COMPRESSRx
with EC3D technology

Comparison of **CompressRx** full-length tight versus noncompression short on 60-minute run and 90-minute cycle.

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OBJECTIVE:
To compare Zoot CompressRx (CRX) tight versus traditional training garments (NC) and their effect on lactate/mmol [La–] levels during extensive bouts of running and cycling.

HISTORY:
Power Lycra™ by Dupont was first introduced in the mid '90s as a certified fabric for muscle support defined by the content level of Lycra in the fabric and garment. This certified level, typically 30% of the fabric's content, received certified performance benefits in reducing the amount of muscle fatigue in athletes. The elastic nature of Lycra™ provided a dynamic web of compression that allowed for unrestricted movement and direct compression of the major muscle groups in the body. This muscle compression reduced the oscillation and vibration of the respective muscle groups, which had been deemed damaging and fatiguing, and allowed for an increased level of performance in athletes using explosive power, such as sprinting, squatting, and jumping. The benefits of this compression–based textile quickly spread to athletes in performance sports like track and field, professional football, and swimming. Lycra™-based textiles now form the foundation for all cycling, triathlon, performance swim, elite running, and other endurance sports. The stretch component of Lycra™ provides a next-to-skin fit, enhancing the performance properties of the garment while reducing aerodynamic and hydrodynamic profile, as well as skin irritations from loose-fitting garments.

The science and technology of power Lycra™ now seems antiquated as tight-fitting compressionlike garments have achieved the same status as moisture-wicking fabrics. "Compression garments equals performance" has unfortunately become as ubiquitous a statement as Coolmax™ keeps you dry.

This generalization regarding compression has opened the door to a broader market of athletes, who now find themselves wearing a compression garment under their athletic apparel. On the leading edge of sports, compression garments help athletes perform better in time trials, swim quicker, and run faster. The question is how and why?

Medically graded compression garments and elastic stockings have long been used to assist with venous return and to reduce peripheral swelling in vascular patients (Lawrence 1980). Relatively recently, commercially available compression garments have been proposed to provide performance benefits to athletes (Wallace 2006). Consequently, professional triathletes such as Tino Bracht and Petr Vabrousek raced in compression socks for most of the 2007 season. These garments, worn during training and competition to aid performance and after exercise to hasten recovery, are suggested to improve peripheral circulation and venous return (Ibegbuna 2003), improve clearance of blood lactate [La-](Chatard 2004), reduce muscle oscillation (Bringard 2006), and improve clearance of markers of muscle damage such as creatine kinase (CK).

Intensive prolonged bouts of exercise can result in deep muscle damage that causes delayed onset muscle soreness (DOMS) (Ali 2007), decreased range of motion (DROM) and impaired physical activity for up to 48 hours. It is this exercise-induced muscle damage (EIMD) that is associated with half- and full-Ironman training and racing (Ebbeling 1989).

It is widely known and supported that medically graded compression serves a major role in recovery where dermal edema is present (Wiess 2001). Furthermore, current research supports the pushing of blood and intracellular fluid in the outer layers of the skin back into the deep venous system to reduce swelling and increase the efficacy of the venous system. This mechanism is viewed as a major component of hemodynamics.

A basic approach to understanding hemodynamics is by "feeling your pulse." Our understanding of hemodynamics is dependent on measuring the blood flow at different points in the circulation. This gives simple information regarding the strength of the circulation via the systolic stroke and the heart rate, both important components of the circulation, which may be altered during intense exercise bouts. The blood pressure can be measured using a plethysmograph or cuff connected to a pressure sensor (mercury or aneroid manometer).

It is through the application of compression to increase tissue pressure, known as compression therapy, that the medical community has established the mainstay of physical treatment of venous insufficiency of the legs and prevention of deep-vein thrombosis. Furthermore, external compression pressure increases tissue pressure, which decreases transmural vascular pressure (i.e., stretch of the veins). This may trigger a myogenic response, resulting in relaxation of the vein. This is important, because during intense bouts of exercise, it is beneficial to increase blood flow to the muscles, therefore allowing greater muscle function for a longer period of time.

Much of the current literature in the field of compression has been conducted using untrained participants and therefore does not reflect the recovery responses of trained athletes who are less susceptible to DOMS and/or EIMD. Additionally, nearly all of the studies that have been published over the past 10 years investigated subjects with deep venous thrombosis (Khan 2003). It is important to note that all but two studies found involving compression garments and exercise looked at explosive, plyometric-based movements (Doan 2003) . such as shuttle runs, vertical jumps, and 5 rep max weight lifting exercises. It seems there has been little or no research into the use of compression in endurance exercise such as triathlon.

