔
				HR	↔
Goh et al. (2011)	Compression tights	~14 calf, ~9 thigh	4 20 min runs at VT followed by run to exhaustion at $\dot{V}O_{2max}$ in cold and hot environments	Time to fatigue	
				-Cold	↔
				-Hot	↔
				RPE	
				-Cold	↔
				-Hot	↓
				$\dot{V}O_2$	↔
Kemmler et al. (2009)	CGS (knee length)	24 ankle, 18 to 20 calf	Stepwise treadmill test to exhaustion	Time to fatigue	↑
				Total work	↑
				Performance at AnT	↑
				Performance at AT	↑
				HR, $\dot{V}O_2$, V_E	↔
Rider et al. (2014)	CGS (knee length)	20 ankle, 15 calf	Maximal treadmill test (3-minute stages)	Time to fatigue	↓
				Blood lactate	↓
				HR, RPE, $\dot{V}O_{2max}$	↔
Varela-Sanz et al. (2011)	CGS (knee length)	15 to 22 ankle dissipating to calf	Time limit test at 105% of recent 10-km pace	Time to fatigue	↔
				% of HR_{max}	↓
				$\dot{V}O_{2peak}$	↔
				RPE	↔
Vercruyssen et al. (2014)	CGS (knee length)	18 ankle, 18 calf	15.6-km trail run at competitive pace	Run duration	↔
				CMJ	↔
				MVC	↔
				HR, blood lactate	↔

AnT, anaerobic threshold; AT, aerobic threshold; CGS, compression garment stockings; CMJ, countermovement jump; HR, heart rate; MVC, maximal voluntary contraction; RPE, rating of perceived exertion; V_E, minute ventilation; $\dot{V}O_2$, oxygen uptake; $\dot{V}O_{2max}$, maximal $\dot{V}O_2$; $\dot{V}O_{2peak}$, peak $\dot{V}O_2$; VT, ventilatory threshold; ↑ indicates significantly higher than the control condition; ↓ indicates significantly lower than the control condition; ↔ indicates not significantly different from the control condition; ~ indicates approximately.

Vercruyssen et al. (36) examined the effects of CGs on performance during a 15.6-km trail run at competition pace involving 11 trained runners; the use of CGs had no effect on physiological variables and performance indicators after prolonged exercise. This finding is consistent with other studies (2,3,14,28). The Table provides an overview of the studies discussed in this section. The potential for a long-term study involving an adaptation period with CGs could yield additional mechanisms by which the cardiovascular system produces favorable results for runners.

Anaerobic Exercise

As with endurance athletes, anaerobic athletes are using CGs in hopes to decrease sprint times, improve jumping performance, or increase muscular strength while resistance training. Jumping and other explosive exercises have been shown to improve with CGs (12,21,22). Increases in performance have been partly attributed to mechanisms such as increased proprioception, improved warm-up because of an increased skin temperature, and a reduction in muscle oscillation (12). Power lifters use compression bench shirts during training and competition to overload and aid in developing muscular strength. It has been reported that the compression bench shirt provides a more efficient bar path, decreases the force on the shoulders, and increases the load capability when compared with no shirt trials (31). Taking this information together, the results suggest that CGs may provide a performance enhancement during anaerobic exercise while simultaneously decreasing the risk of injury by adding stability to joints and decreasing fatigue attributed to muscle oscillation.

Photo courtesy of Rachel Dorie.

COMPRESSION GARMENTS AS A RECOVERY MODALITY

Performance is an important aspect for any individual, but CGs also have been used as a recovery modality (12,20,24). The purpose of a recovery modality is to limit the magnitude and duration of exercise-induced muscle damage (EIMD) that correlates with exercise and training. Endurance running frequently results in EIMD as a consequence of long duration and repetitive eccentric contractions (9). With an eccentric contraction, the muscle elongates while under tension, resulting in damage to the sarcomeres, particularly z-line streaming, leading to an inflammatory response as a result of the mechanical damage (10). Symptoms of EIMD include an increased feeling of soreness, temporary decline in muscular strength and power, reduced range of motion, and increases of intracellular proteins, such as creatine kinase (9). Symptoms associated with EIMD can be problematic for runners attempting to increase exercise volume (running distance or time) and can negatively affect overall training (11,16); this is especially true for endurance runners. The purpose of using CGs after an exercise bout is to shorten recovery time so that subsequent exercise sessions can occur sooner (24). Information pertaining to the possible mechanisms involved in the efficacy of CGs on recovery, in an athletic setting, is limited. Research suggests that CGs worn as a recovery modality reduced perceived muscle soreness (15,24), reduced muscle swelling because of the external pressure gradient (11), and increased removal of metabolic by-products via the enhanced skeletal muscle pump as described earlier (1,11).

