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The effect of self-talk on endurance cycling performance in the heat:

A psychophysiological approach

by

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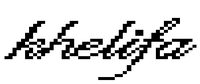

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We the undersigned, certify that this thesis has been approved and that is adequate in scope and methodology for the degree of European Masters in Sport and Exercise Psychology.

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Abstract

The purpose of the present study was to examine the effectiveness of self-talk (motivational self-talk) on endurance cycling performance in the heat. Sixteen (M = 22.50 years, SD = 4.89) trained and active participants were assigned to self-talk and control group randomly after completing a baseline $\dot{V}O_{2max}$. Self-talk groups received two consecutive days of self-talk trainings while pedaling the Monark bicycle ergometer at a cadence of 60 rpm for 12 min with a total load of 126 watt whereas control groups subjected to conditioning training with a similar pedaling protocol as that of the self-talk group without any treatment. During the experimental testing, all participants were taken to an environmental (hot) chamber to pedal the Monark cycle egormeter at a cadence of 60 rpm for 30 min with a constant RPE of 14 on a 6-20 Borg's scale. Key measures include performance (power) output, VO_2, respiratory quotient, urine specific gravity, thermal comfort and thermal sensation. The 2 (group: experimental, control) × 6 (time: six 5 min interval) repeated measures ANOVA were calculated to test for differences in power output throughout the 30 minutes of exercising as a function of group. The analysis yielded a significant group by time interaction, $F(5, 10) = 7.63$, $p < .01$. In general, self-talk group exhibited greater power output in endurance cycling performance in the heat than control group. Results are discussed in terms of statistical significance, psychological and physiological effects.

Key words: self-talk; motivational self-talk; endurance; euhydration; heat; physiological effects; rating of perceived exertion, thermal comfort; thermal sensation; urine specific gravity

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INTRODUCTION

The study of self-talk has attracted an increasing attention in the sport psychology literature (Hardy, 2006; Hatzigeorgiadis, Zourbanos, Goltsios, & Theodorakis, 2008). Self-talk as a cognitive strategy aiming at enhancing performance has been well-established (Hatzigeorgiadis et al., 2008). Moreover, the types of interventions used in various studies have been given great consideration for skill acquisition and performance enhancement. Overall self-talk interventions have proven effective in facilitating learning and enhancing sport task performance. For instance, the effectiveness of self-talk using interventions (e.g., Johnson, Hrycaiko, Johnson, & Hallas, 2004; Perkos, Theodorakis, & Chroni, 2002), experimental tasks (e.g., Harvey, Van Raalte, & Brewer, 2002; Mallett & Hanrahan, 1997; Theodorakis, Weinberg, Natsis, Douma, & Kazakas, 2000; Van Raalte et al., 1995) and single-subject multiple baseline designs (Hamilton, Scott, & McDougall, 2007; Landin & Hebert, 1999; Ming & Martin, 1996) has been demonstrated.

The effectiveness of self-talk in a physically demanding tasks (such as endurance) have been supported, though results are mixed, using laboratory based sit-up task (e.g., Theodorakis et al., 2000), cycling endurance task (Hamilton et al., 2007), cross-country running task (Donohue, Barnhart, Covassin, Carpin, & Korb, 2000), one mile running task (Miller & Donohue, 2003), and a field based one-mile endurance running task (e.g., Weinberg, Miller, & Horn, 2012).

Despite those aforementioned investigations, studies examining the effectiveness of self-talk interventions and strategies (instructional, motivational, and combined) in endurance tasks are scares in the literature. Moreover, one study have examined the effect of positive self-talk combined with other psychological skills training (such as goal setting, arousal regulation, mental imagery) in endurance (90 min running on the treadmill) task in the heat (e.g., Barwood, Thelwell, & Tipton, 2008). In addition, up to this point, there is no single study examining the pure self-talk effect on endurance performance in extreme environmental conditions. In other words, examining the sole effect of self-talk exclusively on endurance performance in stressful environments is missing in the self-talk literature. Therefore, one of the purposes of the present investigation was to examine the effectiveness of motivational self-talk on endurance task in the heat. In addition, physiological measures had not been emphasized in previous self-talk literatures, although various suggestions and speculations were posited (e.g., Theodorakis, Hatzigeorgiadis, & Zourbanos, 2012). Barwood et al. (2008), however, included physiological measures in their studies, although a non-significant result was obtained between PST and control groups. Hence, whether the use of self-talk enhances the physiological efficiency of athletes exercising in the heat is worth investigating. As a result, key physiological measures are included in this study to examine the physiological effects of self-talk on endurance performance in extreme environment (in the heat).

The present investigation is groundbreaking in two ways: First, the effectiveness of self-talk (motivational self-talk) as a cognitive strategy in extreme environmental conditions (in the heat) during endurance cycling performance was examined for the first time. Second, the effect of self-talk on selected physiological parameters was established for the first time in the self-talk literature.

Planned and productive self-talk is considered to be an effective strategy for performance enhancement (e.g., Hardy, Gammage, & Hall, 2001; Zinsser, Bunker, & Williams, 2006). Thus, the present investigation suggests for athletes, coaches, and sport psychologists the importance of developing, designing and implementing comprehensive self-talk training plans for endurance performance tasks in stressful environments. In line with this, the use of manipulation checks during the self-talk training session and after the experimental testing should be given great emphasis. Moreover, the present investigation signifies the effectiveness of motivational self-talk on endurance cycling performance in the heat. Finally, the present investigation encourages the combination of psychological and physiological measures for future self-talk investigations.

LITERATURE REVIEW

Definitions and conceptualization

A number of suggestions have been forwarded concerning the definition or description of self-talk in the sport psychology literature. Anderson (1997), for example, suggested that self-talk refers to self-statements that athletes' addresses to themselves in order to think clearly as to their performance hence achieve a desired outcome. Theodorakis et al. (2000) defined self-talk as "what people say to themselves either out loud or as a small voice inside their head" (p. 254). However, a comprehensive definition of self-talk is suggested by Hardy (2006) as "(a) verbalizations or statements addressed to the self; (b) multidimensional in nature; (c) having interpretive elements associated with the content of statements employed; (d) is somewhat dynamic; and (e) serving at least two functions; instructional and motivational for the athlete" (p. 84). This definition by Hardy is exclusive; however, he posited that improvement of this definition is to be expected through further research developments. Following such suggestion and taking social influences into account, Zourbanos, Hatzigeorgiadis, Tsiakara, Chroni, and Theodorakis. (2010) suggested that self-talk can be "malleable to perceptions and interpretations of stimuli from the social environment" (p. 782).

Research approaches to the study of self-talk

It is important to underscore the research approaches used to study self-talk. Two different approaches have been identified in studying self-talk: (a) self-talk as content of thoughts and (b) self-talk as a mental strategy (e.g., Hatzigeorgiadis & Biddle, 2008). The former is explaining the factors that affect and shape athletes' self-talk content (e.g., Zourbanos, Hatzigeorgiadis, Goudas, & Papaioannou, 2011). The latter gives emphasis on the positive effects of self-talk on performance enhancement (e.g., Mallet & Hanrahan, 1997). The literature regarding these approaches is presented in a more detail fashion below.

Self-talk as content of thoughts

Within this approach research has mostly focused on the actual content of athletes' thoughts, the valence, and antecedents. Several research attentions have been given to describe these underlying dimensions of self-talk. Initially, Theodorakis et al. (2012) suggested bipolar nature of self-talk depending on the content: positive and negative self-talk. Positive self-talk (e.g., "great shot") comprises of praise and encouragement (e.g., Moran, 1996), and helps the athlete focused on the present, not on the past mistakes or the distant future (e.g., Weinberg, 1984). Conversely, negative self-talk (e.g., "this sucks") is a form of criticism and self-preoccupation (e.g., Moran, 1996), and "…that gets in the way because it is inappropriate, irrational, counterproductive, or anxiety-producing" (Theodorakis et al., 2000, p. 254). In addition, depending on the content self-talk can be characterized as instructional and motivational. Instructional self-talk refers to cues related to focus or direct attention, and provide instruction with regard to technique, strategy, or kinesthetic attributes of a skill (e.g., "elbow straight," "reach," "bend," "high knee lift," and "follow-through.", whereas motivational self-talk refers cues that can psych-up and build confidence (e.g., "get tough," "hang in there," "you can do it," and "stay strong." However, Theodorakis et al. (2012) proposed that focusing only on the content of the statements rather than on the impact can separate the distinction between positive and negative self-talk. Thus, the content of self-talk should be viewed as a separate dimension from the impact (such as performance as n outcome variable) of self-talk as it can be regarded as facilitating (which may play a role in enhancing performance and have desirable effect) or debilitating (which may affect performance or have damaging effect). Furthermore, regarding the distinction between the positive-negative self-talk, Theodorakis et al. (2012) suggested to describe cues as instructional or motivational on the basis of the content rather than the function they serve.

Antecedents of self-talk. There are substantial evidences about the antecedents of self-talk that affect athletes self-talk. Three major factors have been identified; personal, situational and social environmental. Personal antecedents refer to factors that influence athletes' use of self-talk on a personal level. Self-concept and forms of anxiety may be antecedents of self-talk. However, preliminary evidence suggests that motivation-based personality disposition and achievement goal orientation may be the other factors. In line with this Hatzigeorgiadis and Biddle (1999) examined the relationships between goal orientations and negative self-talk. Their results showed that task orientation was negatively related to disengagement thoughts irrespective of perception of competence. Also, a study conducted by the same authors (2000) found that athletes with high ego and low task orientations were more vulnerable to disengagement thoughts than athletes with different goal profiles. In general, the results suggest that task orientation has been linked with positive self-talk, whereas ego orientation has been associated with worrying and disengagement thoughts. Such relationships could also depend on other personal or situational factors.

Numerous research have examined the effects of situational factors on the use and content of self-talk; such as task difficulty (e.g., Behrend, Rosengren, & Perlmutter, 1989), match circumstances (e.g., Van Raalte, Conrelius, Hattern, & Brewer, 2000), and anxiety (Hatzigeorgiadis & Biddle, 2008). In particular, the relationship between task difficulty and private speech, in that the greatest use of private speech is observed on moderately difficult tasks (Behrend et al., 1989; Ferneyhough & Fradley, 20005). In addition, self-talk is used to cope with more difficult tasks but is less likely to be employed for tasks that are perceived as too hard or for which no strategies have been learned or developed.

The last dimension, which has been initiated by Zourbanos (2008), on influencing the content of self-talk, is social-environmental factors. This refers to the presence of behavior of those around the athlete, particularly significant others and their influence on athletes (e.g., Zourbanos, Theodorakis, & Hatzigeorgiadis, 2006). Initial research was carried out involving pre-school children. The result showed that children produced greater frequency of private speech in the presence of significant others, such as mothers (e.g., Behrend et al., 1989). Moreover, a study taken educational environments found that teachers negative statements have been linked with an increase frequency of negative self-talk in male students, and teachers' positive statements with an increase in positive self-talk in both male and female students (Burnett, 1999). Within sport settings, coaches are commonly regarded as an influential significant others. Findings from a cross-cultural study suggested that coaches promote the use of positive self-talk by their athlete and perceive it to be an effective confidence enhancing intervention (e.g., Weinberg, Grove, & Jackson, 1992). Zourbanos et al. (2006) and Zourbanos, Hatzigeorgiadis, and Theodorakis (2007) found that coaches' behavior, support, and statement communicated to athletes are linked to athletes' positive and negative self-talk. With respect to social environmental factors, the importance of motivational climate is evident. Though investigation in this line is missing, Hatzigeorgiadis, Zourbanos, Latinjak, and Theodorakis (in press), for example suggested that a learning motivational climate i.e., a climate related to mastering skills and personal improvement is associated with more positive and less negative self-talk from the part of athletes. Conversely, a climate centering on wining and outperforming others has been related to negative self-talk. Overall, personal, situational characteristics and social-environmental factors play an important role in shaping athletes' self-talk.