Recently, Zoot finished a six-week study investigating the efficacy of its new compression line called CompressRX. CompressRX was developed in partnership with a leading medical compression company to provide the first-ever zoned-muscle and graduated-compression line. It is through current and past research that Zoot has set out to prove that CompressRX is a viable solution for multisport athletes as both a recovery and training tool. Please review our findings below.

METHODS:
We used two crossover-randomized exercise sessions (CRX, NC) to investigate the effects of CRX vs. NC on performance standards in trained subjects. Over a six-week period, participants were required to visit the Zoot laboratory on three separate occasions: 1) for the collection of baseline venous blood samples and the determination of baseline scores for perceived muscle soreness and a V02max (Bruce Protocol) to establish 80% of VO2max for the endurance test (ET); 2) to complete the first ET, depending on the mode of exercise involved, running 60 minutes at an estimated 80% of VO2max or cycling 90 minutes at an estimated 80% of VO2max without compression; and 3) to complete the first ET, depending on the mode of exercise involved, running 60 minutes at an estimated 80% of VO2max or cycling 90 minutes at an estimated 80% of VO2max without compression. A schematic representation of the study design is shown in figure 1.

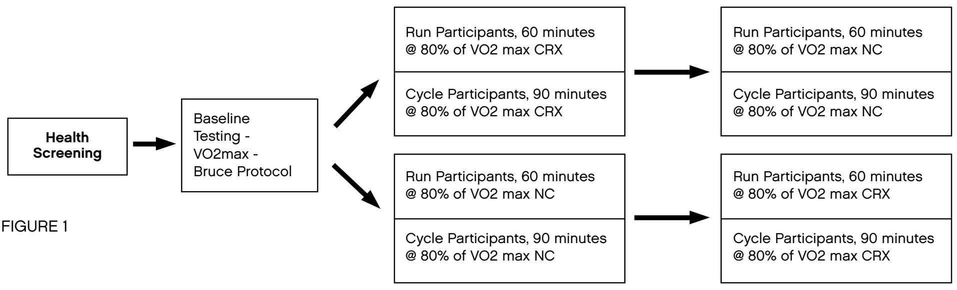


FIGURE 1

SUBJECTS
Fifteen healthy males with more than one year of triathlete training experience volunteered to participate (34.9 +/- 6.1 yr, 69.38 +/- 10.35 kg, 169.5 +/- 6.5 cm). All subjects were actively participating in competitive triathlons at the time of the study; each had more than one year in their respective sport; and standards ranged between recreational performers to national-level athletes. After being informed of the testing procedures, the associated benefits, and potential contraindications of the investigation, each subject signed an approved consent form. Before entering into the study, subjects completed a health-screening questionnaire, and each was cleared of any medical disorders that might confound or limit their ability to participate fully. None of the subjects were following specialized dietary interventions, and each was required to refrain from nutritional supplementation throughout the investigation.

PROCEDURES
During the initial visit to the Zoot laboratory before commencing data collection, subjects completed a battery of pretests that included health screening, height, weight, bodyfat percentage, and circumference measurements of chest, bicep, hips, waist, thigh, and calf. Subjects were instructed to report to testing in a >3 hour postprandial state. Two days after baseline testing, subjects returned to the Zoot laboratory to perform the first ET. Half of the subjects (group 1) were tested without compression while the other half (group 2) was instructed to train/sleep in CompressRx (42.5 +/- 6.5 hrs) for the next 7 days. Upon completion of the 7 days, group 2 returned to the lab to complete their first ET. After completion of ET1, group 1 subjects were then instructed to train/sleep in CompressRx (42.5 +/- 6.5 hrs) and return in 7 days to complete ET2. Group 2 was instructed to train/sleep without CompressRx and return in 7 days to complete ET2. Throughout the study, experimental testing took place at the same time of the day to minimize diurnal biological variation. During each session, measures of weight, heart rate, room temperature, change in body mass, rate of perceived exertion and perceived muscle soreness were recorded via the visual analog scale (VAS). Capillary blood samples were analyzed every 5 minutes during running and every 10 minutes during cycling for lactate and pH. Ratings of perceived muscle soreness were also obtained 24 hours after exercise. It is important to note that each subject carefully documented the prior day's nutrition and training to replicate before ET2.

EXPERIMENTAL TEST BATTERY
LIMB GIRTHS
Chest mesosternale (CMG), arm relaxed (ARG), waist minimum (WMG), midthigh (MTG), midcalf (MCG), and ankle minimum (AMG) were assed on the right side of the body according to the International Society for the Advancement of Kinanthropometry guidelines (Marfell-Jones 2006). See figure 2.

