



Perceived Influence of a Compression, Posture-Cueing Shirt on Cyclists' Ride Experience and Post-Ride Recovery

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Received 30 July 2013; received in revised form 25 November 2013; accepted 23 December 2013

Key indexing terms:

Posture;
Back pain;
Clothing

Abstract

Objective: The purpose of this study was to evaluate the opinions of experienced cyclists on perceived influence of a posture-cueing shirt with compressive properties on their comfort and recovery.

Methods: Twenty experienced cyclists wore a compressive shirt during rides and as a postride recovery shirt; cyclists rated their perceived experiences during rides and recovery. They completed 2 separate questionnaires specific to riding or recovery; scores ranged from -3.0 (negative influence) to +3.0 (positive influence), addressing posture, discomfort, breathing, and recovery. Data analysis included frequencies and *t* tests to compare groups.

Results: Cyclists completed 53 rides, averaging 95.48 km (SD = 31.72 km), wearing the shirt and reported a perceived benefit (mean score = 1.17, SD = 0.25). For their postride recovery perceptions, scores averaged 1.99 (SD = 0.48) for perceived benefits for recovery. No differences in scores were identified between male and female cyclists during rides ($t = -0.28, P > .05$); however, female riders perceived greater benefit during recovery ($t = -2.24, P < .05$). There were no correlations with scores and cyclist age, experience, or ride distances during rides or recovery ($r = 0.02-0.35$).

Conclusion: A posture-cueing, compressive shirt was rated to have a perceived benefit by experienced cyclists for riding posture, postride posture, spine discomfort, and postride recovery. This study did not evaluate physical or physiologic variables to confirm these perceptions.

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Introduction

Cycling is an endurance activity often requiring long bouts of physical exertion in a position of forward flexion. Multiple studies have shown that a cyclist's upper body orientation can influence the muscle

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activity and recruitment pattern in the lower body.¹⁻⁴ To produce a smooth and effective pedaling motion, a coordinated pattern of muscle recruitment is used to transmit power from the body to the crank of the bike. The work that a muscle is able to produce is dependent on the length-tension and force-velocity power relationships of the involved muscles.¹ Therefore, a cyclist's posture may affect not only muscle recruitment and performance but also the resulting fatigue from the activity due to changes in the activation and timing of these muscles that may lead to an earlier onset of fatigue.²⁻⁴ A number of aids have been developed to assist with fatigue and to improve motor function and posture in athletes, including compression garments and Kinesio taping.

Compression garments were developed and have been used for many years to treat medical pathologies, including venous insufficiencies, by compressing superficial veins to increase venous return to the heart.⁵⁻¹⁰ Only more recently have compression garments been used to enhance sport performance and improve recovery. It is thought that wearing compression garments during high-intensity activities will increase venous return, which helps to facilitate clearance of metabolites, reduce swelling, limit the resulting inflammatory response, and decrease blood lactate concentration and creatine kinase levels post-exercise. As a result, many studies have shown a decrease in reported muscle soreness, decrease in pain, decrease in fatigue, and increase in vitality during the recovery period after exercise.⁵⁻¹⁰ Because previous studies have shown that compression garments can alter venous flow and decrease reports of fatigue and exertion in other populations of athletes, examination of these garments in the cycling population is appropriate.^{5,8,9}

Kinesio tape has been used on athletes in an attempt to increase force production and improve proprioception. It is thought that the fiber direction and elasticity of the tape provide pulling forces on the skin to lift the fascia and increase cutaneous stimulation. Results vary on the ability of Kinesio tape to alter force production; but multiple studies have shown that it can alter cutaneous sensation, which can lead to other improvements.¹¹⁻¹⁶ A study by Wong et al¹⁶ (2012) demonstrated that, in a group of healthy women, the time to achieve peak torque knee extension and flexion was significantly decreased while wearing Kinesio tape on the knee. This suggests that an increase in cutaneous sensation may lead to increased ease of recruitment of motor units.¹⁶ Also, an athlete's force sense in forearm muscles was enhanced with Kinesio tape, despite a lack

of increased grip strength.¹⁶ Although taping may not always lead to increased force production and muscle strength, the cutaneous cue it provides may lead to a decreased sense of difficulty with activity.

Numerous theories have been presented to explain the benefits of taping on the skin for performance improvement and pain management, and it has been suggested that tape applied directly over the skin provides improved sensor-motor function by way of facilitated activity of the working muscles while inhibiting activity of the antagonist muscle groups.¹⁷ Additional theories include increased body part stability, support of body and joints, and correction of body segment alignment such as posture.¹⁷⁻¹⁹ Studies by Ackermann et al¹⁷ (2002) and Cools et al¹⁸ (2002) reported improved kinesthetic coordination of the movement of the scapula during activities involving the upper extremity, whereas Host¹⁹ (1995) theorized that improved alignment of the scapula, resulting from tape application, improved shoulder pain.

