WHY ELITE ATHLETES NEED CUSTOM-FIT COMPRESSION

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Introduction

Despite being widely used by athletes at all levels, there is still considerable debate about how compression physiologically impacts the body, and if it makes any difference to athletic performance. This paper aims to provide the facts on professional remedial compression by describing how pressure garments can augment physiological performance, and by how much. It also provides guidelines on how elite athletes should choose their compression garments.

Impact on physiology

There has been considerable research into the effects of pressure on the human body. The Aerospace Industry, for example, have been intensely interested in this area for decades because of the range of pressures that pilots and astronauts are exposed to (and potentially exposed to) through their operating environments or their tight suits. The Medical Industry has a substantial interest in compression garments as they are used extensively in the treatment of burns, lymphoedema, circulation insufficiencies etc. Of course the Sports Industry has also conducted hundreds of studies.

Exposing localised regions of the body to different levels of pressure has been shown to have very significant impacts on the body, both positive and negative. Mild compression has been shown to improve blood flow, allowing for the improved delivery of oxygen and nutrients to muscles, while flushing away metabolic waste products. Mild compression on the skin changes the pressure differential across the walls of the superficial blood vessels, ultimately causing them to expand (known as myogenic vasodilation). This effect can be further increased with larger compression levels as it may cause the central venous pressure at the heart to rise, causing the blood vessels to relax further through a sympathetic nervous response.

Mild compression may improve physiology and performance via other mechanisms. The lymphatic system may be augmented, reducing swelling and oedema in muscles. The nerve cells may be triggered, causing in an increase in proprioceptive feedback and coordinative function. A mechanical support benefit may also be seen, as a reduction in muscle oscillation leads to a reduction in muscle fibre recruitment, energy cost and fatigue, with an increase in movement economy. Other scientists have proposed improved thermal properties in the musculature assist performance, and others refer to psychological impacts. It has been theorised that the garments may also aid performance by providing a passive torque about the joint as the elastic material around the outside of the joint is stretched, but beneficial effects have not been found by increasing the passive torque. Compression garments assist in the recovery of muscle function following exercise through reduction in the magnitude of exercise induced muscle damage. Compression garments have been shown to reduce levels of muscle swelling and creatine kinase (CK) (a marker of muscle damage) during the recovery period from exercise.

If too much compression is applied, intramuscular pressure receptors can be triggered which will lead to the overall constriction of vessels (vasoconstriction), or perhaps the collapse of the vasculature, and the impairment or loss of blood flow. Such occlusion may cause problems such as pain, loss of sensation, or compartment syndrome. It is known that several hours of 30 mmHg over-pressure in passive muscle constitute a compartment syndrome and therefore may risk tissue viability. Exercise improves tolerance by facilitating blood flow and venous return via action of skeletal muscle pumps, perhaps because occlusion of the superficial vessels may shunt blood flow into the deeper musculature where, during exercise, muscle pumps are more effective in the return of blood flow to the heart.

Sizing is Critical

The clear evidence across many industries is that compression can have a profoundly positive impact. Why then is there so much doubt over sports compression garments? The key issue is that off-the shelf compression garments are not accurate enough. Hill et. al. (2015) conducted a landmark UK study into compression by analysing the pressure regime of 3 major, well-known sports compression brands, fitted as per manufacturer recommendations. They found that the size of subjects varied critically within each garment size, and the compression from the different brands varied too. For one brand, subjects of medium sizes had thigh and calf circumferences that ranged from 46.1 to 56.3 and 33.0 to 39.5 cm respectively, leading to compression that ranged from 4 to 16.7 mmHg at the quadriceps and from 10.3 to 25 mmHg at the calf. The compression garments did not meet minimum pressures necessary to elicit physiological response for the thigh for the tested males and females, nor for the calf in females. They also found that some individuals may be receiving excessive compression.

To show that compression works, and that compression regime is critical, used a variety of regimes on a study cohort and identified the sizing of the compression garment influenced performance in a countermovement jump task. Comparing four different sizes (from extra-small to large) to a control condition (loose shorts), the best results were recorded at the compression regime when wearing medium shorts, and the majority had the worst results when wearing small shorts (just one size different), and jumped lower than if they were no compression at all. Many sports studies (including meta-studies, which aggregate the findings from multiple studies) show that compression garments worn during exercise have a negligible effect on performance, but the majority of studies do not measure or even report the compression regime.