Self-talk as a mental strategy

Talking to ourselves has been shown to have benefits in various domains. The idea that self-talk can have benefits is among the fundamental principles underlying the development of cognitive-behavioral therapies; treatments aiming at changing individuals' thoughts, interpretations, and behavior (Meichenbaum, 1977). Therefore, planned, productive self-talk is considered to be an effective strategy used for psyching up, for emotion and effort, relaxation and calming down, attentional focusing, maintaining confidence, and self-evaluation/self-reinforcement (e.g., Hardy et al., 2001; Zinsser et al., 2006). In addition, self-talk is used as a cognitive strategy to direct and facilitate human performance. When examining self-talk within the purpose it serves, being motivational or instructional, Theodorakis et al. (2000) argued that the effects of self-talk on performance might depend on the type of task being performed. Instructional self-talk refers to statements aiming to direct attention and guide action through technical remarks or tactical choices, whereas motivational self-talk refers to statements aiming to increase confidence, regulate effort, and create positive moods (Zinsser, Bunker, & Williams, 2001). Several mental training techniques are associated with self-talk, including thought stopping, thought replacement, countering, reframing, and cognitive restructuring (e.g., Zinsser et al., 2006).

Athletes and coaches believe that self-talk is an intervention that enhances sporting performance and various psychological states, such as confidence (Vargas-Tonsing, Myers & Feltz, 2004; Wang, Huddleston & Peng, 2003). Furthermore, many sport psychologists promulgate the benefits athletes and coaches can expect from using self-talk interventions.

The use of self-talk as a performance-enhancement strategy in applied sport psychology (e.g., Harris & Harris, 1984) has been advocated and it should not come as a surprise that a common emphasis in the self-talk literature has been its association with sporting performance.

Effectiveness of self-talk interventions

The types of interventions used in various studies have been given great consideration. Most of the studies have used cross-section interventions; few studies have used short training interventions, even fewer studies have used longer interventions, and only some studies have used single-subject multiple baseline designs. On two occasions, Hatzigeorgiadis et al. (2008) and Hatzigeorgiadis, Zourbanos, Mpoumpaki, and Theodorakis (2009) have employed a 3-day self-talk short training programs that have supported the effectiveness of self-talk strategies in young tennis players particularly on forehand accuracy performance. During the training sessions participants practiced various types of self-talk on a backhand activity. Such training was meant to acquaint participants with the use of self-talk with a variety of cues, but also while attempting to minimize learning effects. The findings (both studies) revealed that intervention groups showed significant improvements than control groups. Similar short training interventions in a golf putting task (e.g., Cornspan, Overby, & Lerner, 2004); in tennis forehand task (e.g., Cutton & Landin, 2007); and in water polo task (e.g., Hatzigeorgiadis, Zourbanos, & Theodorakis, 2007) have been carried out with student samples.

On the other hand, two studies have employed extensive self-talk interventions with athletes. The first study carried out a 12-week intervention (including one self-talk training session per week) with young basketball players (Perkos et al., 2002). The finding revealed that the intervention group executed better than the control group in passing and dribbling skills. The second study carried out a 12-week intervention, included 24 self-talk training sessions with a sample of adult wheelchair basketball players. The result showed that the intervention group's passing and dribbling performance improved significantly, whereas performance of the control group remained unchanging. Furthermore, in order to assess learning effects on an overhand throw, Anderson, Vogel, and Albrecht (1999) carried out a school based intervention including a nine-session self-talk training program during physical education classes for 3-weeks. They found out that self-talk training group performed better than a traditional learning and a demonstration-only group.

The self-talk interventions have also been studied in combination with various mental skills strategies. Most of the following studies have been conducted in combination with self-talk using single-subject multiple-baseline designs: relaxation (e.g., Rogerson & Hrycaiko, 2002), imagery (e.g., Cumming, Nordin, Horton, & Reynolds, 2006), goal setting (e.g., Papaioannou, Ballon, Theodorakis, & Auwelle, 2004), combined goal setting, imagery, and relaxation (e.g., Blakeslee & Goff, 2007; Patrick & Hrycaiko, 1998; Thelwell & Greenlees, 2003), combined goal setting, arousal regulation, and mental imagery (e.g., Barwood, Dalzell, Datta, Thelwell, & Tipton, 2006; Barwood et al., 2008), and lastly, combined performance feedback (e.g., Cutton & Landin, 2007; Latinjak, Torregrosa, & Renom, 2011). These studies have proved the effectiveness of self-talk in facilitating and enhancing performance. As Hardy, Oliver, and Tod (2009) noted that to identify whether the effect was due to the combined strategies or the sole effect of any of these strategies used is impossible. Experimental studies, however, involving combined strategy groups beside pure self-talk groups can prove such effects (e.g., Cutton & Landin, 2007; Latinjak et al., 2011; Papaioannou et al., 2004).

The effectiveness of self-talk interventions has been supported in a number of studies and receiving increased research attention in recent years. Particularly, most of the experimental studies have underscored on the effectiveness of the self-talk interventions on performance. Weinberg, Smith, Jackson, and Gould (1984) and Hamilton and Fremouw (1985) in their studies explored the effectiveness of self-talk strategies reported that endurance and basketball performance were improved using positive self-talk, respectively. Ziegler (1987) in his study on the effect of a four-step self-talk instruction strategy on tennis forehand and backhand strokes found significant improvement for both strokes. The impact of three different types of self-talk (instruction, mood, and positive self-talk) on skiing was studied (Rushall, Hall, Roux, Sasseville, & Rushall, 1988). Their findings revealed that improvement in performance was evident in all types of self-talk cues. Following these studies, the self-talk intervention literature has flourished extensively. Many studies have proved the effectiveness of self-talk in facilitating learning and enhancing performance in a wide range of tasks, skills, and populations, varying from novel tasks (e.g., Hatzigeorgiadis, Theodorakis, & Zourbanos, 2004) to learned tasks (e.g., Malouff & Murphy, 2006), from fine motor skills (e.g., Van Raalte, Brewer, Lewis, Linder, Wildman, & Kozimor, 1995) to gross motor skills (e.g., Edwards, Tod, & McGuigan, 2008), and from students (e.g., Theodorakis, Chroni, Laparidis, Bebestos, & Douma, 2001) to young and beginner athletes (e.g., Goudas, Hatzidimitriou, & Kikidi, 2006; Perkos et al., 2002), to more experienced (e.g., Landin & Hebert, 1999) and elite athletes (e.g., Mallettt & Hanrahan, 1997).

Theodorakis et al. (2000) examined the effectiveness of different self-talk strategies on increasing performance in motor tasks. They carried out four (soccer accuracy test, a badminton service test, a sit up test, and a knee extension task on an isokinetic dynamometer) laboratory experiments to examine the effect of motivational versus instructional self-talk strategies. They found that instructional self-talk was effective for two accuracy tasks (soccer passing task and a badminton serve task) than motivational self-talk. No effect in the sit-up endurance test was obtained. For the isokinetic strength task, both instructional and motivational self-talk were effective. They suggested a matching hypothesis that is that when using self-talk cues, they should be suitable for particular tasks. For instance, instructional and motivational cues are more appropriate for fine motor skill tasks and gross motor tasks, respectively. Hatzigeorgiadis et al. (2004) examined the effect of instructional and motivational self-talk on water polo task. They conducted two experiments in swimming pool; the first one included a precision task (throwing a ball at target) and the second one included a power task (throwing a ball from distance). Their results revealed that both types of self-talk improved performance for the precision task, however, greater effect was recorded with instructional self-talk. Only motivational self-talk was effective for the power task. Edwards et al. (2008) examined the effect of instructional and motivational self-talk on vertical jump performance in male rugby union players. Their results revealed that both instructional and motivational cues were effective. However, Tod, Thatcher, McGuigan, and Thatcher (2008) found only motivational self-talk was effective in improving participants'. Lastly, both instructional and motivational cues were found equally effective for basketball (chest pass) task. And also both types of self-talk were effective for a push-up task, however, greater effect for motivational self-talk was evident than instructional self-talk (Kolovelonis, Goudas, & Dermitzaki, 2011). In general, the above mentioned studies have proved the matching hypothesis suggested by Theodorakis et al. (2000); though few disparities exist in the use of instructional and motivational self-talk on performance among different tasks.

The effectiveness of self-talk in enhancing performance using single-subject multiple-baseline designs have been well-established in endurance (cycling) performance (e.g., Hamilton et al., 2007), in figure skating routines (e.g., Ming & Martin, 1996), sprinting performance (e.g., Mallett & Hanrahan, 1997), a tennis sequential shots task (e.g., Landin & Hebert, 1999), and a soccer shooting task (e.g., Johnson et al., 2004).

On the other hand, the results that did not support the effectiveness of self-talk on performance are also worth mentioning. To mention few; instructional self-talk did not improve performance on a power water polo task (e.g., Hatzigeorgiadis et al., 2004); motivational self-talk did not improve performance on a soccer shooting task and neither instructional nor motivational self-talk improved sit-up endurance performance (e.g., Theodorakis et al., 2000); instructional self-talk did not improve on a shooting (basketball) task after 12-week intervention (e.g., Perkos et al., 2002); and no differences was obtained in accuracy for a golf put task between self-talk and control groups and the use of instructional self-talk was uncorrelated with golf-putting performance (e.g., Harvey, Van Raalte, & Brewer, 2002). Four possible justification might be posited for such findings: (a) use of alternative types of self-talk; (b) choice of the tasks; (c) lack of self-talk training (especially when well-learned tasks are used); and (d) choice of statistical criteria (Theodorakis et al., 2012). Finally, because self-talk was also used by participants in control groups Hall, Gibbs, and Greenslade (2005) suggested the use of appropriate manipulation checks. They further suggested that the absence of support of these manipulation checks lead researchers to reconsider their methodologies and appropriate self-talk plan in relation to the context. Overall, self-talk interventions have proven effective in facilitating learning and enhancing sport task performance.

Recently a research synthesis on the relationship between self-talk and performance was established through a meta-analysis approach by Hatzigeorgiadis et al. (2011). In general, their analysis revealed a moderate positive effect size (d = .48) supporting the facilitative effects of self-talk on sport performance. Furthermore, they found that interventions including training were more effective (d = .80) compared to those not including training (d = .37). They also found that self-talk was more effective for novel (d = .73) rather than learned tasks (d = .41). They also found that self-talk was more effective for tasks characterized by precision, coordination, or fine execution (d = .67), rather than gross tasks requiring strength and endurance (d = .26). Lastly, matching hypotheses were drawn; i.e., instructional self-talk proved more effective than motivational self-talk for fine tasks; and instructional self-talk was more effective for fine tasks as compared to gross tasks. In conclusion, their results backed evidence for the effectiveness of self-talk interventions and supported the beneficial effects of self-talk strategies on performance, in facilitating learning, and enhancing sport task performance.