BODY COMPOSITION
Measurements were taken in accordance with the American College of Sports Medicine and the 7 site guidelines using a Lange skin caliper. Each site was measured 3 times, and the average was recorded.

BODY WEIGHT
Each subject was measured pre-test and post-test using a Health-O-Meter professional physician balance beam scale (model 402LBWH). Also documented was the amount of H20 consumed during each ET1 so as to be replicated in ET2.

SORENESS VAS
Perceived muscle soreness or pain was determined using a 10cm-long VAS previously reported elsewhere in the literature. This scale has labels on either end that correspond to "no pain" and "extreme pain," respectively. Subjects marked and verbally stated their level of subjective pain using a vertical line along the continuum, and the distance was reported as the raw score. Muscle soreness was assessed as a baseline and then +24 post ET1 and ET2. See figure 3.

FIGURE 2

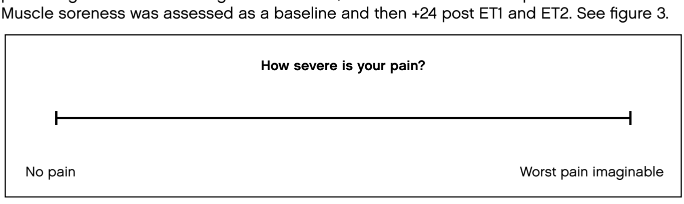
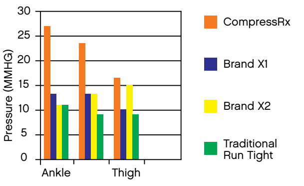


FIGURE 3

BLOOD COLLECTION
Samples were collected from a suitable finger at baseline and then every 5 minutes during exercise for the determination of circulating lactate. Blood and lactate concentrations were determined using a commercially available lancet device (Accu-Chek, Basel, Switzerland) and reader (Lactate Pro, Kyoto, Japan) according to the manufacturer's guidelines. Each site used for collection was first cleaned with an alcohol pad and lanced. The first droplet of blood was then wiped to rid samples of any fibrin particles and other debris. The sample was always taken with the second droplet of blood to ensure a proper reading.



PRESSURE COLLECTION
All pressure readings were taken using a differential pressure manometer (Extech) and were calibrated before each sampling. Using a medium manniquin (GMF model 2006), baseline pressure measurements were taken on CompressRx active tight (size M), two commercially available compression tights (size M), and a traditional running tight (size M). Each sample was taken from the same locations (midthigh, midcalf, and medial ankle) three times and then averaged. Figure 4 shows the findings.

Prior to each subject's ET with CRX, pressure readings were taken in the same locations as the baseline measurements.

RESULTS
Initial subject readings between 0 and 25:00 minutes showed similar lactate levels in CRX as in NC. Each subject showed lactate buildup in the first 20:00-30:00 minutes close to lactate threshold, which is defined as the point at which the lactic acid reaches a concentration of 4mmol. This concentration is similar to what would be seen in the later stages of a 4- to 8-hour exercise bout. The initial accumulation of lactate during the first 20 minutes may be attributed to the capillaries adjusting to the workload. After the aforementioned time period, lactate levels began to level off for the remainder of the test. This was observed in every subject, whether running or cycling. Minor changes in lactate were seen as shown in figure 4 but always seemed to hover around 3.8mmol +/- .4 mmol.

Significant differences were seen in lactate levels from 25:00-60:00 minutes. This is where the current debate resides. How could one subject, let alone 15 subjects, possibly see a 29% reduction in lactate levels over the course of 60 minutes? There are several explanations as to why this might occur while wearing CompressRx. CompressRx is a zoned muscle and graduated compression garment. Thus the garment is able to apply not only graduated compression from the ankle cuff to the waist ranging from 18mmhg to 30 mmhg, but also is able to apply varying ranges of compression to different muscle groups through a unique construction called EC3D. It is through this three-dimensional construction that the tight is able to apply strategic amounts of compression to the major movers in running and cycling to reduce the edemic response caused by extensive bouts of exercise. It is hypothesized that this, specific to muscle compression, reduces the amount of CK produced as well as reducing muscle vibration. Through the use of this specific to muscle compression, lactate production could be reduced and filtration increased, both leading to a potential for improved performance.

Figure 5 represents an average of each subject's lactate/mmol per 5-minute interval over the course of 60 minutes.