Off-the-shelf garments are not accurate enough to reliably impose the appropriate compression regimes, and therefore the results are variable.

Performance Benefits

Studies which have a rigorous measurement or assessment of compression imposed on the body have shown significantly positive effects to repeat sprint performance, strength, endurance and recovery.

Compression has enhanced performance during repeat-sprint and endurance by 1.3 to 5%. On intermittent exercise, the distance run increased by 0.46 km in a 45 minute interval test, sprint times reduced by 2.8%, repeat sprint-cycling power increased by 5.3%, and repeat 5km running times reduced by 10sec. The magnitude of these performance benefits (>1%) have been deemed practically worthwhile and could be included in practice to improve performance.

There is strong evidence from multiple meta-analyses for the use of compression to be worn during recovery periods to assist in the recovery of muscle function, recovery from exercise induced muscle damage and reduced perceptions of muscle soreness. The reduction in muscle swelling has been considered the key mechanism in which compression assists the recovery process. Meta-analyses show that compression significantly reduced perception of muscle soreness compared to control ($p < 0.05$). Importantly, compression garments can also be used to enhance the recovery of muscle power and endurance performance.

Compression is also of benefit for elite athletes to minimise travel impact. Deep vein thrombosis, pulmonary embolism and venous thromboembolism are circulatory conditions where blood clots are formed in the lower limbs due to pooling of blood. The full consequence of the condition is fatality, as the clot formed in the lower limbs dislodges within the vein and enters the lung. People that travel long

durations, hospital patients or those standing for extended periods are exposed to extended immobility and are at a risk of developing DVT, and/ or experience associated symptoms such as swollen or painful calves or thighs. The effect of compression garments to increase blood flow during immobilised settings has been well documented. While the risk of developing DVT while travelling is low, studies have shown compression reduces the incidence of symptomless deep vein thrombosis by 90%, reduced superficial vein thrombosis by 54%, and reduced swelling/oedema by 47%.

Graduated Compression Regimes

Graduated compression regimes are not necessary. Compression graduation that starts highest at the feet is commonly targeted with an easing of compression up the leg intended to improve venous return back to the heart. If such a passive pressure regime can aid blood flow return to the heart, it may also hinder arterial inflow, reducing the overall effect. A graduated regime which is loosest at the ankle may increase blood pooling in the feet as arterial blood may move past the garment, but venous pressure is insufficient to return. Two studies have found that off-the-shelf compression garments can have pressure in the reverse direction when worn to manufacturers recommendations. Both studies found that the calf compression was approximately twice that of the ankle, and Rimaud et al (2010) found the garments resulted in raised lactate levels. Regimes including graduation must be very carefully imposed.

Choosing Compression Apparel

The key requirement for elite athletes seeking physiological benefit from compression is that garments must be custom-fit, and the regime chosen for the application.

Do not be tempted to buy garment sizes which are smaller than recommended. Some professional athletes use a rule of thumb to purchase garments two sizes smaller, however this can result in applying pressure that is too high (found to impede performance worse than no compression) and/or exacerbating a reverse gradient. The cuffs of retail compression apparel is also regularly formed with a folded hem. Such manufacturing doubles the strength of the material at the edging, causing a much tighter localised pressure and a potential tourniquet effect. Garments which utilise softer elastic cuffs that are designed to ease the compression transition at each end of the garment are necessary.

Conclusion

Accurate compression has been found to bring significant physiological benefits to athletes by enhancing performance, optimising recovery and reducing travel risks. The sizes of off-the-shelf compression garments, however, are not capable of sufficient precision to bring consistent and genuine advantage. Medical-grade, custom-fit compression garments, imparting specific compression regimes, is necessary to realise benefit, and is therefore recommended for athletes to perform at elite capability.

About the Author

James Waldie, PhD

Co-founder, CEO, Cape Bionics

Assoc Adjunct Professor, RMIT University.