Self-talk interventions in endurance tasks

The effectiveness of self-talk in physically demanding tasks (such as endurance tasks) in a laboratory experiments have provided mixed results. As mentioned earlier, Theodorakis et al. (2000) found no differences in both instructional and motivational self-talk on laboratory sit-up endurance task. Hamilton et al. (2007) examined the effectiveness of three different self-talk (self-regulated positive self-talk, assisted positive self-talk, and assisted negative self-talk) interventions on cycling endurance (Monark cycle ergometer). Their findings indicated that all intervention conditions produced a positive impact on performance with the greatest increase being found in the assisted self-talk condition for the cycling task. They also concluded that positive self-talk, whether self-regulated or assisted, does have a beneficial impact on endurance performance. Donohue, Barnhart, Covassin, Carpin, and Korb (2000) examined the effectiveness of self-talk in a sample of female cross-country runners. In their study, they allowed each participant to select her own statements from a broader list of statements. During their warm-up session prior to a race these instructional or motivational statements were reiterated as a result runners were able to repeat these statements themselves. Their results revealed no significant performance differences between instructional and motivational self-statements. However, both instructional and motivational self-statements significantly improved performance compared to a control condition. Furthermore, Miller and Donohue (2003) examined the influences of two mental preparation interventions on 1.6 km run performance in 90 high school long-distance runners. They compared the instructional and motivational self-statements to a music condition and a control condition for an endurance task (one mile run). After a 1.6 km baseline run, participants were randomly grouped into motivational and running statements on headphones, listening to music on headphones, and listening to no sound on headphones. A list of 40 Motivational statements including (e.g., "I believe in you," "you can do it," "let's go, let's do it"), and a list of 26 running technique statements (i.e., task-relevant instructions) including (e.g., "stretch your muscles," "pump your arms," "get your body warmed up") were used. They adopted these statements from previous study (Donohue et al., 2000). Their results indicated that motivational and running technique statements significantly improved participants' running performance. Lastly, but very recently Weinberg, Miller, and Horn (2012) examined the effectiveness of different types of self-talk (instructional, motivational, and combined) and the self-determined nature of self-talk (assigned versus freely chosen) on one-mile run (endurance) performance. Eighty-one collegiate cross-country runners participated in their non-laboratory study. After participants completed a one-mile baseline run, they were assigned to one of six intervention groups; (1) combined motivational/instructional self-set, (2) combined motivational/instructional assigned, (3) motivational self-set, (4) motivational assigned, (5) instructional self-set, and (6) instructional assigned. Then, participants were administered a list of self-statements with an additional space for self-generated items adopted from the previous studies (e.g., Donohue et al., 2000; Miller & Donohue, 2003). The self-statements included 25 motivational (e.g., "stay tough," "I'm a winner," "I can do it") and 25 instructional (e.g., "high knee lift," "pump your arms," "run on your toes"). Their results revealed that the combined self-set, motivational self-set, and instructional assigned groups showed significant improvements in performance from pre-to post-test.

Despite these few field and laboratory investigations, studies examining the effectiveness of self-talk interventions and the reproducibility of self-talk strategies (motivational, instructional, and combined) in improving endurance performances are still missing or at its embryonic stage in the literature. However, Weinberg et al. (2012) field study mentioned above is regarded as a breakthrough for the advancement of designing and planning effective self-talk strategies for a one-mile run or related endurance tasks in the upcoming studies, though it was not pure self-talk intervention. Furthermore, Miller and Donohue (2003) used a one-mile run (an endurance task) in a non-laboratory environment but compared instructional and motivational self-statements to a music and control conditions. In addition, Donohue et al. (2000) used both instructional and motivational self-statements on female cross-country runners (again a non-laboratory environment). More importantly, the arousal-performance relationship has been emphasized when using an endurance task as compared to a fine motor task (e.g., Gould, Greenleaf, & Krane, 2002; Landers & Arent, 2010).

Self-talk in extreme environments

On the other hand, the effectiveness of self-talk on performance in extreme environments is lacking. Recently, two studies have examined the combined effects of positive self-talk with psychological skills training (goal setting, arousal regulation, and mental imagery) in stressful environments; in the cold (Barwood et al., 2006) and in the heat (Barwood, Thelwell, & Tipton, 2008). In particular, Barwood et al. (2008) examined the psychological skills training (goal setting, arousal regulation, mental imagery, and positive self-talk) effect on endurance performance (90 min run on the treadmill) in the heat in an environmental chamber. Eighteen participants completed three maximal-effort run of 90 min in the heat (30°C; 40% relative humidity). After the second run, participants were randomly assigned to a control and psychological skills training (PST) group. Self-talk was used to control negative statements that occurred before and during the third run. Participants were given the chance to identify the negative cognitions they experienced in the first and second run (e.g., "my legs are stiff, I feel tired" or "the heat is overwhelming, I'll have to slow down"). These negative statements were restructured in to positive ones and directed towards motivating themselves (e.g., "this is a challenge I'm going to meet, I have the mental tools to cope"). Also, participants were supplemented with statements about feelings of control over their running (e.g., "head up, shoulders back, and keep my stride length"). Their results revealed that the PST group ran significantly farther in the third run (8%; 1.15 km). They further concluded that PST suppressed the temptation to reduce exercise intensity during the final run. However, to identify the sole effect of any of these strategies used is impossible (Hardy et al., 2009).

The present study

Many theories linked with premature fatigue exercising in the heat acknowledged the existence of a reduction in the "drive" or motivation to exercise (Bridge, Weller, Rayson, & Jones, 2003; Gonzalez-Alonso, Teller, Anderson, Jensen, Hyldig, & Nielsen, 1999; Nybo & Nielsen, 2001). However, studies showed that this can be altered through psychological skills trainings (Patrick & Hrycaiko, 1998; Thelwell & Greenlees, 2003). Moreover, it has been hypothesized that endurance tasks such as one-mile run would be best performed at higher levels of arousal (Weinberg et al. 2012) as motivational self-talk usually focuses on increasing effort, energy, and positive affect (i.e., arousal). But, the effectiveness of self-talk investigated exclusively on endurance performance in the heat is lacking in the literature. Taken together, this study is the first to examine the effectiveness of self-talk (particularly motivational self-talk) on endurance cycling performance in stressful environment (i.e. in the heat).

Lastly, the exclusive effect of self-talk on physiological parameters has not been published so far. Barwood et al. (2008), however, included key physiological measures (e.g., $\dot{V}O_2$, skin and aural temperature, sweat production and evaporation, interleukin-6, and prolactin in whole blood) in their studies, although a non-significant result was obtained between PST and control groups. Hence, whether the use of self-talk enhances the physiological efficiency of athletes exercising in the heat is worth investigating. This study involved the following few but important physiological measures: oxygen consumption as it is associated with oxygen utilization (Colak & Ozcelik, 2003; Whipp 1994), respiratory quotient as it is associated with substrate utilization (Fink, Costill, & Van Handel, 1975; Rowell, 1974), and urine specific gravity as maintaining good hydration is important (Shirreffs, 2005) during endurance performance in extreme environmental conditions (such as humid and hot). Altogether, this study is the first to explore the effectiveness of self-talk on the above selected physiological parameters while cycling in stressful environment (such as in the heat).

METHOD

Participants

Participants were initially invited through advertisement, which mainly emphasized on looking for active and trained individuals. Following the advertisement sixteen male adults volunteered to participant in the study. Their mean age was 22.50 years (SD = 4.89). All participants were non-smokers, non-alcoholic, free from respiratory, metabolic, or cardiovascular disease, musculoskeletal or joint problems, and previous heat illness at the time of the study. Overall, participants were active and trained (involved in an organized sport such as swimming and cycling four to five times per week), healthy and well-aware of cycle ergometer exercise.

Procedures

The study received ethical approval from the University of Thessaly ethics committee. Participation involved four visits including a baseline assessment followed by training and then experimental testing that took place over a period of 5 days to determine the effect of the experimental conditions.

Preliminary assessment

Day 1 / Session 1. All participants gave their written informed consent to participant following brief explanation about the procedures of the overall experiment; benefits and associated risk of the study were given upon their first lab visit. No participants declined post-consent participation. During this visit, clear instructions about the baseline maximum oxygen uptake ($\dot{V}$ O_{2max}) protocol were conveyed to all participants. Height (cm) and weight (kg) were measured using standard laboratory equipment. Then, participants’ baseline $\dot{V}$ O_{2max} was also measured using a breath-by-breath-based portable system (Oxycon Mobile, CareFusion - Jaeger, Hoechberg, Germany). The breath-by-breath data were processed in the PC-software called LabManager version 5.3.0 (Windows XP) program. The software recorded data at every 5 seconds. The test was generated from Flouris, Metsios, Jamurtas, & Koutedakis (2010), which was involved a 3-min warm-up period of steady-state cycling (Monark 874 Ergomedic, Sweden) at 60 watt, followed by increments of 30 watt per min until volitional exhaustion. Pedaling rate was maintained at 60 rpm throughout. The highest oxygen uptake (ml/kg/min) for any 5-second interval was taken as the participant's maximal oxygen uptake. Eventually, participants were randomly assigned to the following groups based on their baseline $\dot{V}O_{2max}$ score: self-talk group (n = 8) and control group (n = 8).

Training phase

Day 2-3 / Sessions 2-3. On the second and third successive days of the study, the self-talk group received self-talk training. The training included using self-talk cues while pedaling on Monark bicycle ergometer. The test involved a 2-min warm-up period of steady-state cycling at 60 watt, followed by increments of 30 watt for every two min at a cadence of 60 rpm for 12 min with a total load of 126 watt. The specific self-talk (motivational self-talk) cues used were "let's go", "nice", "keep going", "stronger", "hold on" etc. in a local language. Participants were given the opportunity to choose from the given lists of motivational self-talk cues. In addition, participants were carefully instructed and asked to rate their perceived exertion on Borg's scale (6 = no exertion at all to 20 = maximal exertion) in every two min. This manipulation was used to increase the resistance on the Monark and to get participants familiar with the RPE measure. Furthermore, the RPE was used as a reminder for participants to use the self-talk cues. At the end of the self-talk training participants were given a manipulation check questionnaire asking how often did they use the key words that they selected on a 10- point scale, from 1 (not at all) to 10 (all the time). None of the participants had prior experience in the use of structured self-talk strategies. The self-talk training was carried out by a specialist. But, participants' in the control group were subjected to conditioning training with a similar pedaling protocol as that of self-talk group without any treatment. Also, participants were asked to rate their perceived exertion in every two min.

Day 4. All participants went off on the fourth day. At this time, participants were instructed not to eat and drink (except water) within three hours, to avoid passive smoking, caffeine ingestion (e.g., coffee) within twelve hours, no strenuous exercise within 24 hours, and to rest completely prior to the experimental testing.

Experimental testing

Day 5 / Session 4. Prior to the actual experiment, the chamber was heated until the average ambient temperature reached to 35 degree Celsius (ºC). All the volume and gas calibration for the VO_2 was done inside chamber. On the experiment day, all participants ingested a 0.5 liter of water prior to the initiation of pedaling exercise on Monark bicycle to ensure that everyone started at the same level of hydration and promote euhydration to all participants in both groups. A study conducted by Nolte, Noakes & Vuuren (2011) concluded that the *ad libitum* fluid intake ensures safe thermoregulation and preserves serum sodium concentration while exercising in extreme dry heat environment. However, water consumption after the start of the experimental was prohibited for both groups. While drinking their given 0.5 liter of water, brief description about the experiment was reiterated once again to each participant to ensure better understanding of the protocol and procedures.

After drinking their water participants were given identical white T-shirt made of the same material. Height and percent body fat measurements were obtained barefooted. Then, participants were asked to collect 80 ml urine sample through a high degree of transparent disposable plastic urine cup container. Afterward, participants' body weight was measured barefooted. Finally, participants were asked to wear a comfortable vest for the Oxycon Mobile units and a face mask before subjecting them into the environmental chamber.

Experimental protocol

Before the experiment. Warm-up was not prescribed for both groups before pedaling. However, participants had the opportunity to do stretching exercises before taken into the environmental chamber. Then participants were taken to the chamber and the ambient conditions inside the environmental chamber were ranging from 34.5 ºC to 35.5 ºC. Relative humidity inside the environmental chamber was within the range of 25% - 77%. Seat height and handlebars of the Monark bicycle ergometer were adjusted at the participants' convenience

During the experiment. Participants performed pedaling at a cadence of 60 rpm for 30 min while maintaining a rating of perceived exertion (RPE) of 14 on a 6 – 20 Borg's scale, which corresponds to an intensity between 'somewhat hard' and 'hard' (Borg, 1982; Hartley, Flouris, Plyley & Cheung, 2012). All participants completed the 30 min cycling exercise in the heat.

