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Graduate Studies

THE EFFECT OF TONING PANTS ON ENERGY COST AND MUSCLE ACTIVATION

A Manuscript Style Thesis Submitted In Partial Fulfillment Of The Requirements For The Degree Of Master of Science in Clinical Exercise Physiology

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THE EFFECT OF TONING PANTS ON ENERGY COST AND MUSCLE ACTIVATION

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ABSTRACT

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The purpose of this study was to determine the effects of wearing Fila toning capris on energy cost, heart rate, rating of perceived exertion (RPE), and muscle activation. Sixteen females, ages 18-24 years, were asked to perform two randomized treadmill trials. During one trial, subjects wore regular athletic shorts, while during the next trial subjects wore Fila toning capris. During each of the trials subjects walked a total of 15 minutes (five minutes at 2.5, 3.0, 3.5 mph on a level treadmill). During each trial, oxygen consumption (VO_2), heart rate, RPE, and electromyography (EMG) were recorded. EMG was used to measure the muscle activation of the subjects' gluteus maximus, bicep femoris, and vastus lateralis. Results showed a significant difference in VO_2 (15.3 vs 14.9 ml/kg/min) and RPE (9.2 vs 8.8) when wearing the Fila toning capris versus athletic shorts. However, there were no significant differences found in muscle activation between the Fila toning capris and athletic shorts.

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INTRODUCTION

The exercise industry has been developing different products, attempting to improve exercise effectiveness, for years. Most recently the exercise industry has developed athletic wear that is designed to help with toning, increasing energy costs (VO_2), and increasing muscle activation. Varying types of clothing that have been developed include shorts, capris, full length pants, and stockings; each claiming to result in a more intense work out. Fila has developed pants, capris, and tank tops that claim to increase muscle activation during exercise.

For example, Bringard et al. (2006) examined the effect of wearing compression tights, classic tights, and shorts on VO_2 while running. The main finding was that compression tights reduced energy cost of exercise by 26 and 36%, respectively, when compared to elastic tights and athletic shorts. They hypothesized that the compression and elastic tights may have given the muscles extra support, thus increasing proprioception, muscle coordination, and propulsive force. They postulated that this resulted in a decreased VO_2.

Similarly, Sperlich et al. (2009) tested four compression conditions to see what effect they would have on VO_2 and rating of perceived exertion (RPE). The conditions tested included: no compression, compression socks, compression tights, and whole body compression. Results showed no significant changes in VO_2 or RPE between the different clothing types. Time to exhaustion was also unaffected by the type of clothing worn.

While some athletes are wearing full length compression tights, others are utilizing compression stockings in attempts to enhance performance. Originally, these stockings were developed for patients suffering from deep vein thrombosis and varicose veins. Manufactures claim graduated compression stockings will improve performance, enhance perception of muscle awareness, and improve various physiological responses. Ali et al. (2010) conducted a study to examine potential physiological and perceptual responses to wearing graduated compression stockings during fast-paced running. Results showed no significant differences in VO_2 or RPE between low compression or high compression stockings in comparison to no compression stockings.

Not only do compression garments claim to increase VO_2, but they also claim to aid an athlete in recovery after a muscle damaging activity. Jakeman et al (2010) studied the effect of compression garments on muscle damage after plyometric activity. After exercise "damage," one group of subjects was given a pair of lower limb compression tights and were instructed to wear the tights for 12 hours. The second group had a passive recovery. Results showed that subjects who wore the compression tights had a significantly lower perceived soreness at 1, 24, 48, and 72 hours following damaging exercise. These results support the claim that wearing some type of compression garment could improve recovery time after intense exercise.

New company products are claiming to increase the intensity of exercise by the addition of "toning panels." Fila has developed a clothing line which utilizes this type of design. The tag on the toning capris used in this study, states that muscle activation is increased by 50%. Theoretically, this increase in muscle activation would result in an increase in caloric expenditure and muscle tone. In a press release from Fila in 2010, Fila

states that the body toning system is "designed to increase muscle exercise which improves the efficiency as well as recovery of an existing workout" (Sparks, 2010). The purpose of this study was to determine whether wearing Fila toning capris had an effect on VO_2 and muscle activation.