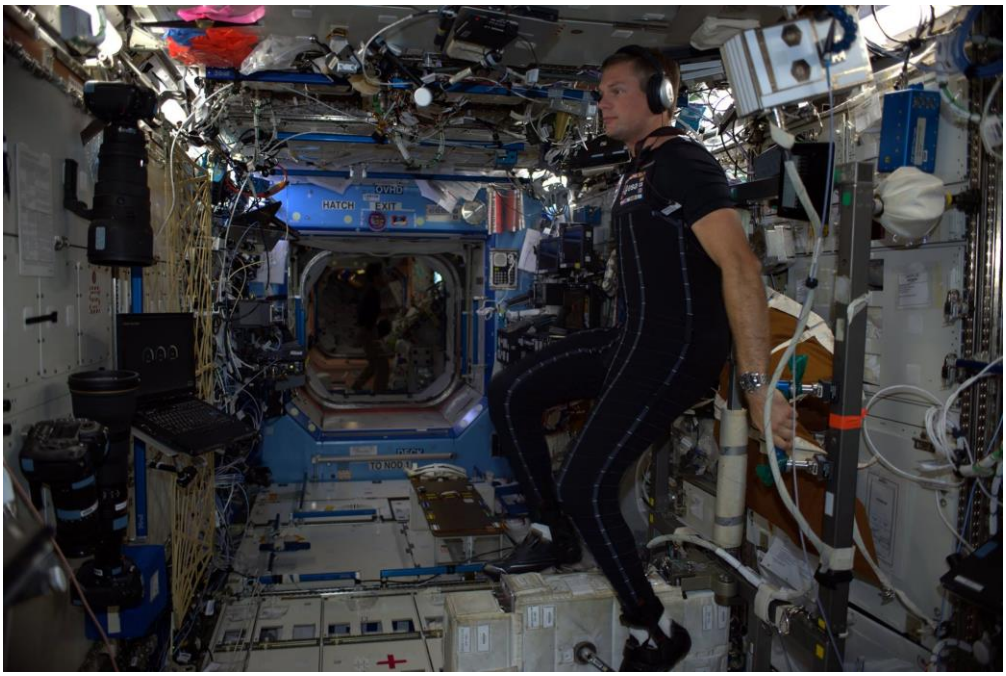
Dr James Waldie has been developing advanced compression garments for almost 2 decades. As a graduate Aerospace Engineer in 1999, James designed a skintight garment to impose G-loading on astronauts. This suit (called the Gravity Loading Countermeasure Skinsuit) would restore normal loading on the bones, and reduce skeletal atrophy on long duration missions. He was accepted as a Research Scholar at the University of California in San Diego at Masters level, working under Prof Alan Hargens (NASA Distinguished Service Medal), testing the physiological effects of compression, and measuring the pressure regimes of NASA elastic spacesuit garments on the body. He continued his studies and earned a PhD from RMIT, working on advanced skinsuits and Bioastronautics.

He was subsequently selected as a Postdoctoral Fellow at the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology (MIT), working principally on his Skinsuit design, but also consulting to NASA Johnson Space Centre to aid in studies of astronaut fingernail damage due to pressure from the spacewalking (EVA) gloves. Dr Waldie patented the Skinsuit with his MIT Professor Dava Newman (now retired NASA Deputy Director). As an Adjunct Associate Professor at RMIT, Dr Waldie served as a Principal Investigator with the European Space Agency (ESA) on the Skinsuit programme, which deployed a Skinsuit to the ISS for a 2 week mission in October 2015, and for 6 months in 2017.

Dr Waldie saw the disparity in compression technology used in other industries compared to the sports industry, and so co-founded Cape Bionics in 2016 to brings the world's most advanced tailor-made compression technology using his experience – and that from the aerospace and medical industries in general - to aid elite athletes. Cape Bionics has garments on over 50 elite athletes at Essendon, St Kilda and Port Adelaide AFL teams, and the Melbourne Rebels Rugby Union team.

Dr Waldie testing the physiological effects of an advanced compression glove for NASA in a hypobaric chamber in 2000.

Andreas Mogensen wearing the Waldie Skinsuit on the International Space Station in 2015 (copyright European Space Agency)



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