Perceived exercise intensity protocol. The perceived exercise intensity employed for this study was generated from Hartley et al's. (2012) perceived exercise intensity protocol. A RPE of 14 on 6 – 20 scale (between 'somewhat hard' and 'hard') was chosen as results proved that pedaling at a higher level of perceived exertion such as 16 on the Borg scale, even in 15^{o}C, would cause decreased power output continuously and volitional fatigue in less than 60 min (Borg, 1982). On the other hand, pedaling at a RPE of 14 would permit completion of exercise without premature fatigue (Hartley et al., 2012). However, in this study participants were instructed to cycle at 60 watt for the first min, followed by increments of 30 watt/min until participants' attained a RPE of 14. Participants were asked their perceived exercise intensity for every 30 watt increment. On the average participants required four min to reach to 14 in Borg's scale was recorded. Then participants had given the freedom to ask the experimenter to put off weight whenever their perceived exercise intensity reached to a higher level of perceived exertion or to add weight whenever they perceived a lower level of perceived exertion. In other words, participants had free control of the resistance, hence the power output. Participants received no feedback on the load and time; every effort was maintained with this regard by the experimenter. The laptop (display monitor) was shielded from the participants. Also, the time on Monark screen was covered throughout by an adhesive tape to avoid any temporal clues from the participants. The only feedback the participants received during the experimental testing was a reminder at 5 min intervals to maintain an RPE of 14. Participants were accustomed with how to rate RPE carefully during the training sessions and well instructed prior to the test to ensure consistency among participants.

During the experimental testing, participants reported every 5 min their rate of perceived exertion, to ensure they were within the appropriate range and in addition their perceptions of thermal comfort and thermal sensation. Participants of the self-talk group were instructed to use the reporting of the RPE as a reminder for using their self-talk cues.

Finally, the temperature and the humidity of the environmental chamber were recorded every 5 min.

After the experiment. Following data collection, the attached sensors were removed and participants were taken outside the chamber. Post-body weight was measured immediately. Then participants were asked to collect 80 ml of urine sample. Then participants were given water.

Measures

Anthropometric measurements

Height. Height (cm) measurement was obtained barefooted at mid-expiration using a stadiometer (Seca, Vogel and Halke, Hamburg, Germany).

Percent body fat. Participants were asked to undergo percent body fat (using TANITA BF522W, Tokyo, Japan) measurement with barefoot.

***Body weight*.** All participants' body weight (kg) was measured using a precision weighing instrument (KERN & SOHN GmbH D-72336, Balingen, Germany) before and immediately after cycling.

Manipulation checks

***Self-talk use in training and experimental testing*.** Two protocols were used for the manipulation check. The first involved the use of self-talk during training for the participants of the self-talk group. Participants were asked to indicate how frequently they were using the motivational self-talk cues on a 10-point scale, from 1 (not at all) to 10 (all the time). The second protocol involved the use of self-talk for the experimental testing.

Participants in the self-talk group were asked to indicate (a) how frequently they were using their chosen self-talk cues, (b) whether they were using some other type of self-talk, (c) if so, what were they saying to themselves, and (d) if so, how often, on a 10-point scale (1 = few times, 10 = all the times). During the experimental testing, participants in the control group were asked to indicate (a) whether they used any forms of self-talk, (b) if so, what were they saying to themselves, and (c) if so how often, on a 10-point scale (1 = few times, 10 = all the times) after the final test.

Temperature and humidity of the environmental chamber. The temperature and humidity of the chamber were recorded every five min.

Rating of Perceived Exertion (RPE). Developed by Borg (1982) is a simple method to assess an athlete's level of intensity in training and competition. It is an individual's rating of exercise intensity, formed by assessing their body's physical signs such as heart rate, breathing rate and perspiration/sweating. The 15 point scale i.e. 6-20 (6 = No exertion at all, 20 = Maximal exertion) was used. Participants were asked as to whether they maintained a RPE of 14 or not at every 5 min.

Experimental measures

Performance measure

Power Output. The mechanically braked Monark cycle ergometer (Monark 874 Ergomedic, Sweden) devise was used to assess the aerobic capacity (performance output) of the participants. Participants were cycled at a cadence of 60 rpm for 30 min based on the perceived exercise intensity protocol mentioned above. In a calibrated common friction-braked cycle ergometers (e.g., Monark) have flywheel diameters that allow 6 m of horizontal distance traveled per flywheel revolution (6 $m.rev^{-1}$). The force is determined by the amount of resistance on the flywheel. Power output was calculated using the following equation:

$$\text{Power Output } (kg.m.min^{-1}) = rev.min^{-1} \times m.rev^{-1} \times kg$$

Power output for the entire 30 min was calculated using the above equation and the data was fragmented into six interval taking averages at every 5 min for the data analysis.

Physiological measures

Oxygen consumption (VO_2). Keller and Katch (1991) defined oxygen consumption (VO_2) as a measure of the volume of oxygen that is used by the body to convert the energy from the food we eat into energy molecules, known as adenosine triphosphate (ATP). VO_2 was measured using Oxycon Mobile, CareFusion - Jaeger, Hoechberg, Germany (a breath-by-breath-based portable system). First, the mouthpiece sensor was attached to the face mask; second the Oxycon Mobile units (total weight 950 gram) to the vest on the participant's chest. Then the devise recorded breath-by-breath data were processed in the PC-software called LabManager version 5.3.0 (Windows XP) program in order to determine the VO_2. The software recorded data at every 5 seconds. Then the data were split into six intervals taking averages at every 5 min for the data analysis.

Respiratory quotient. McClave, Lowen, Kleber, McConnell, Jung, and Goldsmith (2003) defined it as the ratio of carbon dioxide production (VCO_2) to oxygen consumption (VO_2). It is a sort of an indirect calorimetry (IC). Respiratory quotient was determined by taking the ratio of VCO_2 to VO_2 which were measured using Oxycon Mobile processed in the PC-software (LabManager version 5.3.0, Windows XP). Similarly, the software recorded data at every 5 seconds. Then the data were split into six intervals taking averages at every 5 min for the data analysis. Based on the previous physiologic studies, a very specific well-documented physiologic range for the overall respiratory quotient exists between 0.67 - 1.3. But, the following index was used based on the measured respiratory quotient for each participant: 0.70 for fat, 0.80 for protein, and 1.00 for carbohydrate.

***Urine specific gravity*.** All the collected urine samples were analyzed using a refractrometer (Atago, Tokyo, Japan) (Flouris & Cheung, 2010) for the determination of urine specific gravity. A pipette was used to put a drop of urine sample on the refractrometer to read the result. Euhydration was defined as urine specific gravity < 1.02 according to internationally accepted standards (Hartely et al., 2012; Kavouras, 2002).

Psychological measures

Thermal comfort and ***thermal sensation***. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (1966) defined thermal comfort as a state of mind which expresses satisfaction with the thermal environment. Thermal sensation, which has a large influence on thermal comfort, denotes an individual's assessment of the thermal status of the immediate surroundings. Both are assessed by subjective evaluation. The 5 point scale based on ANSI/ASHRAE Standard 55 for thermal comfort (1 = comfortable, 3 = uncomfortable, 5 = extremely uncomfortable) and "0 = unbearably cold, 5 = neutral, 10 = unbearably hot" for the thermal sensation scale was used. Thermal comfort and thermal sensation were recorded at every 5 min. Furthermore, temperature and humidity of the environmental chamber was recorded every 5 min. The data for thermal comfort, thermal sensation, temperature and humidity of the chamber were split into seven intervals taking averages at every 5 min for the data analysis.

Statistical analysis

Groups were compared for baseline differences in $\dot{V}O_{2max}$, percent body fat, urine specific gravity, and body weight using an independent samples t-test. Two-Way Repeated Measures ANOVAs with one repeated factor (time: six 5-min intervals) and one independent factor (group: experimental, control) were conducted to test for differences in power output, urine specific gravity, VO_2, and respiratory quotient. Two-Way Repeated Measures ANOVAs with one repeated factor (time: seven 5-min intervals) and one independent factor (group: experimental, control) were also employed to test for differences in thermal comfort and thermal sensations and to test for manipulation check differences in temperature and humidity of the chamber. Statistical analyses were carried out using the software program IBM SPSS, version 20.0 (Statistical Package for Social Sciences, Chicago, IL). In all cases, α level 0.05 was taken.

RESULTS

Baseline differences

% body fat and body weight. To ensure that body fat and body weight of the two groups were similar, independent samples t-test was calculated to test for differences in % body fat, and body weight as a function of group. The analysis revealed no significant differences between the two groups in % body fat, $t\ (14) = 0.42\ (p = .68)$ and in body weight, $t\ (14) = 1.51\ (p=.15)$.

VO_{2max}. To ensure that the aerobic capacity of the two groups was similar, independent samples t-test was calculated to test for differences in $\dot{V}O_{2max}$ as a function of group. The analysis revealed no significant differences between the two groups, $t\ (14) = 0.60\ (p=.56)$.

Urine specific gravity: To ensure that euhydration status of the two groups was similar, independent samples t-test was calculated to test for differences urine specific gravity as a function of group. The analysis revealed no significant differences between the two groups in their pre- urine specific gravity, $t\ (14) = -1.25\ (p = .23)$.

Manipulation checks

Use of self-talk during training and testing. Participants of the experimental group reported consistent use of self-talk during both training (mean score 8.25±1.16) and experimental testing (mean score 8.75±1.04). In addition, no participant from the control group reported consistent use of self-talk during the experimental testing.

Temperature of the chamber. The temperature for the cycling was (M = 34.76 ºC SD = .35). Two-way (2 × 7) mixed measures ANOVA with one repeated factor (time:

seven 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in temperature of the chamber throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, $F\ (6, 9) = 1.51, p = .28$, $\eta^2 = .50$, observed power = .34. A non-significant main effect was identified for time, though approached significance, $F\ (6, 9) = 3.17, p = .06$, $\eta^2 = .68$, observed power = .65, showing the temperature of the chamber increased from min 0 to min 5, then increased for the rest of the periods. However, the increase was within the predetermined range (34.5 ^oC – 35. 5 ^oC). Temperature of the chamber throughout the 30 min of cycling exercise is displayed in Figure 1.

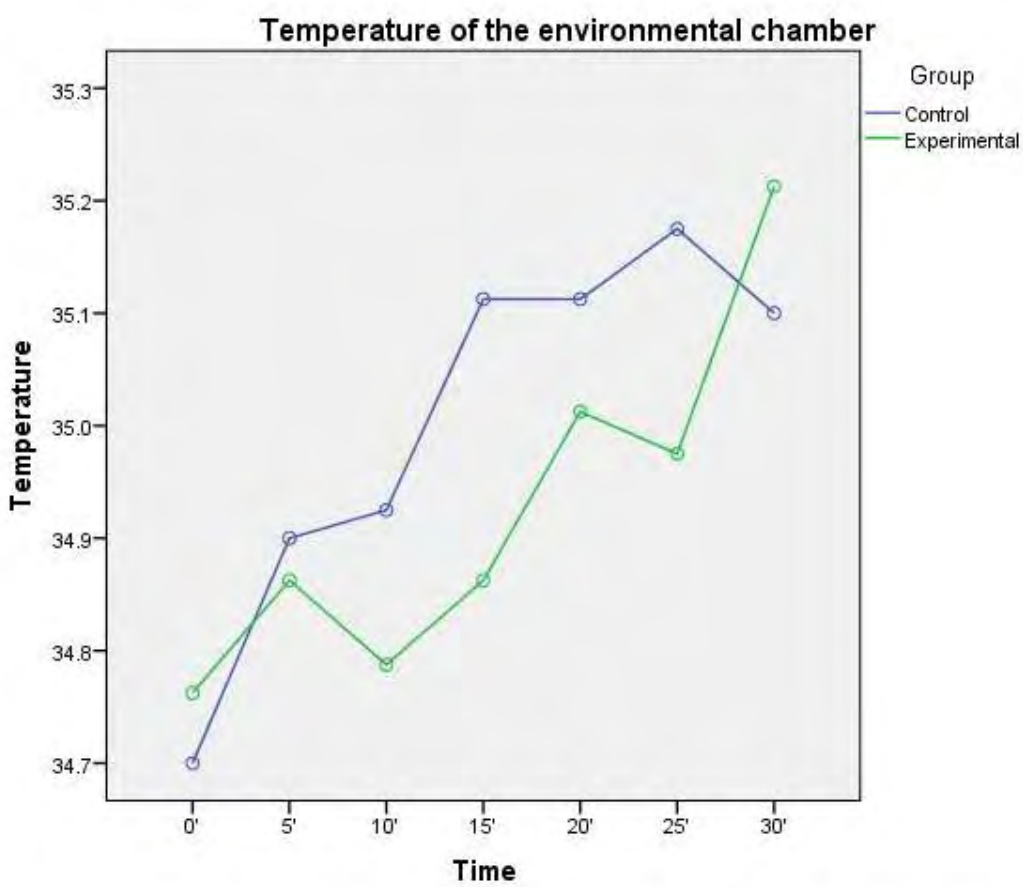

Figure 1. Temperature of the environmental chamber per group for every 5 min.