Recently, garments have been developed that attempt to provide the effects of Kinesio tape and compression directly into the clothing material. Intelliskin is a line of compression garments designed to improve upper body alignment by stimulating the appropriate nerve endings to produce specific postural cues. According to Intelliskin, the pressure of the compression garment and alignment of the stitching of the garment material are proposed to provide sensorimotor stimulation to the cutaneous nerve receptors of the skin, whereas the panels are intended to correct muscle imbalances and are intended to improve anatomical alignment. By combining the proprioceptive input seen similarly in Kinesio tape with the fit of a compression garment, the Intelliskin is purported to provide performance, enhancing posture cueing and recovery compression. Two recent studies suggest that the garment might be effective in improving the performance of overhand athletes such as throwers and volleyball players. Russell et al²⁰ (2013) determined that the use of a compression posture-cueing shirt resulted in improved throwing performance and less pain in pitchers. In an unpublished study presented at the American Orthopaedic Society of Sports Medicine annual meeting (2012), volleyball players reported fewer shoulder injuries over the course of a season while wearing a posture-cueing compression shirt.

Because the performance of a cyclist is dependent on proper riding posture and adequate postride recovery, the effectiveness of a posture-cueing and compression shirt is of interest and worthy of study. Therefore, the purpose of this study was to determine cyclists' perceptions of (1) wearing a posture-cueing shirt on

Table 1 Subject Demographic and Cycling Experience Level

Age	Category	Hours/week	Miles/week	Height	Weight
42.8 ± 11.1 y	1 (n = 4)	14.0 ± 2.1 h/wk	170.6 ± 61.6 miles/wk	Men 1.78 ± 09 m	75.14 ± 8.63 kg
	2 (n = 4)			Women 1.65 ± 04 m	
	3 (n = 6)				
	4+ (n = 6)				

perceived performance during a ride, (2) wearing compression type shirt on perceived performance during a ride, and (3) wearing a posture-cueing and compression type shirt on perceived “postride” recovery. It was hypothesized that a posture-cueing and compression type shirt would have no influence on cyclists’ perceived ride performance but would have a positive influence on the riders’ perception of postride recovery.

Methods

Recruitment and Subject Characteristics

Twenty healthy adult (age range, 24-65 years) recreational and competitive cyclists participated in this study. Cyclists were recruited from local cycling clubs in the Southern California region. Table 1 provides the subjects’ descriptive information. Inclusion criteria included cyclists who ride a minimum of 100 km/wk and/or a minimum of 8.0 h/wk and who are currently on a consistent riding and racing schedule. Participants needed to be willing to wear a compressive base-layer posture-cueing shirt under their normal cycling jersey during a minimum of 2 rides. Ride distance needed to be a minimum of 40 km each ride. In addition, participants needed to be willing to wear a compressive posture-cueing shirt as a postride recovery shirt, following at least 2 rides of 40 km or longer each. This study was reviewed and approved by the institutional review board of Chapman University. All cyclists consented to participating in this study.

Measures

This study used an investigator-developed questionnaire to determine rider experience while wearing a posture-cueing shirt during rides (Fig 1). In addition, questions were developed to determine rider experience while wearing the posture-cueing shirt as a postride recovery shirt (Fig 1). Each question provided the cyclist with the opportunity to rate his/her experience

based on a rating scale of -3 (substantial negative influence) to +3 (substantial positive influence), with intermediate categories representing moderate, minimal, or no influence. Cyclists were asked to complete the questionnaire by comparing their normal conditions (ie, normal clothing that a cyclist wears during rides and after rides) to those while wearing the investigational garment.

Procedures

The study was divided into 2 conditions: (1) self-reported experience while wearing the posture-cueing shirt during riding sessions and (2) self-reported experience while wearing the posture-cueing shirt as a postride recovery shirt. The Foundation Zipper posture-cueing shirt (Intelliskin, Newport Beach, CA) was fitted to each cyclist at the beginning of this study. Cyclists were asked to wear the posture-cueing shirt as a base-layer shirt during each riding trial and to

Questions to respond to during a ride (R)

- R1. Effect on my trunk and neck riding posture
- R2. Influence on my feeling of fatigue during the ride
- R3. Feeling of discomfort in my neck during the ride
- R4. Feeling of discomfort in my mid-back area during the ride
- R5. Feeling of discomfort in my lower back during the ride
- R6. Effect on my breathing during submaximal effort
- R7. Effect on my breathing during extremely hard effort