METHODS

Subjects consisted of 16 female volunteers from the University of Wisconsin La-Crosse campus. Subjects were 18-24 years of age and were required to be moderately active. After approval by the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects, all subjects provided written informed consent (appendix B). Prior to testing, each subject came in for a toning capri fitting to be sure the pants fit correctly. The toning capris this study utilized were manufactured by Fila (USA Fila Branch, New York, New York).

Each subject completed one testing session. During testing subjects were required to walk on a level treadmill at 2.5, 3.0, and 3.5 mph for 5 minutes at each speed. This sequence was repeated twice; once while wearing the toning capris and once while wearing regular athletic shorts. The order was randomized and each subject was given 5 minutes of rest between trials. During each trial VO_2 was measured continuously using open circuit spirometry (AEI inc., Pittsburgh, PA), as well as heart rate (HR) was measured each minute using radiotelemetry (Polar, Woodbury, NY). Ratings of perceived exertion (RPE) were determined every 5 minutes (after each stage) using the 6-20 borg scale (appendix C).

In addition to HR and VO_2, EMG was recorded during all treadmill testing. Three separate bipolar surface (2.0 cm center-to-center) electrode (BIOPAC Systems Inc., Santa Barbara, CA; 4mm silver/silver chloride) arrangements were place over the gluteus maximus, vastus lateralis, and biceps femoris according to the recommendations of

SENIAM 8 (citation). The electrodes for the gluteus maximus (GM) were positioned at the midpoint between the sacral vertebrae and the greater trochanter, and were oriented in the direction of the line of the posterior superior iliac spine and the middle of the posterior aspect of the thigh. The electrodes for the vastus lateralis (VL) muscle were placed over the lateral portion of the muscle approximately 33% of the distance between the superior, lateral border of the patella to the anterior superior iliac spine (ASIS). With the subject in the standing position and the dominant leg fully extended, a reference line was drawn from the ASIS to the superior lateral border of the patella to identify the VL electrode-placement site (citation). The electrode-placement sites were located 3 – 4 cm lateral to the reference line (citation). A standard goniometer (Smith & Nephew Rolyan, Inc., Menomonee Falls, WI) was used to orient the electrodes at a 20- angle to the reference line to approximate the pennation angle of the VL muscle (Fig. X) (citations). . The electrodes for the biceps femoris (BF) were placed at 50% of the distance on a line between the ischial tuberosity and the lateral epicondyle of the tibia. The reference electrode was placed over the iliac crest. Interelectrode impedance was kept below 2000 Ω by shaving the area and by careful skin abrasion.The EMG signal was preamplified (gain 1000x) using a differential amplifier (BIOPAC Systems Inc., Santa Barbara, CA; bandwidth 10–500 Hz). Fifteen seconds of the EMG signal were collected at the end of each 5 minute stage.The raw EMG signals were digitized at 1000 Hz and stored in a personal computer (provide specifics for your computer here) for subsequent analyses. All signal processing was performed using custom programs written with LabVIEW programming software (version 2009, National Instruments, Austin, TX). The EMG signals were digitally band-pass filtered (fourth-order Butterworth) at 10–500 Hz.

The EMG amplitude (microvolts root mean square [μVrms]) values were calculated for each trial. The EMG values (μVrms) were normalized to maximal voluntary isometric contractions (MVC) for each muscle and reported as %MVC.

Statistical analysis was done 2-way ANOVA (2 x 3) for each variable. Where there was a significant ratio, Tukey's post-hoc tests were used to detect pairwise differences. Alpha was set at 0.05 to achieve statistical significance for all analyses.

RESULTS

Subjects were 16 moderately active, college-aged women. Descriptive characteristics of the subjects are presented in Table 1.

Table 1. Descriptive characteristics of the subject population.

	Mean ± SD	Range
Age (yrs)	21.4 ± 1.86	18-24
Height (cm)	166.5 ± 5.37	158.7-177.8
Weight (kg)	61.3 ± 6.53	47.7-75

The physiological response to walking at each of the speeds in regular athletic shorts and Fila toning capris are presented in Table 2.