Humidity of the chamber. The humidity for the cycling was (M = 38.44%, SD = 9.71). Two-way (2 × 7) mixed measures ANOVA with one repeated factor (time: six 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in humidity of the chamber throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, $F(6, 9) = 1.22$, $p=.38$, $\eta^2 = .45$, observed power = .27. A significant main effect was identified for time, $F(6, 9) = 36.03$, $p < .01$, $\eta^2 = .96$, observed power = 1.00, showing the humidity of the chamber increased from min 0 to min 5, then increased for the rest of the periods. However, the increase was dependent upon the number of materials placed inside the chamber, sweating from the participant, and the presence of the experimenter. Humidity of the chamber throughout the 30 min of cycling exercise is displayed in Figure 2.

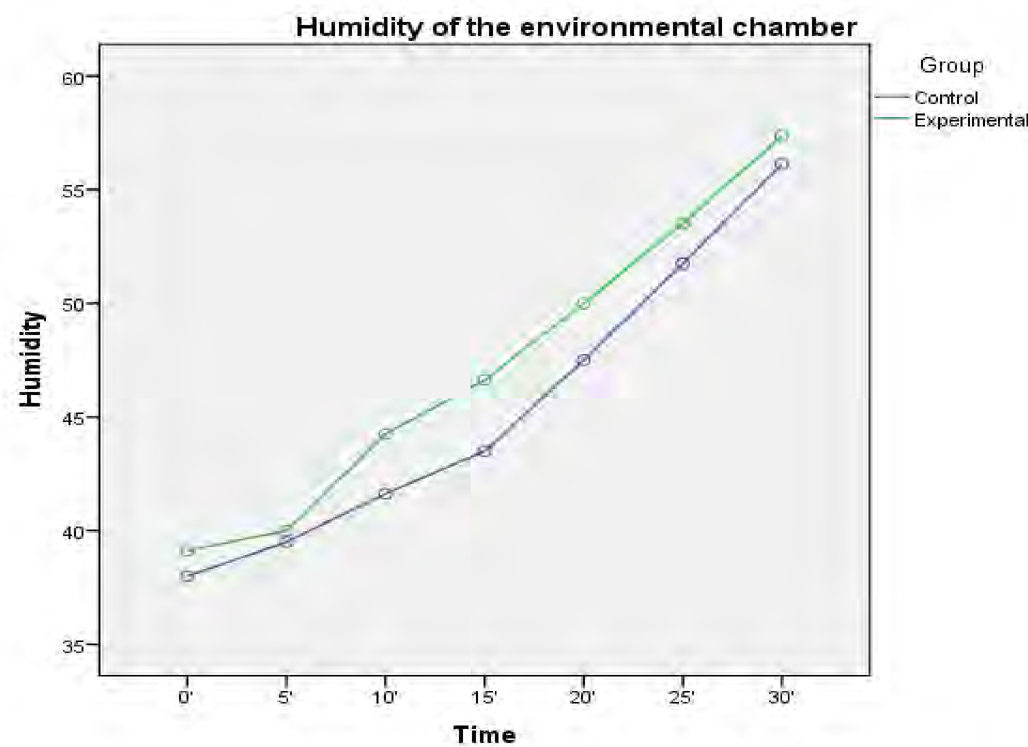

Figure 2. Humidity of the environmental chamber per group for every 5 min.

Rating of perceived exertion. Two-way (2 × 6) mixed measures ANOVA with one repeated factor (time: six 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in RPE throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, $F(5, 10) = 1.98, p = .17, \eta^2 = .50$, observed power = .43. A significant main effect was identified for time, $F(5, 10) = 10.47, p < .01, \eta^2 = .84$, observed power = .99, showing the RPE increased from min 0 to min 5, then increased for the rest of the periods. However, the increase was within the predetermined range in the Borg's scale i.e., 13 - 15. RPE throughout the 30 min of cycling exercise is displayed in Figure 3.

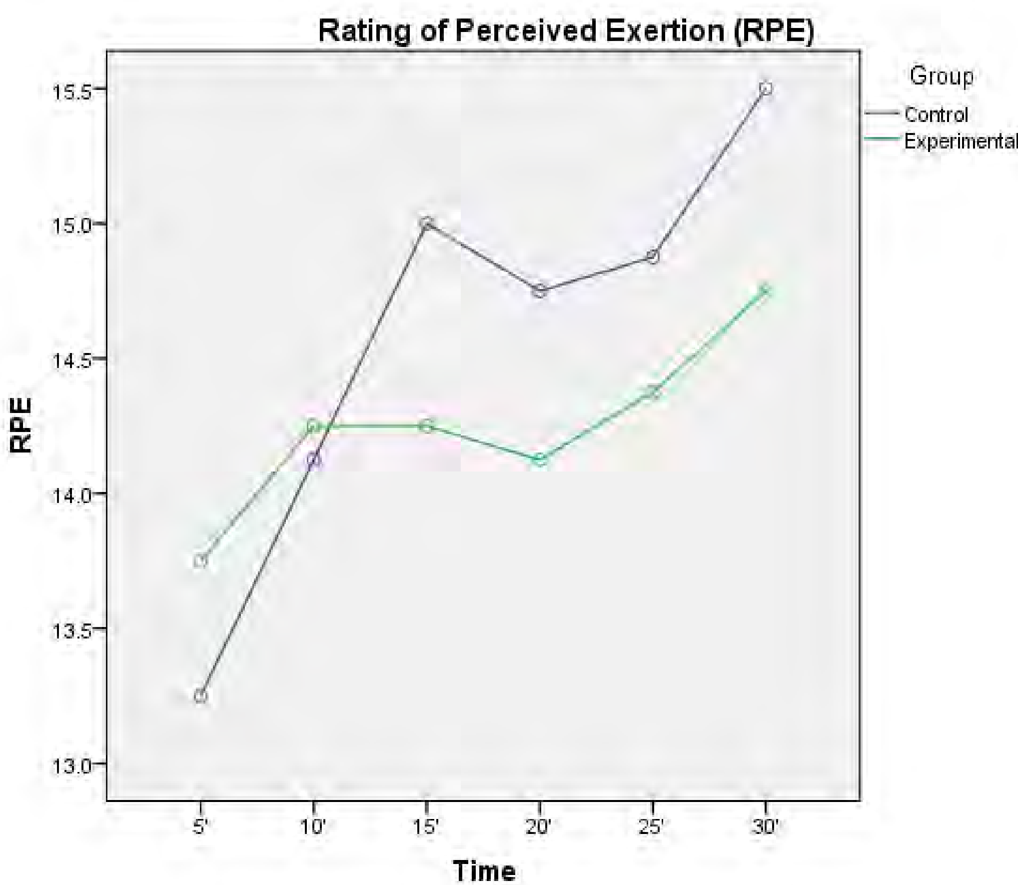

Figure 3. Rating of perceived exertion per group for every 5 min.

Experimental measures

Performance (power) output. Two-way (2 × 6) mixed measures ANOVA with one repeated factor (time: six 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in power output throughout the 30 min of exercising as a function of group. The analysis revealed a significant group by time interaction, $F (5, 10) = 7.63, p < .01$, $\eta^2 = .79$, observed power = .97. Examination of the pairwise comparisons per time revealed that, for the control group power output increased from min 5 to min 10 (p <.01) and then decreased steadily to min 15 (p < .01), min 20 (p < .01), min 25 (p < .01), but not significant for min 30 (p = .35); whereas for the experimental group power output increased from min 5 to min 10 (p < .01) and then remained stable throughout the rest of the exercising time. Examination of the pairwise comparisons per group showed that there were no significant differences between the two groups at min 5, although it approached significance, (p = .06), at min10 (p = .49), min 15 (p = .83), and min 20 (p = .12), however a significant difference was observed for min 25 (p < .01) and min 30 (p < .01), when the self-talk group had higher scores than the control group. Performance output throughout the 30 min of cycling exercise is displayed in Figure 4.

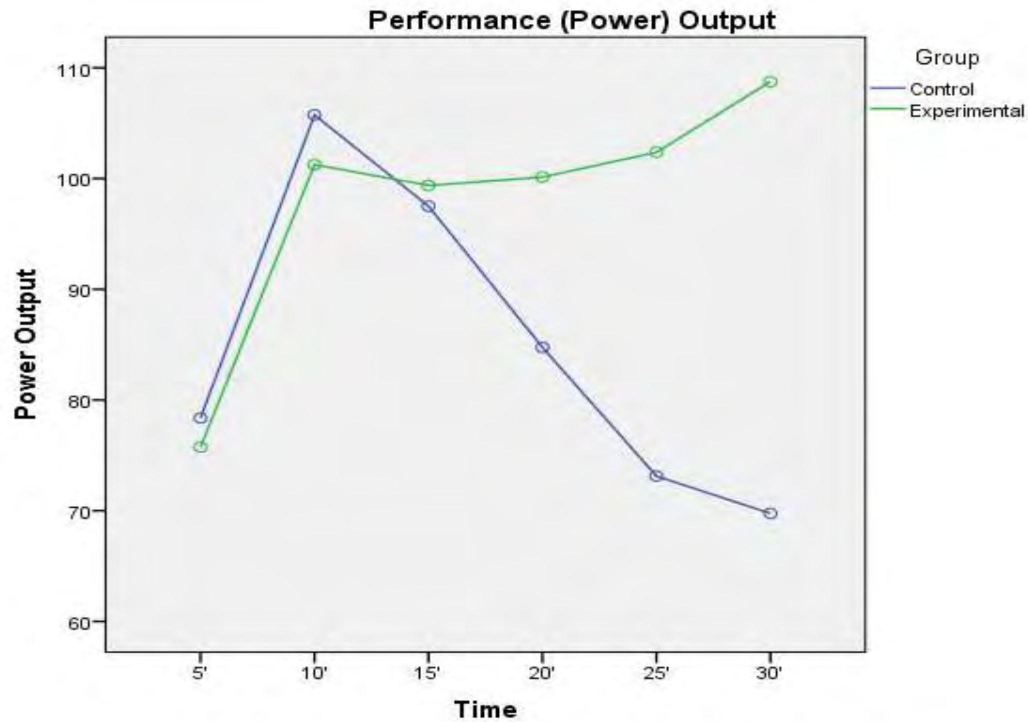

Figure 4. Performance (power) output per group for every 5 min.