Questions to respond to during recovery (NR)

- NR1. Effect on my sitting posture after a ride
- NR2. Effect on my standing posture after a ride
- NR3. Feeling of discomfort in my neck after a ride
- NR4. Feeling of discomfort in my mid-back area after a ride
- NR5. Feeling of discomfort in my lower back after a ride
- NR6. Effect on my breathing at rest, after a ride
- NR7. Feeling of tension in my spine after a ride
- NR8. Effect on my recovery after a ride
- NR9. Feeling of recovery in my subsequent ride

Fig 1. Questions specific to riding experience and recovery experience. Cyclists rated each question on a scale of -3 (very negative) to +3 (very positive). *NR*, not a ride; *R*, ride.

complete a minimum of 2 rides while wearing the posture-cueing shirt before completing the “ride experience” questionnaire. For the postride recovery trials, cyclists were asked to wear the posture-cueing shirt under their normal clothing following a minimum of 2 rides before completing the “recovery experience” questionnaire. The postride recovery trials were to be completed following rides during which the cyclist did not wear the posture-cueing shirt while riding. Cyclists were given a 6-week time period to complete the study. All questionnaires were returned anonymously by mail.

Data Analysis

Data were analyzed by calculating mean scores per item as well as total mean scores for each condition. Frequencies were obtained for each category rating on each item. The perceived responses between male and female cyclists were compared using an independent *t* test. Finally, ride distance, rider category, and age were tested for correlation with ride and postride sum scores using bivariate correlations. Significance was set at .05 for all statistical tests.

Results

The 20 cyclists completed a total of 53 rides, averaging 95.48 km (SD = 31.72 km), for the evaluation of the posture-cueing shirt during rides. The average rating based on all 7 ride questions was a score of 1.17 (SD = 0.25), where a positive value suggests a positive influence of the posture-cueing shirt while riding. Item-by-item ratings are provided in Table 2, which includes the average rating per item as well as the distribution of ratings per item.

The cyclists wore the posture-cueing shirt for postride recovery for a total of 59 postride days. The

Table 3 Rider Responses to Questions as a Postride Recovery Trial

Question	Mean (SD)								
		3	2	1	0	1	2	3	
NR1 sit posture	2.80 (0.41)	0	0	0	0	0	4	16	
NR2 stand posture	2.75 (0.44)	0	0	0	0	0	5	15	
NR3 neck	1.83 (1.29)	0	0	1	3	4	5	7	
NR4 midback	2.05 (1.35)	0	0	2	1	4	2	11	
NR5 low back	1.79 (1.44)	0	1	1	1	5	4	8	
NR6 breath	1.65 (1.53)	0	0	4	0	3	5	8	
NR7 spine	1.95 (1.23)	0	0	2	0	3	7	8	
NR8 recovered	1.70 (1.34)	0	0	3	0	3	8	6	
NR9 next ride	1.40 (1.09)	0	0	2	0	9	6	3	
Score distribution		0	1	15	5	31	46	82	

Mean values represent average score for a given item.

average ride for the recovery evaluation was 86.46 km (SD = 26.08 km). The average rating based on all 9 post-recovery ride questions was a score of 1.99 (SD = 0.48). Table 3 provides the item-by-item average ratings as well as the category distribution of ratings for each item.

There was no difference in perception between male (mean total score = 7.8 ± 6.2) and female (mean total score = 8.5 ± 1.5) riders for the ride condition ($t = -0.28$, $df = 18$, $P > .05$). However, female riders tended to perceive a more favorable influence of the posture-cueing shirt for postride recovery ($t = -2.2$, $df = 18$, $P < .05$), with total mean scores of 15.6 (SD = 9.3) and 22.2 (SD = 4.4) for male and female riders, respectively. Finally, there were no significant correlations with ride distance ($r = 0.03$), age ($r = -0.19$), or category level ($r = 0.01$) on ratings for the ride experience; there were no correlations of perceived influence on recovery with ride distance ($r = 0.03$), age ($r = 0.04$), or rider category level ($r = 0.35$).

Discussion

This study attempted to determine self-reported experience of competitive and recreational cyclists while wearing a compression-based posture-cueing shirt, both as a riding shirt and also as a postride recovery shirt. The shirt was not expected to provide benefit as a riding shirt because of the essentially static posture maintained on the bike. However, because the garment provides compression to the upper body as well as a reported posture-cueing influence on the torso, it was anticipated that cyclists would find the use of the shirt to be a positive influence during recovery.