Table 2. Physiological responses to wearing athletic shorts and toning capris (N=16).

	Athletic Shorts	Toning Capris
	Mean ± SD	Mean ± SD
Heart Rate (bpm)		
2.5 mph	99 ± 10.0	99 ± 10.9
3.0 mph	105 ± 10.9	106 ± 11.1
3.5 mph	115 ± 11.9	115 ± 11.9
VO_2 (ml/kg/min)		
2.5 mph	12.7 ± 0.83	13.2 ± 0.96*
3.0 mph	14.7 ± 0.93	15.0 ± 0.89
3.5 mph	17.5 ± 1.10	17.6 ± 1.10
Kcals/min		
2.5 mph	3.88 ± 0.437	4.02 ± 0.399*
3.0 mph	4.48 ± 0.483	4.58 ± 0.410
3.5 mph	5.34 ± 0.486	5.37 ± 0.480
RPE		
2.5 mph	7.4 ± 0.62	7.7 ± 0.79
3.0 mph	8.6 ± 1.02	9.1 ± 1.15*
3.5 mph	10.4 ± 1.31	10.7 ± 1.40

*Significantly greater than athletic shorts ($p < .05$)

There were significant increases in HR, VO_2, and RPE with increasing speed when wearing both athletic shorts and toning capris. However, there was no significant difference in HR when comparing toning capris and athletic shorts at any speed. Overall, there was a significantly higher VO_2 when wearing toning capris versus athletic shorts (15.3 vs 14.9 ml/kg/min). Pairwise comparisons revealed that this difference was only significant at 2.5 mph. Similarly, there was also a significantly higher caloric expenditure when wearing the toning capris versus athletic shorts (4.66 vs.4.57 kcal/min). Pairwise comparisons revealed that this difference was only significant at 2.5 mph. There was also a significantly higher overall RPE when comparing toning pants with athletic shorts (9.2 vs 8.8). Pairwise comparisons revealed that this was only significant at 3.0 mph.

The EMG data for the toning capri and athletic short conditions are presented in Table 3.

Table 3. Muscle activation (%MVC) of the gluteus maximus, bicep femoris, and vastus lateralis while wearing athletic shorts and toning capris

	Athletic Shorts Mean ± SD	Toning Capris Mean ± SD
Gluteus Maximus (N=16)		
2.5 mph	34 ± 27.3	28 ± 16.4
3.0 mph	32 ± 19.9	30 ± 17.3
3.5 mph	34 ± 19.5	32 ± 17.7
Bicep Femoris (N=15)		
2.5 mph	19 ± 13.1	18 ± 10.5
3.0 mph	21 ± 12.7	21 ± 12.3
3.5 mph	24 ± 13.5	24 ± 12.5
Vastus Lateralis (N=13)		
2.5 mph	26 ± 8.7	27 ± 9.8
3.0 mph	32 ± 9.7	32 ± 10.4
3.5 mph	39 ± 10.2	39 ± 12.1

Muscle activity in the biceps femoris and vastas lateralis increased significantly with increasing speeds when wearing both the athletic shorts and toning capris. There was no significant difference in muscle activation across speeds for the gluteus maximus. When comparing muscle activation while wearing athletic shorts or toning capris, there were no significant differences between the two conditions.

DISCUSSION

This study assessed the effects of wearing Fila toning capris on HR, VO_2, RPE, and muscle activation (via EMG). While there was no significant difference in HR between wearing toning capris and athletic shorts, there was a small but significant difference in VO_2. This difference in VO_2 was approximately 2% higher (0.4 ml/kg/min or 0.09 Kcal/min) when wearing toning capris. In regards to muscle activation, there were no significant differences in the quadriceps, hamstrings, or buttocks when wearing toning capris versus athletic shorts.