Physiological measures

Oxygen consumption (VO_2). Two-way (2 × 6) mixed measures ANOVA with one repeated factor (time: six 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in oxygen consumption throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, though approached significance, $F(5, 8) = 3.25$, $p = 0.07$, $\eta^2 = .67$, observed power = .60. Examination of the pairwise comparisons per time revealed that, for the control group VO_2 increased from min 5 to min 10 ($p < .01$) and then decreased gradually to min 15, but not significant ($p = .17$), min 20 ($p = .11$), min 25, but significant ($p < .01$) and min 30 ($p < .01$); whereas for the experimental group VO_2 increased from min 5 to min 10 ($p < .01$) and then remained stable, but not significant for min 15 ($p = .92$) and min 20 ($p = .32$). Then VO_2 increased from min 25 to min 30 (p <

.01). Examination of the pairwise comparisons per group showed that there were no significant differences between the two groups at min 5 (p = .93), at min 10 (p = .67), at min 15 (p = .96), at min 20 (p = .65), at min 25 (p = .20), and at min 30, although it approached significance, (p = .08), when the experimental group had higher scores than the control group. Despite the lack of significance the identified pattern for VO_2 resembled as that of the performance output. Oxygen consumption throughout the 30 min of cycling exercise is displayed in Figure 5.

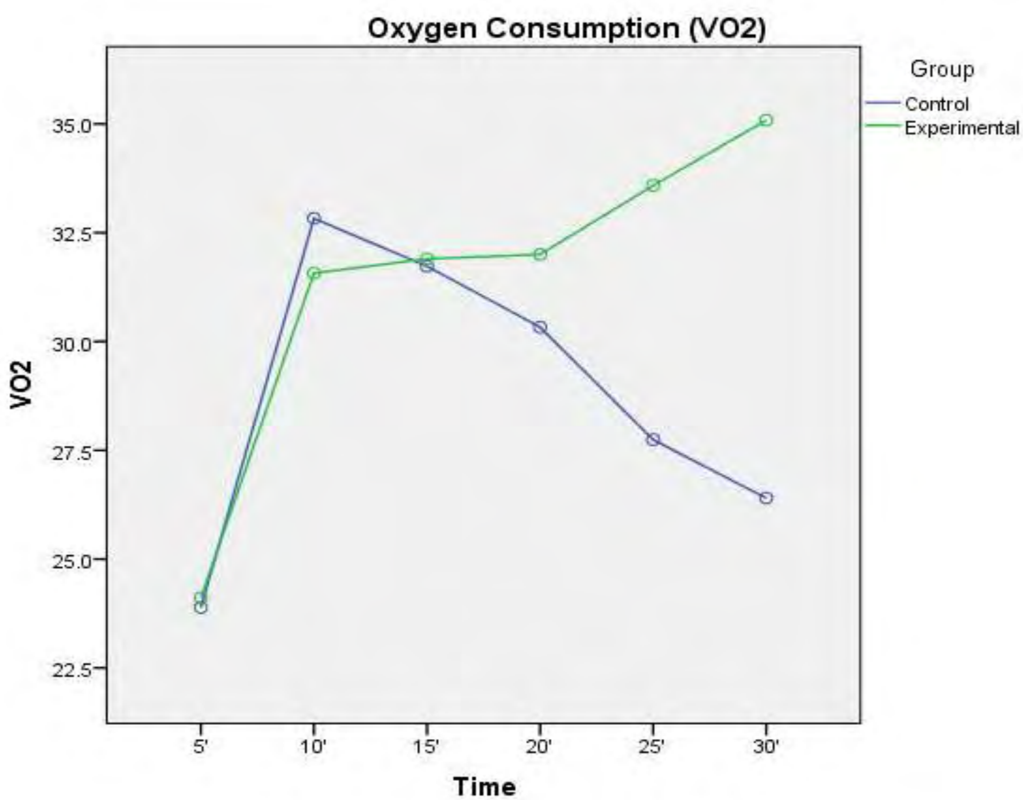

Figure 5. Oxygen consumption per group for every 5 min.

Respiratory quotient. Two-way (2 × 6) mixed measures ANOVA with one repeated factor (time: six 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in respiratory quotient throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, *F (5, 8) = 1.18*, *p = .40*, η^2 = .42, observed power = .24. A significant main effect was identified for time, *F (5, 8) = 10.45, p < .01*, η^2= .87, observed power = .99, showing the respiratory quotient increased from min 0 to min 5, then decreased from min 10 to min 15, to min 20, to min 25, and to min 30. Respiratory quotient throughout the 30 min of cycling exercise is displayed in Figure 6.

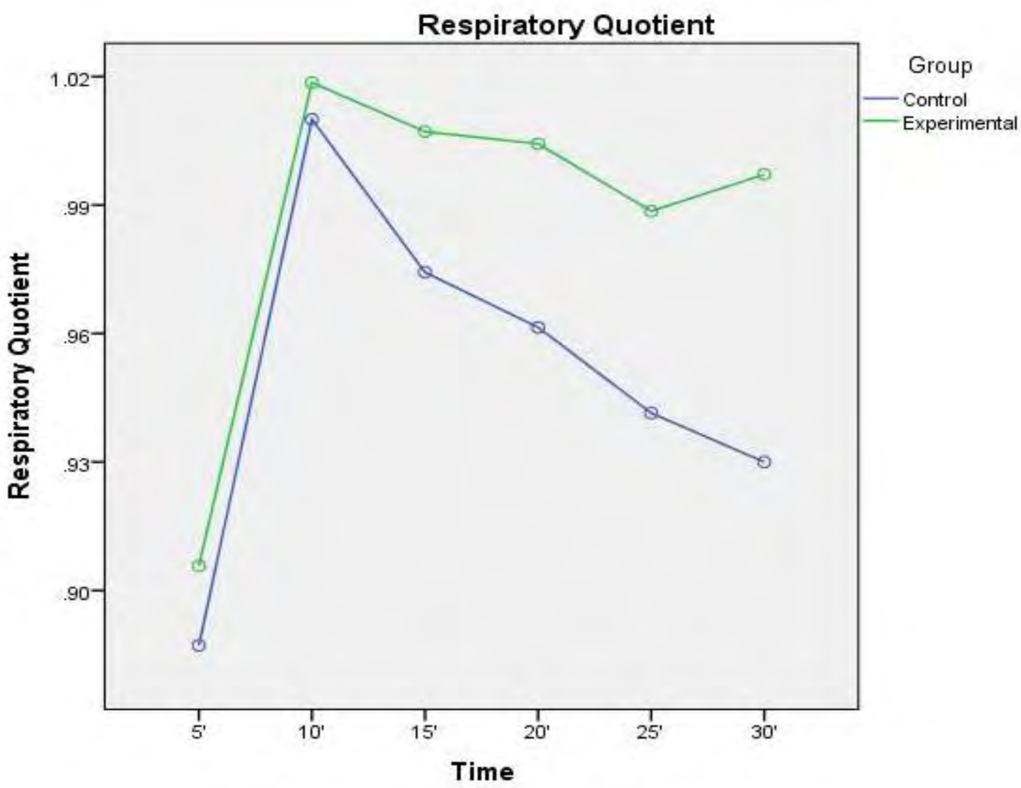

Figure 6. Respiratory quotient per group for every 5 min.

Urine specific gravity. Two-way (2 × 2) repeated measures ANOVA with one dependent factor (time: pre, post) and one independent factor (group: experimental, control) were calculated to test for differences in the change of urine specific gravity before and after pedaling for 30 min in a hot chamber as a function of group. The analysis showed a significant time by group interaction, *F (1, 14) = 6.11, p < .05*, η^2 = .30, observed power

= .63. Examination of the pairwise comparisons per time showed that urine specific gravity for the control group decreased ($p < .01$) whereas for the experimental group did not change significantly ($p = .45$). Examination of the pairwise comparisons per group showed no significant differences pre- ($p = .23$) and post-cycling ($p = .61$). Pre- to post- urine specific gravity change for both groups is displayed in Figure 7.

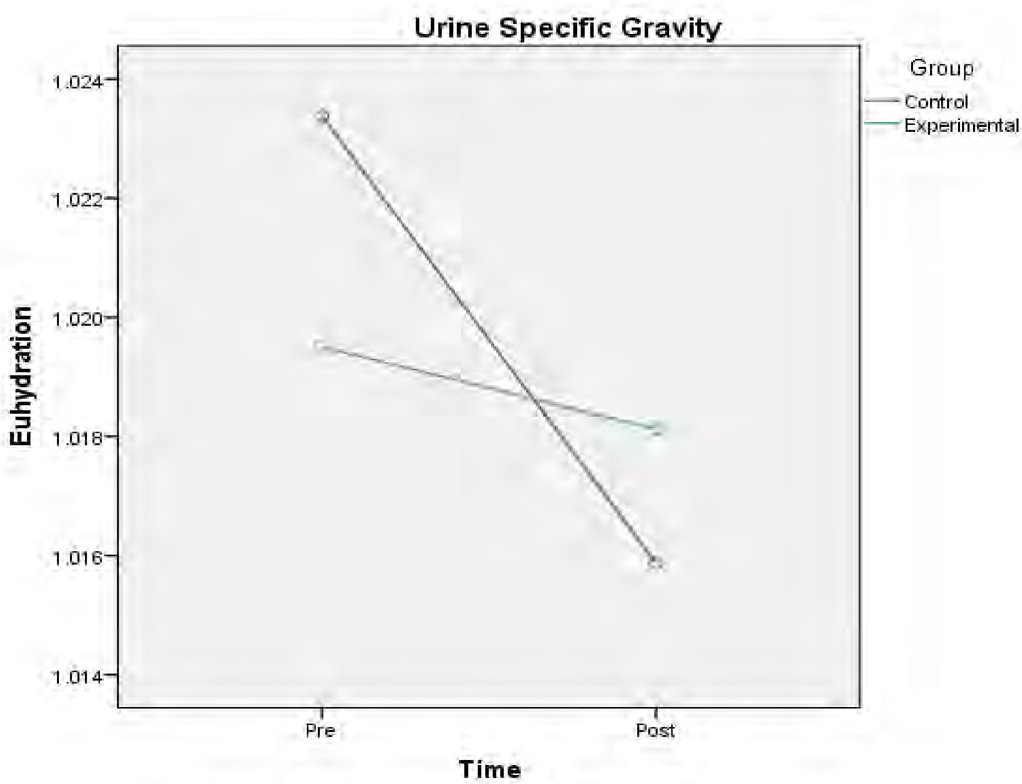

Figure 7. Urine specific gravity per group for pre- and post- experiment

Psychological measures

Thermal comfort. Two-way (2 × 7) mixed measures ANOVA with one repeated factor (time: seven 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in thermal comfort throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, $F\ (6, 9) = 1.56$, $p = .26$, $\eta^2 = .51$, observed power = .35. A significant main effect was identified for time, $F\ (6, 9) = 25.83$, $p < .01$, $\eta^2 = .95$, observed power = 1.00, showing thermal discomfort increased from min 0 to min 5, then increased for the rest of the periods. Thermal comfort throughout the 30 min of cycling exercise is displayed in Figure 8.