Table 2 Rider Responses to Questions During a Riding Trial

Question	Mean (SD)	-3	-2	-1	0	1	2	3
R1 posture	1.50 (0.69)	0	0	0	0	12	6	2
R2 fatigue	1.30 (0.86)	0	0	1	0	13	4	2
R3 neck	1.05 (1.18)	0	0	3	1	12	1	3
R4 midback	1.20 (1.19)	0	0	3	0	10	4	3
R5 low back	1.37 (1.26)	0	1	1	1	8	7	2
R6 breath submax	0.95 (1.23)	0	2	1	0	10	7	0
R7 breath hard	0.80 (1.15)	0	2	1	0	13	4	0
Score distribution		0	5	10	1	78	33	12

Mean values represent average score for a given item.

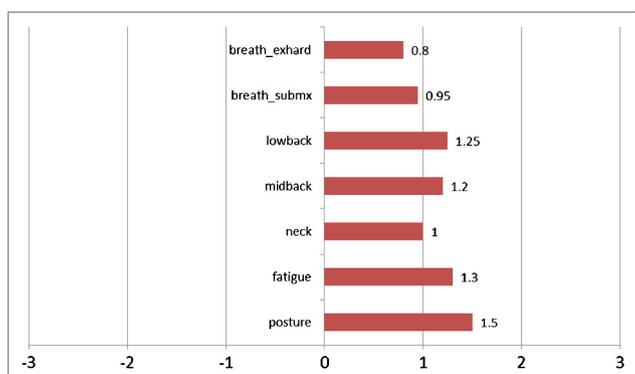


Fig 2. Distribution of scores, ranging from -3 (very negative) to +3 (very positive) during the ride experience. (Color version of figure is available online.)

Based on this study, the cyclists perceived a benefit of wearing the shirt, albeit the benefit appears to be greater as a postride recovery shirt than an actual ride shirt. Figs 2 and 3 provide graphical representation of the rider experiences and suggest that the shirts were valued as a positive influence in general for both a ride shirt and a postride recovery shirt. Values that approach 0.0 suggest that the shirt provided no influence, whereas values in the negative range would suggest an adverse experience and values in the positive range would suggest a beneficial experience. The average score for each item of both questionnaires exceeds 0.0, indicating positive perceptions in all areas. These experiences are strictly subjective and are not based on physiological or biomechanical analyses of the riders' experiences.

When looking at individual items from the 2 questionnaires, the influence on posture, both during a ride and during postride recovery, yielded the highest scores in terms of a positive influence. Cyclists perceived a positive influence from the shirt in terms of their sitting, standing, and riding

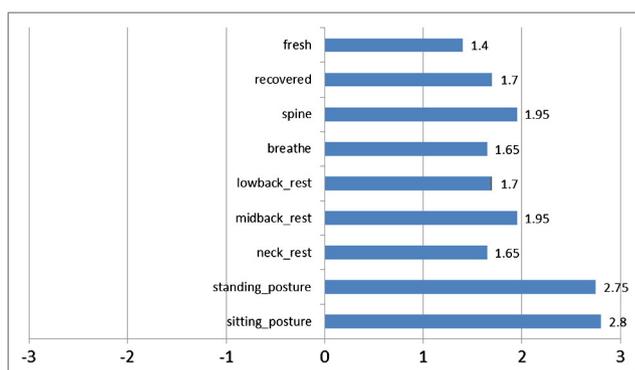


Fig 3. Distribution of scores, ranging from -3 (very negative) to +3 (very positive) as a postride recovery experience. (Color version of figure is available online.)

posture. The cyclists also perceived a positive influence in terms of lower back, midback, and neck discomfort, both during rides and as a postride recovery shirt. These perceptions are consistent with the findings by Russell et al (2013), who found that baseball players reported less shoulder pain while wearing a posture-cueing shirt.²⁰ This is also consistent with the work by Christou²² (2004) and Whittingham et al²³ (2004), who found that the use of Kinesio tape, applied around the knee, resulted in decrease pain associated with patella-femoral pain syndrome, despite the fact that the tape only provided tactile sensation to the skin overlying the muscles of the knee.