Energy cost data from the current study contradicts the findings of previous studies in the literature. Sperlich et al. (2009) found no significant differences in VO_2 while running at a predetermined submaximal speed under four conditions: no compression (41.1$\pm$5.6 ml/kg/min), compression socks (41.6$\pm$7.1 ml/kg/min), compression tights (40.8$\pm$6.7 ml/kg/min), and whole body compression (40.1$\pm$6.6). In contrast, Bringard et al. (2006), found that VO_2 was significantly lower when wearing compression tights (26 and 36%) when compared to elastic tights and athletic shorts. They hypothesized that the compression and elastic tights may give the muscles extra support, allowing for an increased proprioception, muscle coordination, and propulsive force, which resulted in decreased VO_2 while running.

While there was a significant difference in caloric expenditure when wearing toning capris versus athletic shorts (4.66 vs. 4.57 Kcal/min), however the difference was only 2%. While wearing the toning capris, subjects burned an extra 0.09 Kcal/min.

When this difference is extrapolated out to 1 hour, the difference is only an additional 5 calories.

Our study also found a significant increase in subject's RPE while walking in the toning capris compared to athletic shorts. This finding is also contradictory to data in the literature. Referring back to the study done by Sperlich et al. (2009), they found no differences in RPE between their four conditions: no compression (13.2±1.5), compression socks (12.6±1.5), compression tights (13.1±1.0), and whole body compression (12.7±1.1). Similar results were found by Bringard et al. in 2006.

To help explain the differences in RPE, subjects were asked write down what they felt while wearing the toning capris compared to the athletic shorts. Several subjects stated that they felt increased compression and resistance around the hip joint. A study by Doan et al. (2003) supports their statements regarding hip resistance. They looked at the effects of custom fit compression shorts on range of motion, muscle oscillation, jump power, and skin temperature. Results for the range of motion tests revealed a significant reduction in hip range of motion while wearing the compression shorts.

Muscle activation of the gluteus maximus, bicep femoris, and vastus lateralis were also examined in the present study. In a press release from Fila in 2010, it was stated that the body toning system is "designed to increase muscle exercise which improves efficiency, as well as recovery of an existing workout" (Sparks, 2010). Additionally, the tag located on the toning capris at the time of purchase states that the capris will increase muscle activation by 50%. We found no difference in muscle activation when wearing the toning capris compared to athletic shorts. Our study supports the findings of Liu et al. (2008) who found that as walking speed increased,

support contributions from the gluteus maximus, gluteus medius, and vastus lateralis also increased. The present study found a significant increase in the bicep femoris and vastus lateralis activation as speed increased while wearing both the athletic shorts and toning capris. We did not however, find a significant difference in activation of the gluteus maximus. This phenomenon could be explained by the data of Lieberman et al. (2006). They found that in some subjects, the increase in muscle activity in the gluteus maximus with increasing speed can cause blurring of the activity bursts, making them increasingly more difficult to read.

CONCLUSION

In conclusion, we found no difference in muscle activation between the toning capris and athletic shorts. Subjects perceived the toning capris to be harder to walk in due to the increase in compression around the hip joint. This perceived increase in difficulty was accompanied by small, but significant increases in energy cost. However, this 2% increase in VO_2 would amount to only 5 extra calories expended per hour, at speeds between 2.5 and 3.5 mph. Consumers will have to decide for themselves if this small 2% increase is worth the cost of the capris.

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APPENDIX A

REVIEW OF LITERATURE

INTRODUCTION

The exercise industry has been developing different products, in attempts to improve exercise effectiveness, for years. Most recently, the exercise industry is experimenting with clothing designed to help with toning, increasing oxygen consumption (VO_2), and increasing muscle activation. Varying types of clothing that have been developed include shorts, capris, full length pants, and stockings, each making their own claims of enhancing athletic performance. Brands such as Reebok and Fila have developed pants, capris, and tank tops that claim to increase muscle activation during exercise. All products make claims as to what they are going to accomplish for your workout, but it's the research that shows whether or not these claims are attainable.

MUSCLE ACTIVATION WITH NO COMPRESSION WHILE WALKING

Before going into muscle activation while wearing compression garments, it is important to understand muscle activation while walking with normal athletic clothing. A study done in 2008 by Liu et al. investigated muscle contributions and support over a range of walking speeds. Their results showed that walking speed significantly affected support contributions from the gluteus maximus, gluteus medius, hamstrings, and vastus lateralis. Support contributions from the vastus lateralis increased dramatically as speed increased from a slow to moderate speed. Contributions from the gluteus maximus, hamstrings, and soleus also increased.