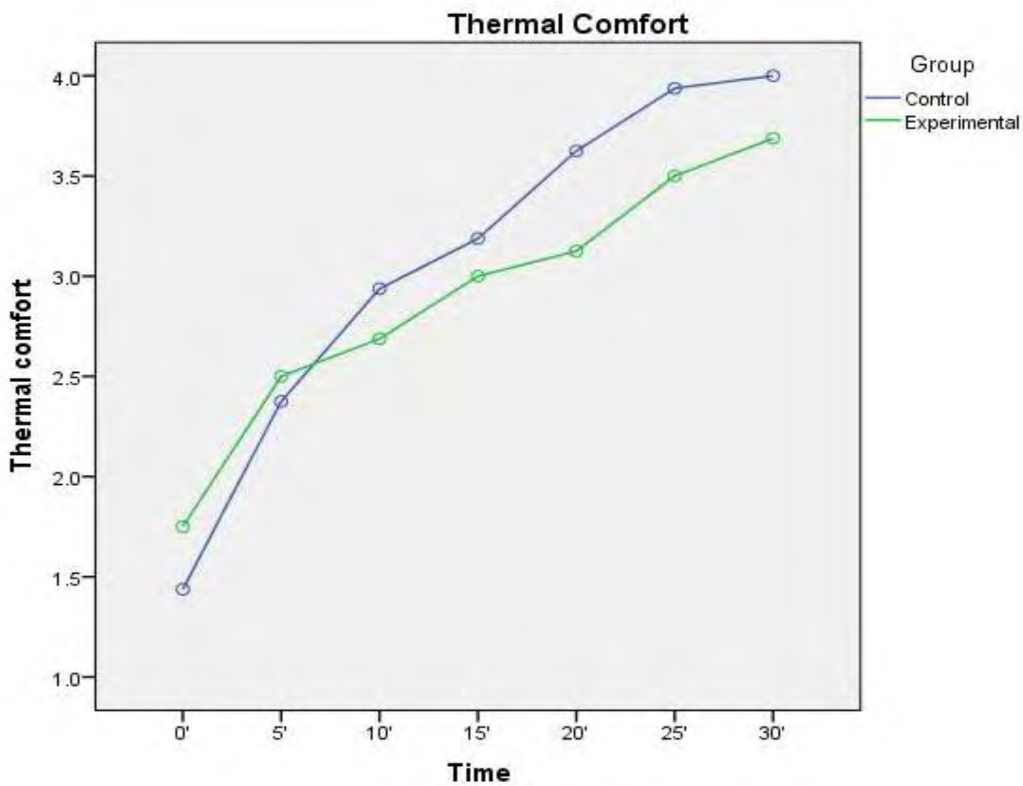

Figure 8. Thermal comfort per group for every 5 min.

Thermal sensation. Two-way (2 × 7) mixed measures ANOVA with one repeated factor (time: seven 5-min intervals) and one independent factor (group: experimental, control) were calculated to test for differences in thermal sensation throughout the 30 min of exercising as a function of group. The analysis revealed a non-significant group by time interaction, $F\ (6, 9) = 1.37$, $p = .32$, $\eta^2 = .48$, observed power = .31. A significant main effect was identified for time, $F\ (6, 9) = 15.47$, $p < .01$, $\eta^2 = .91$, observed power = 1.00, showing thermal sensation increased from min 0 to min 5, to min 10, to min 15, to min 20, to min 25, and to min 30. However, the increase in thermal discomfort and thermal sensation was partly due to the increased temperature and humidity of the environmental chamber. Thermal sensation throughout the 30 min of cycling exercise is displayed in Figure 9.

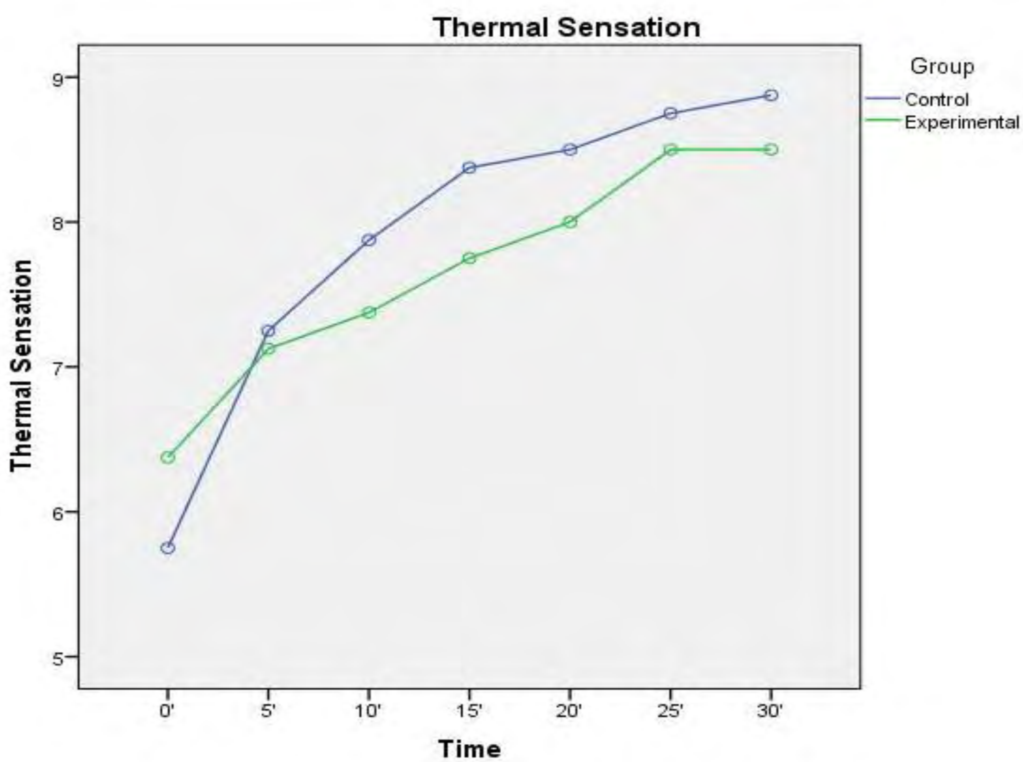

Figure 9. Thermal sensation per group for every 5 min.

DISCUSSION

This study examined, for the first time, the effect of a self-talk intervention on endurance cycling performance in the heat in male adults. Furthermore, effects on psychological (thermal comfort and thermal sensation) and physiological measures (VO_2, respiratory quotient, and urine specific gravity) were recorded to assess whether increases in those measures were related to increases in performance output. This study is unique in two ways. Firstly, the effectiveness of self-talk as a cognitive strategy (particularly the impact of motivational cues) in stressful environmental (i.e., in the heat) conditions during endurance exercise was tested. Secondly, the study involved physiological measures for the first time in the self-talk literature. In the literature, self-talk has been well-documented as an effective strategy for performance enhancement. The findings of this study enable us to understand how participants' cycling endurance performance improved through a self-talk strategy in extreme environment (e.g., in the heat).

The independent samples t-test analysis revealed that there was no significant differences between the self-talk and control group in their baseline measures; $\dot{V}O_{2max}$, % body fat, urine specific gravity, and body weight. This ensured to identify the post-performance difference was due to the treatment given or other factors. As for the manipulation checks, identified by Hardy, Hall, Gibbis, and Greenslade (2005) the importance of detailed post-manipulation checks, because participants assigned in the self-talk group might use additional self-talk and participants in the control group might use self-talk as well. As a result, the experimental validity would be at stake. Following Hardy et al.'s recommendation, manipulation checks were assessed during the self-talk training sessions (only for the self-talk group) and after the experimental testing (for both self-talk and control groups). The results from the self-talk manipulation checks showed that participants of the experimental group made adequate use of self-talk in both training and testing, whereas participants of the control group did not report any systematic pattern of self-talk strategies. Two more manipulation checks were applied involving the testing conditions. The results showed no group by time difference in chamber temperature and humidity, thus confirming that the testing conditions were similar for the experimental and the control groups and strengthening the internal validity of the study. Finally, the most important manipulation check involved the reported rating of perceived exertion, as this was the cornerstone on which the experimental protocol was based. The results showed no group by time interaction, thus suggesting that the two groups experience similar rates of perceived exertion during the testing, and allowing to meaningfully examining whether participants of the two groups produced different performance while reporting similar physical exertion.

The results from the performance output revealed that the self-talk group produced greater power output. Particularly the self-talk group improved their cycling performance by pedaling in a higher power output from the 25^{th} min to the 30^{th} min. Conversely, the control group produced lesser power output from the 15^{th} min onward (Fig. 4). In addition, rating of perceived exertion remain unchanged despite the greater output produced by self-talk group. The thermal tension linked with this study might be the cause for control groups' dropped power output. Hartley et al. (2012) concluded that the thermal environment influences voluntary power output and physiological responses while cycling at a constant perceived effort. The seemingly ability of overwhelming their RPE consciously by the self-talk group could be one of the reasons for their greater output. This is supported by Tikuisis, McLellan, and Selkirk (2002) that they suggested that the potential to suppress RPE, and sensations of hyperthermia could be the means by which performance is improved in trained individuals. Such results indicated that participants in self-talk group sustained their pedaling (on the Monark cycle ergometer) by suppressing the temptation to reduce the RPE. This phenomenon was also supported in Barwood et al.'s (2008) laboratory experiment involving endurance exercise (running on the treadmill) in the heat using psychological skills training (PST).

It has been hypothesized that endurance tasks (e.g., one-mile run) would be best performed at higher levels of arousal (Gould et al., 2002; Landers & Arent, 2010). This suggests that motivational self-talk, which usually focuses on increasing effort, energy and positive affect (i.e., arousal), can have significant impact on endurance cycling performance in the heat. Lastly, the effectiveness of self-talk used in this study was found a high positive effect size (d = .79). Hatzigeorgiadis et al. (2012) in their meta-analytic study found an overall moderate positive effect size (d = .48), and also a moderate effect size for learned tasks (d = .41), and a lower effect for tasks requiring strength and endurance (d = .26). Self-talk seemed to be effective in enhancing performance in this laboratory experiment to a larger extent, as identified by the effect size, thus suggesting that the effectiveness of self-talk strategies (particularly motivational self-talk cues) may be more effective for endurance performance in extreme environments.

One of the purposes of this study was to examine the effect of self-talk on selected physiological parameters. These parameters are now discussed. Regarding VO_2, although results only revealed an effect that approached significance, the self-talk group seemed to consume larger amount of oxygen (Fig. 5). Particularly the self-talk group consumed larger amount of oxygen from the 20th min onward. Conversely, the control group's oxygen consumption lowered from the 10th min onward. Such elevated oxygen consumption observed by the self-talk group might be due, in part, to increased effort made to complete the 30 min cycling endurance performance in the heat. This in turn may help to produce greater output; hence it supports the performance output findings. Despite little agreement regarding the effects of environmental temperature on oxygen consumption during exercise, most experimental investigations agreed that there are increased energy requirements in order to accommodate the elevated cost of respiration, circulation, and sweating effects on tissue metabolism in the heat (Fink et al, 1975; Rowell, 1974). This experiment also supports this hypothesis.

Respiratory quotient reflects the body's muscles substrate utilization (Colak & Ozcelik, 2002). The results of this study showed a non-significant group by time interaction for respiratory quotient (Fig. 6). In general, the substrate carbohydrate was utilized by both groups with more efficient utilization during cycling in the hot environment for the 30 min period. This may be associated with oxygen utilization which is more efficient in carbohydrate utilization (Colak & Ozcelik, 2003; Whipp, 1994). Overall, this study provides information concerning thermal strain may influence consumption of oxygen and utilization of carbohydrate substrate in endurance cycling performance. Therefore, it might be possible for the self-talk group to produce greater power output while cycling in the hot environment due to increased effort; hence increased oxygen consumption; hence utilization of carbohydrate substrate chiefly used by their working muscle.

In order to determine the hydration status of the two groups urine specific gravity was measured. It is commonly used, more of practical, non-invasive and a reliable instrument (Armstrong, Maresh, Castellani, Bergeron, Kenefick, et al., 1994; Shirreffs & Maughan, 1998; Kavouras, 2002; Oppliger & Bartok, 2002; Osterberg, Horsewill, & Baker, 2009; Flouris & Cheung, 2010) which has also been shown to correlate with urine osmolality (Casa, Armstrong, Hillman, Montain, Reiff, Rich, et al., 2000). In this study both groups started the experimental testing by consuming a 0.5 liter of water. Results showed a significant ($p < .05$) time by group interaction for differences in the change of urine specific gravity before and after the test. The control groups' urine specific gravity exhibited a slight dehydration (i.e., ~1.023) prior to cycling and nearly hydrated (i.e., 1.016) after cycling (Fig. 7) whereas urine specific gravity for the self-talk group did not change significantly throughout the 30 min endurance cycling performance. According to Casa et al. (2000), a urine specific gravity between 1.021 and 1.030 corresponds with a level of dehydration of 3% to 5% of body mass. However, self-talk groups' urine specific gravity was in a normal hydration state, ~1.019 and ~1.018 in the pre- and post- cycling periods, respectively. The importance of maintaining good hydration for endurance performance is also established (Shirreffs, 2005). The precise mechanism, however, that enabled the self-talk group produced greater power output in relation to their normal hydration status is difficult to justify.