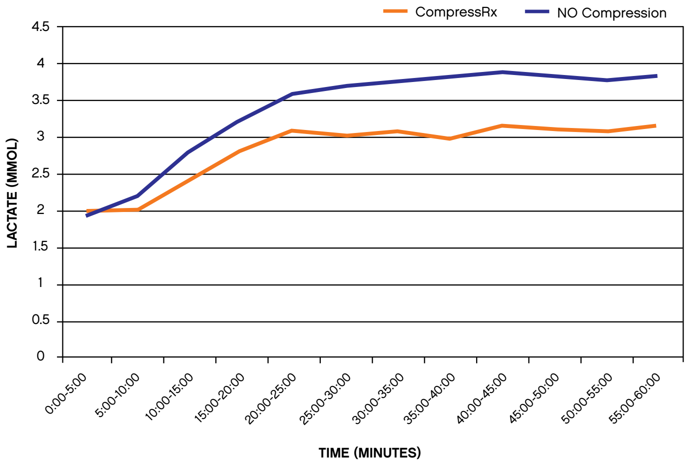


Figure 5

As seen in figure 6, subjects' rate of perceived exertion was globally lower throughout the CRX testing period. This response has been seen in other studies utilizing compression during and following eccentric exercise (Kraemer 2001). Subjects often commented post-CRX test that they felt secure in the tights and their legs rarely felt fatigued. Others commented that their legs had "more snap" and acceleration than without compression tights. One could attribute this to the lower lactate levels as well as less vibration in the muscles and therefore a decrease in the caloric expenditure, proprioception, or the subjective feeling of being secure (Bringard 2006). Either way, it is clear that CompressRx provided a lower rate of perceived exertion than that without compression.

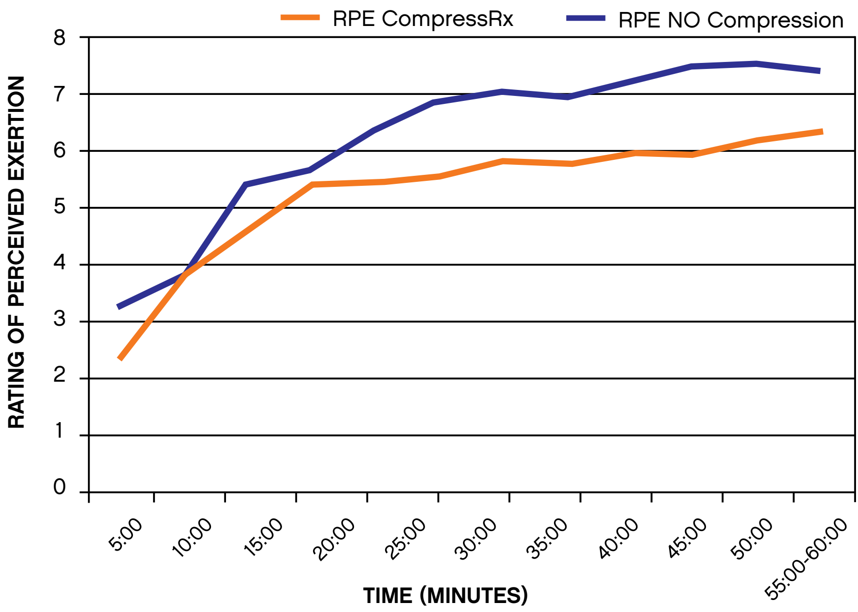


Figure 6

CONCLUSION
The use of compression garments in triathlon is becoming increasingly more common among athletes as the garments have been shown to promote everything from an increase in oxygenation to a decrease in recovery time. However, findings show that current sport-based compression provides similar ranges of compression compared to a traditional running tight. Zoot's CompressRx provides a much higher and more controlled level of compression than that which is currently available. Our findings from the study indicate that differences can be observed in the areas of physiological, physical, performance, and perceived exertion measures in CompressRx. Furthermore, triathlon is a sport that requires hours of training and racing and is known to cause deep muscle damage as part of a normal training regimen. That being understood, the triathlete's needs to avoid chronic muscle damage to maintain consistent training and racing, and the desire to reduce the recovery time associated with such training, suggests that CompressRx would be a viable solution.

It is through the reduction in lactic acid as well as perhaps Creatine Kinase and other intracellular fluid that we found a performance increase. Wearing CompressRX for 3 hours or more immediately after a strenuous training session will significantly reduce the triathlete's recovery time. To fully understand the cellular response while wearing CompressRX, further research must be done looking at blood markers such as CK and cytokines interleukin (IL-1 receptor antagonist, IL-6, and IL-10).

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