A study by Lieberman et al. (2006), looked at the gluteus maximus and its role during walking and running. During the walking portion of their testing, it was observed

that the gluteus maximus contracts at low levels (less than 10% of MVC). Secondly, it was observed that normalized electromyography (EMG) magnitudes in the gluteus maximus became higher with increasing speed. However, with this increase in velocity, bursts can become blurred in some individuals causing them to be difficult to read.

COMPRESSION GARMENTS AND THEIR EFFECT ON PHYSIOLOGICAL FACTORS

A study by Bringard et al. (2005) examined the effects of wearing compression tights, classic tights, and shorts on VO_2 while running. The main findings of the study showed that wearing compression tights decreased VO_2 by 26 and 36%, respectively, when compared to elastic tights and athletic shorts. They hypothesized that the compression and elastic tights may have given the muscles extra support, which increased proprioception, muscle coordination, and propulsive force. It was felt that this resulted in the decreased VO_2.

Sperlich et al. (2010) performed a study testing for VO_2 and RPE. Subjects initially completed a treadmill VO_2 max test. They then completed four tests wearing a different type of exercise clothing. The four types of clothing included: compression socks, compression tights, whole body compression, and conventional running clothing. Time to exhaustion was unaffected by clothing type and there were no significant changes in VO_2 or RPE between the different clothing types.

In 2003, Doan et al. completed a study that evaluated a custom fit lower body compression garment. The aim of their study was to compare a custom fit compression garment to a looser athletic bottom. Ten male and ten female track athletes were used as subjects in the study. Each subject completed a 60 m sprint (range of motion) test,

muscle oscillation test, jump power test, and skin temperature test. The study concluded that there was a significant decrease in range of motion during the sprint with the compressive garment. However, it was noted that the actual motion of sprint was unaffected. For both men and women there was a significant increase in single maximal countermovement vertical jump height. Skin temperature was found to dramatically increase with the custom fitted compressive garment for both men and women. The increase in temperature was noted to have the ability to decrease the possibility of injury. The study noted that the best temperature for optimal muscle function is 38.5 degrees Celsius. Therefore, the results of this study could imply that the use of these compression shorts could decrease warm-up time, thereby enhancing muscle performance.

While several athletes are utilizing the full length compression tights, other runners are utilizing compression stockings. Originally these stockings were developed for patients suffering from deep vein thrombosis and varicose veins. Claims made by manufactures of graduated compression stockings include: performance gains, enhanced perception, and improvements in various physiological responses. Ali et al. (2010) conducted a study to examine the physiological and perceptual responses to wearing graduated compression stockings during fast-paced running. There were three different conditions in the study: a compression stocking with no compression, a stocking with low compression (15 mmhg at the ankle, 12 mmhg at the knee), and a stocking with high compression (32 mmhg at the ankle and 23 mmhg at the knee). Subjects performed three, 40 minute running trials on a treadmill. Heart rate, VO_2, and lactate were recorded throughout each timed trial. Results showed no significant differences in VO_2 between the three stocking conditions (no compression=3.9$\pm$0.1 L/min, low compression=3.9$\pm$0.1

L/min, and high compression=4.0±0.1 L/min). There were also no significant differences in HR between the three trials. Similar results were found with the perceptual data. There were no significant difference found in RPE between no compression (13.4±1.2), low compression (13.8±1.0), and high compression (13.9±1.1) stockings.

COMPRESSION GARMENTS AND THEIR ROLE IN RECOVERY

Many compression garments have been used in attempts to improve recovery. Whether or not these compression garments actually assist in muscle recovery is still unknown. Kraemer et al. (1998) completed a study looking at the effect of compression shorts on muscle fatigue. In order to study this, they used 10 male and 10 female subjects. The goal was to examine a range of motion to see if compressive forces of the garment would cause fatiguing of the muscles. Half of the subjects wore the compressive shorts and the second half wore a generic gym short. Two different tests were performed: squat testing and isokinetic testing. The results of the two tests found no significant differences between the compression garment and control conditions for squat testing and isokinetic testing.