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Hill et al. (16) conducted a randomized study to evaluate lower-body CGs on recovery after a self-paced marathon run by studying 7 females and 17 males who either wore CG tights for 72 hours postmarathon or received sham ultrasound treatment for 15 minutes postmarathon in which the machine was turned off. The researchers reported that subjects in the CG group experienced less muscle soreness 24 hours after the marathon when compared with the control group. The authors also reported a tendency for enhanced recovery of maximal voluntary isometric contraction and a reduction of creatine kinase in the CG group. Fletcher et al. (13) evaluated the effect of CG socks on lower-leg muscle swelling and soreness after a 2-hour run in 16 recreational runners. The runners completed the 2-hour run while wearing CG socks or pantyhose during the run and for 8 hours after exercise. The authors noted a decrease in lower-extremity volume measurements and limited muscle soreness 24 hours after exercise in the CG group. However, no statistical differences existed between the conditions. Thus, CGs worn for 24 hours postmarathon running might help in alleviating muscle soreness brought on by EIMD.

In a recent meta-analysis examining CGs across all forms of exercise, Hill et al. (15) concluded that CGs worn after, or during

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and after exercise, moderately reduce reductions in strength and power, moderately reduce the severity of muscle soreness, and diminish concentrations of creatine kinase in the serum. The meta-analysis consisted of 12 studies, ranging from repetitive arm curls to 30 minutes of downhill walking. The implications from this analysis, although not directly related to endurance running, are significant and further justify reasons to explore CGs as a recovery modality within endurance events. Future studies by health and fitness experts could add to the understanding of correct application length and pressure when CGs are used as a recovery modality after exercise.

CONFOUNDING VARIABLES

Most studies on CGs and endurance running are conducted in laboratory settings, focusing on time to exhaustion, and do not fully meet the exercise duration seen with ultramarathon or marathon events, thus making it difficult to assess the efficacy of CGs in a field setting (36). Furthermore, studies of high quality implement different testing protocols, which effectively produce different mechanical stresses, additionally adding to the inconsistencies. In conjunction with a lack of field studies and different exercise protocols, one confounding variable is the type or brand of CG being used. With vast CG types available (full body, socks, tights,

Photo courtesy of Comrades Marathon Association.

stockings), it becomes difficult to compare body coverage of one type of CG with another (24,32). Another consideration involves the pressure exerted across the body, which will depend on the sizing, manufacturer, and type of CG used. Such measurements are primarily based on standard measurements such as stature, mass, waist size, calf girth, or shoe size; and therefore, the exact pressure at each area will vary slightly from person to person (15,24). In addition, CG application length, fitness levels, and training duration further obscure comparative information between studies. Lastly, it is not uncommon for the placebo effect to play a factor, given that confounding variables with CGs are difficult to control (1,19).

COMPRESSION GARMENT RECOMMENDATIONS

Based on research, CG prescription for performance should consist of a CG that is comfortable to the individual and is not so tight that it is counterproductive. Values can range from 18 to 26 mmHg at the ankle and dissipate toward the knee. Pressures higher than this amount seem to cause discomfort for certain individuals and are not recommended. The same recommendations apply when using CGs as a recovery modality. The duration of application time can vary, ranging from 2 to 72 hours. Individual ratings after 24 hours of wearing CGs were not significantly different from those in a control group (16); thus, wearing CGs longer than 24 hours after exercise does not seem to provide any extra physiological or perceived benefit.

SUMMARY

Current evidence on the efficacy of CGs in endurance running is inconclusive. Possible mechanisms associated with CGs include an enhanced blood return to the heart, a reduction in muscle oscillation, and increased proprioception during exercise. However, these benefits are primarily localized, and the effects may or may not extend to the whole body. Most studies illustrate a slightly improved endurance performance in addition to improving various anaerobic performance aspects. Studies also have suggested favorable results when CGs are used as a recovery modality after exercise that elicits muscle damage. Although limitations exist in the current body of evidence, there is little to suggest that CGs hinder or have detrimental side effects on running performance or recovery. To best help health and fitness experts make comparisons and recommendations for athletes, future studies involving CGs should address the type of CG used, how much pressure is exerted across the body, the duration of application, and type of exercise performed. Former winner of the Comrades 90 km/56 mile ultramarathon, 10-time gold medalist, and 17-time silver medalist Shaun Meiklejohn has this to say about compression stockings: "I only started using CGs in recent years, probably after completing 22 Comrades Marathons. The benefit I feel that I have enjoyed has definitely been less pain experienced during Comrades and a quicker recovery after the event as well. I have been amazed at how my legs have been 'saved' immediately after removing the socks, especially after the 'down' Comrades event" (personal communication, March 26, 2015). It is important to understand that endurance runners choose to wear CGs, and this illustrates that these athletes place extensive faith in the fact that CGs will help performance. As the utilization of CGs increases and the technology improves, the efficacy and physiological benefits of CGs may become more evident.

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BRIDGING THE GAP

The use of compression garments in endurance events is increasing. Equivocal evidence exists when examining compression garments and aerobic performance. Utilization of compression garments as a recovery modality may reduce symptoms associated with exercise-induced muscle damage and may decrease recovery time between exercise bouts, allowing endurance runners to train more effectively.