Lastly, results for thermal comfort and thermal sensation revealed a non-significant effect for both groups. In general, both groups' discomfort (Fig. 8) increased steadily from the beginning (i.e., slightly uncomfortable) to the end (i.e., very uncomfortable) as time passed by while cycling in the heat. As for thermal sensation (Fig. 9), results showed that participants from both groups rated slightly warm at the beginning of cycling and very hot at the end of the experiment. Discomfort and thermal sensation and their physiological responses in the heat have been associated with increased body temperature, increased skin temperature, and sweating (Gagge, Stolwijk, & Hardy, 1967). Hence, participants in both groups were more uncomfortable while cycling in a hot environment; temperature of (M = 34.76°C, SD = .35) and humidity of (M = 38.44%, SD = 9.71). A study suggested that when participants are more uncomfortable during the hot conditions, the motivation to continue exercising would be compromised and the drive to exercise would reduce gradually (Bruck & Olschewski, 1987).

Overall, findings from this study revealed that no differences in manipulation checks (temperature, humidity, and RPE), psychological measures (thermal comfort and thermal sensation) and physiological measures (VO_2 and respiratory quotient) were obtained. Despite the non-significant for VO_2, the pattern supported the power output results. However, significant differences for power output and urine specific gravity were established. Despite the lack of differences in RPE, the performance of the two groups differed with the self-talk group displaying greater performance output. This performance output was supported through the pattern on VO_2 (which, however, was marginally non-significant). So, what caused the self-talk group to perform better in the hot environment? One reasonable explanation might be that the use of motivational self-talk suppressed feelings of perceived exertion and allowed participants to have a higher effort input, thus producing greater output. The results seem to support the psychological effect of the self-talk strategy in particular with regard to a motivational function.

Limitations

Some limitations of this study deserve comment. First, female populations were not considered as waiting them until they finish their menstrual cycle takes extended time to finish this thesis project. Second, the question of generalizability of the study is lacking. Third, lack of assessing core-temperature and skin-temperature, which are crucial factors during endurance exercise in the heat, probably made the study inconclusive with regard to physiological effects and may highlight the power output decrement by the control group. Moreover, as stated in the discussion section thermal discomfort and thermal sensation and their physiological responses in the heat are directly linked to increased body temperature, increased skin temperature, and sweating. Such limitation should be worth mentioning as increased thermal strain resulted from elevations in core and skin temperature during severe exercise in the heat. These in turn are associated with increased cardiovascular strain (Nybo & Nielsen, 2001; Gonzalez-Alonso, Crandall, & Johnson, 2008), a reduction in central blood volume (Rowell, 1974; Williams, Bredell, Wyndham, Strydom, Morrison, Peter, et al., 1962) and impaired performance (Rushall et al., 1988).

Future directions

Theodorakis et al. (2012) suggested cues involving positive words would increase the physiological efficiency of athletes. In addition, Gibson and Foster (2007) stated that a greater percentage of associative and motivational thoughts (such as feelings and affect, pace monitoring, etc.) are linked with increasing exercise intensity. And also, as exercise intensity increases (especially in extreme hot environment) the level of fatigue increases. Thus, fatigue is one of the major physiological factors that interferes (either one talks to himself/herself to terminate the exercise or to continue striving to reach to the end of the exercise or refrain from terminating the exercise) with the motivational self-talk while cycling in the heat. In line with this, other physiological factors such as excessive sweat, dehydration, and central neurotransmitter substances (e.g., serotonin and interleukin-6) that increase the sensation of fatigue and are known to contribute to the premature termination of exercise even in normal thermic conditions should be carefully considered in future research. Would motivational self-talk play an important role on the conscious suppression of the sensation of fatigue (one physiological factor) arising from high perceived intensity and combined effects of motivational self-talk in an endurance task in the heat are worth posing for further studies.

Self-talk has been recognized as an effective strategy for enhancing performance in various literatures. Hatzigeorgiadis et al. (2008) provided evidence concerning increases in self-efficacy plays an important role for elucidating the facilitative effects of self-talk on sport performance. Particularly, self-efficacy may have impact on endurance cycling performance in the heat. However, self-efficacy is not included in this study. Hence it would be applicable for further research to design and support the mediational role of self-efficacy and possibly other mechanisms to further enhance our understanding of the self-talk effectiveness.

Though the motivational cues resulted in increased power output in endurance cycling performance in the heat, which cues were particularly effective is still a question for future research. In addition, either the use of satisfactory inventories or through qualitative approach, whether how much participants in the self-talk group were satisfied with the cues they used during the training and after the experimental testing should also be considered for further research.

Participants in the self-talk group were given the chance to choose cues from the lists of motivational cues by themselves. This is important as it might allow participants to be more motivated intrinsically. This notion is supported by Deci & Ryan (1991), Vallernd & Losier (1999), and Weinberg et al. (2012). Hence, such concept should be underscored carefully, the way the present investigation implemented, for future investigations.

Lastly, a ground breaking suggestion for future research would be a combined effect of self-talk with hydration and fluid consumption as endurance performances have been highly affected by hydration and fluid consumption in humid and hot conditions (Armstrong, 2007; Shirreffs, 2005). In particular, field studies are missing in endurance performance; hence considering such settings would fill the gap in the literature.

Conclusions

It is a well-known fact that increases in thermal strain has been associated with impaired performance. It is possible to alter this stress by mental strategies. This study is unique in such a way that the effectiveness of self-talk (motivational self-talk) as a cognitive strategy in extreme environmental conditions during endurance exercise was examined. Besides, the combination of psychological and physiological measures in the self-talk literature makes this study groundbreaking. The result from this study revealed that self-talk group produced greater power output with a constant RPE than the control group. Participants' of the self-talk group through the use of motivational cues likely suppressed their temptations to reduce the RPE and sensation of increased temperature; hence greater output on the Monark cycle ergometer cycling exercise in an environmental chamber. Furthermore, the performance output was supported through the pattern on VO_2, though this value is slightly non-significant. Despite the mechanism is unclear, self-talk group maintained normal hydration status throughout the 30 min cycling exercise, which is essential to perform better in endurance tasks particularly in humid and hot environments. Accordingly, these are encouraging for future research in combining the psychological and physiological measures. In conclusion, motivational self-talk can produce greater power output in endurance cycling performance in the heat.

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APPENDICES

Appendix A

Self-talk manipulation check during the self-talk training sessions

Πόσο συχνά χρησιμοποίησες τις λέξεις κλειδιά που σου επέλεξες?

καθόλου									**συνέχεια**
1	2	3	4	5	6	7	8	9	10

Appendix B

Self-talk manipulation check during the experimental testing

Experimental Group

1. Πόσο συχνά χρησιμοποίησες τις λέξεις κλειδιά που σου επέλεξες?

καθόλου									**συνέχεια**
1	2	3	4	5	6	7	8	9	10

2. Τι αποτέλεσμα είχε η χρησιμοποίηση των λέξεων κλειδιά?

Οι λέξεις-κλειδιά που χρησιμοποίησα είχαν ως αποτέλεσμα …	**καθόλου**	**λίγο**	**αρκετά**	**πολύ**	**πάρα πολύ**
1. … να προσπαθώ πιο σκληρά	**1**	**2**	**3**	**4**	**5**
2. … να ενισχύεται η αυτοπεποίθησή μου	**1**	**2**	**3**	**4**	**5**
3. … να εκτελώ σαν αν έχω «αυτόματο πιλότο»	**1**	**2**	**3**	**4**	**5**
4. … να μειώνω τη νευρικότητά μου	**1**	**2**	**3**	**4**	**5**
5. … να συγκεντρώνομαι καλύτερα στην εκτέλεση	**1**	**2**	**3**	**4**	**5**
6. … να εντείνω τις προσπάθειές μου	**1**	**2**	**3**	**4**	**5**
7. … να νοιώθω πιο σίγουρος-η για τον εαυτό μου	**1**	**2**	**3**	**4**	**5**
8. … η εκτέλεση να βγαίνει αυθόρμητα	**1**	**2**	**3**	**4**	**5**
9. … να διώχνω το άγχος	**1**	**2**	**3**	**4**	**5**
10. … να διατηρώ την προσοχή μου	**1**	**2**	**3**	**4**	**5**
11. … να προσπαθώ περισσότερο	**1**	**2**	**3**	**4**	**5**
12. … να νοιώθω πιο δυνατός-η	**1**	**2**	**3**	**4**	**5**
13. … να εκτελώ αυτόματα	**1**	**2**	**3**	**4**	**5**
14. … να νοιώθω πιο χαλαρός	**1**	**2**	**3**	**4**	**5**
15. … να συγκεντρώνομαι καλύτερα σε αυτό που πρέπει να κάνω	**1**	**2**	**3**	**4**	**5**
16. … να συνεχίζω να προσπαθώ στο μέγιστο	**1**	**2**	**3**	**4**	**5**
17. … να εμψυχώνω τον εαυτό μου	**1**	**2**	**3**	**4**	**5**
18. … η εκτέλεση βγαίνει αυτόματα	**1**	**2**	**3**	**4**	**5**
19. … να διακόπτω κακές σκέψεις	**1**	**2**	**3**	**4**	**5**
20. … να κατευθύνω την προσοχή μου εκεί που πρέπει	**1**	**2**	**3**	**4**	**5**
21. … να διατηρώ την προσπάθειά που καταβάλω σε υψηλό επίπεδο	**1**	**2**	**3**	**4**	**5**
22. … να νοιώθω πιο σίγουρος-η για τις ικανότητές μου	**1**	**2**	**3**	**4**	**5**
23. … να εκτελώ ενστικτωδώς	**1**	**2**	**3**	**4**	**5**
24. … να επαναφέρω την ηρεμία μέσα μου	**1**	**2**	**3**	**4**	**5**
25. … να συγκεντρώνομαι σ΄αυτό που κάνω τη στιγμή αυτή	**1**	**2**	**3**	**4**	**5**

3. Εκτός από τις λέξεις κλειδιά που επέλεξες ,
έλεγες στον εαυτό σου **κάτι άλλο συγκεκριμένο** κατά τη διάρκεια της άσκησης; ΝΑΙ
ΟΧΙ

4. Αν ναι **τι** ακριβώς;
…………………………………………………………………………………………………
……

5. Αν ναι, **πόσο** συχνά;

καθόλου									**συνέχεια**
1	2	3	4	5	6	7	8	9	10

Control Group

1. Τη ώρα που εκτελούσες έλεγες συστηματικά στον εαυτό σου **κάτι συγκεκριμένο**;

NAI OXI

2. Αν ναι **τι** ακριβώς;

………………………………………………………………………………………………

3. Αν ναι, **πόσο** συχνά;

καθόλου									**συνέχεια**
1	2	3	4	5	6	7	8	9	10

Appendix C

Rating of Perceived Exertion (RPE) Scale

Borg Scale (6-20)	**Intensity**
6	No exertion at all
7	
8	Extremely light
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Appendix D

Thermal Comfort scale

1	Comfortable
1.5	
2	Slightly uncomfortable
2.5	
3	Uncomfortable
3.5	
4	Very uncomfortable
4.5	
5	Extremely uncomfortable

Appendix E

Thermal Sensation scale

0	Unbearably Cold
1	Very Cold
2	Cold
3	Cool
4	Slightly Cool
5	Neutral
6	Slightly Warm
7	Warm
8	Hot
9	Very hot
10	Unbearably hot