Jakeman et al. (2010) also examined the effects of compression garments on muscle damage after plyometric activity. Their study included 17 female subjects. The plyometric exercise chosen for this particular study was 10x10 repetitions of plyometric drop jumps from a 0.6 m box, along with three vertical squat jumps. After the exercise "damage," a select number of subjects were given a pair of lower limb compression tights and were instructed to wear the tights for 12 hours. The other group had a passive recovery. Results from the study found that the subjects who wore the compression tights had a much lower perceived soreness at 1, 24, 48, and 72 hours after exercise

compared to the passive group. These results imply that wearing some type of compression garment on the lower extremities can improve recovery time after damaging exercise.

SUMMARY

Brands such as Reebok and Fila have developed pants, capris, and tank tops that claim to increase muscle activation during exercise. The Fila toning body system is "designed to increase muscle exercise which improves the efficiency as well as recovery of an existing workout" (Sparks, 2010). The company claims to do this by the addition of toning panels in their compression garments. These panels use a material fabric designed by the company called INVISTA's LYCRA® SPORT. The tag located on the toning capris at the time of purchase states that the capris will increase muscle activation by 50%. Based on the claims made by the company, we will be testing subjects energy cost, ratings of perceived exertion, and muscle activation when wearing Fila toning capris compared to athletic shorts.

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APPENDIX B

INFORMED CONSENT

INFORMED CONSENT

THE EFFECT OF TONING PANTS ON ENERGY COST AND MUSCLE ACTIVITY

I, _____, agree to participate in a research study conducted at the University of Wisconsin-La Crosse.

- The purpose of this study is to view the effects that toning capris (fila) have on an individual's energy cost (VO_2) and muscle activity.
- My personal information will be kept confidential, but the research findings of this study may be published or presented.
- This study will be conducted under the direction of Alexa Kleingartner, a graduate student in the department of Clinical Exercise Physiology. She is working under the supervision of John P. Porcari, who is a professor within the same department.
- My participation in this study will require me to complete walking tests that I may feel fatigued afterwards and may experience muscle soreness the following day.
- During the first trial I will wear an AEI metabolic system that will record my VO_2 (Oxygen Cost). I will also wear a polar heart rate monitor, in which I will have my heart rate recorded every 30 seconds.
    - I have been informed that there will be 2 sessions (one wearing fila toning pants and a second with regular athletic pants) each requiring the completion of two, five minute walking tests: one at the speed of 2.5 and a second at 3.5mph with zero percent grade.
- During the second trial I will be required to have electrodes placed on my hamstring, gluteus maximus, and vastus intermedialis muscles. These electrodes will record my muscle activity throughout the four, five minute walking tests I complete.
    - I have been informed that there will be 2 sessions (one wearing fila toning pants and a second with regular athletic pants) each requiring the completion of two, five minute walking tests: one at the speed of 2.5 and a second at 3.5mph with zero percent grades.
- My participation in this study will require about two hours of my time. I may withdraw from the study at anytime without reason or penalty.
- The risks of participating in this study include possible fatigue and next day muscle soreness. The risks of serious complications are near zero. I have been informed that individuals conducting the study will be trained and certified in CPR and ACLS.
- The test will be terminated if complications occur.
- I have been informed that this study will not directly benefit me but may benefit the community to help women understand the true affect of toning capris.

I have read all the above information; understand the testing protocol and what participation in this study involves. Any questions and concerns have been answered by the investigator. The contact information for Alexa Kleingartner is (701-367-2631) and her research advisor Dr. John P. Porcari, Department of Exercise and Sport Science, UW-L, ( ). Questions Concerning the protection of human subjects, please direct them to the chair of the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, (608-785-8124).

Participant _____ Date _____

Researcher _____ Date _____

APPENDIX C

RATING OF PERCEIVED EXERTION SCALE

Rating of Perceived Exertion

6	NO EXERTION AT ALL
7	
8	EXTREMELY LIGHT
9	
10	
11	LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	EXTREMELY HARD
20	MAXIMAL EXERTION