Finally, the cyclists perceived positive influence in terms of fatigue during rides while wearing the posture-cueing shirt. These perceptions are consistent with the findings by Russell et al (2013), who determined that baseball players demonstrated higher throwing velocities and maintained high throwing velocities after multiple repetitions while wearing the shirt compared with the diminishing velocities observed while not wearing a shirt.²⁰ Russell et al concluded that a posture-cueing compression shirt appears to ward off fatigue in baseball throwers. This is also consistent with the work by Hsu et al²¹ (2009) using Kinesio tape to improve positioning of the scapula and shoulder during throwing motions. Their study determined improved kinematics, less discomfort, and less fatigue in throwers while using posture-cuing tape on the scapula. Subjectively, the riders of our study reported a positive influence on recovery and felt recuperated for subsequent rides when wearing the posture-cueing compressive shirt. This may be a factor related to the compressive nature of the garment. Research supports the use of compression garments for muscular recovery after hard efforts.⁵⁻¹⁰

Rider experience in terms of competitive cyclists or recreational cyclists did not seem to affect the perception of influence of the posture-cueing shirts. There were nonsignificant correlations between rider experience level and experience with the shirt. The postride recovery experience produced a correlation of 0.35 relative to rider experience level, suggesting a possible trend of a greater perception of a positive influence for the lesser-experienced cyclists (ie, Category 4 or higher). Female cyclists reported slightly greater perceived benefits during recovery compared with the male cyclists, and there were no female cyclists in the more experienced cyclist levels (Category 1, 2, or 3). Whether this greater perceived benefit was a result of the influence of the garment or the fact

that the female cyclists might be more aware of their posture cannot be determined with these data. It is possible that the garment is capable of greater physical influence on a female rider because of her decreased body mass compared with a male rider.

Age, both during the ride condition and postride condition, was not correlated with the perceived influence of the shirt. Thus, young and older riders perceived the influences of the compression posture-cueing shirts in a similar fashion. This is somewhat surprising, as it might be expected that an older cyclist could benefit more from a posture-cueing shirt given that it is widely accepted that postural changes appear to be more pronounced in older individuals. However, because cyclists in this study were likely quite fit, the influence of a posture-cueing shirt appeared to be comparable on riders of all ages. The cyclists in this study ranged in age from 24 to 65 years of age.

Finally, riding distance was not correlated with the perceived influence of the compression posture-cueing shirt, whether as a shirt worn during a ride or as a postride recovery shirt, and its influence on a subsequent ride. This lack of correlation was surprising given the wide range of distances ridden by the cyclists. While wearing the shirt during a ride, distances ranged from 56 to 160 km. Subsequent rides, following recovery, ranged from 50 to 137 km. Thus, it appears that the distance of a ride is not a factor in terms of riders' subjective response to the influence of a posture-cueing compression garment.

Practical Applications

The results of this study suggest that a posture-cueing compression shirt, like the Intelliskin, might be a useful ergogenic aid to a cyclist's training regimen. Coaches might recommend that riders wear a compression-type posture-cueing shirt for rides, although it should be noted that this type of garment is perceived as warm and hence might be best as a base-layer-type shirt in cooler riding conditions. Further, this shirt might have more favorable applications as a postride recovery shirt. Because of the fatigue induced by riding effort and the forward flexed posture associated with riding, a posture-cueing shirt that encourages a more upright posture is recommended, particularly during recovery. The length of time to wear a shirt of this nature is not yet determined in the research. Compression garments are recommended to be worn postride for at least 60 minutes or up to 8 to 12 hours.

Limitations

We did not quantify the intensity of rides, which may play a role in perception of the experience with the shirt. Because these were competitive bike riders, it was assumed that ride intensity would be sufficient and relatively similar among riders. In addition, we did not quantify physiologic or power variables relative to the ride. Measuring physiologic and power variables is necessary to determine if the shirts had any actual physical benefits as well. This study can only draw conclusions based on a rider's perceived benefit from wearing a compressive posture-cueing shirt. Finally, it is important to note that we used our own investigator-developed questionnaire that has not been previously used in research and was not evaluated for its validity or reliability indices. Without psychometric properties of these 2 questionnaires, the results of this study should be applied cautiously.

Future Studies

These favorable perceptions found in this study warrant further research to examine actual physiologic and biomechanical variables to determine if true physical benefits can be attained. In addition, it warrants further study to determine if this type of garment can produce postride recovery benefits for a competitive cyclist. This study is only a preliminary investigation using a subjective, untested questionnaire to determine if riders perceive a benefit from wearing a posture-cueing compression shirt. Further research is warranted to determine if true physiologic influences related to biomechanics and posture can be gained with such a garment.

Conclusion

A posture-cueing, compressive shirt was rated to have a perceived benefit by experienced cyclists for riding posture, postride posture, spine discomfort, and postride recovery. This study did not evaluate physical or physiologic variables to confirm these perceptions.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study. The participants of this study

were provided the posture-cueing shirts free of charge and were permitted to keep the shirts if they wished.

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