Motivational self-talk improves 10km time trial cycling compared to neutral self-talk

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Abstract

Purpose. Unpleasant physical sensations during maximal exercise may manifest themselves as negative cognitions that impair performance, alter pacing and are linked to increased RPE. This study examined whether motivational self-talk (M-ST) could reduce RPE and change pacing strategy thereby enhancing 10 km time trial (TT) cycling performance in contrast to neutral self talk (N-ST). **Methods.** Fourteen males undertook four TTs; TT1-TT4. Following TT2 participants were matched into groups based on TT2 completion time and underwent 1) M-ST (*n*=7) or 2) N-ST (*n*=7) after TT3. Performance, power output, RPE, and oxygen uptake were compared across 1 km segments using ANOVA. Confidence intervals (95% CI) were calculated for performance data. **Results.** After TT3 (*i.e.* prior to intervention) completion times weren't different between groups (M-ST: 1120 [113]; N-ST: 1150 [110] seconds). After M-ST, TT4 completion time was faster (1078 [96] seconds); the N-ST remained similar (1165 [111]). The M-ST group achieved this through a higher power output and VO_2 in TT4 (6^{th}-10^{th} km). RPE was unchanged. CI data indicated the likely true performance effect lay between 13 and 71 s improvement (TT4 vs TT3). **Conclusion.** M-ST improved endurance performance and enabled a higher power output whereas N-ST induced no change. The VO_2 response matched the increase in power output yet RPE was unchanged thereby inferring a perceptual benefit through M-ST. The valence and content of self-talk is an important determinant of the efficacy of this intervention. These findings are primarily discussed in the context of the psychobiological model of pacing.

Keywords. Self-pacing, self-talk, motivation, time trial, perceived exertion

Introduction

Pacing is the spontaneous variation in power, and therefore speed, during self-paced exercise[1]. Pacing strategy refers to the pattern of deployment of the available energetic resources to complete a self-paced exercise task[1,2]. Optimal pacing during prolonged exercise (> ~ 4 minutes[3]) enables the exhaustion of the available physiological resources on task completion without significantly compromising speed and therefore performance[4,5]. Accordingly, during fixed distance endurance events such as time trial (TT) cycling, cyclists typically start with a high power output with a steady decline throughout the task but often manage to produce an end spurt increase in power that matches or exceeds their initial power production[6,7]. The power output that is achieved may be influenced by afferent feedback signals from the physiological systems that are under strain[8]. The salience of these signals varies in accordance with the specifics of the task and environment and increase in intensity as the task ensues[9]. Significant sources of strain during a TT performance include, but are not limited to, neuromuscular fatigue[8], energy substrate availability[10], heat stress[7], reductions in blood pH[11] and hypoxia[12]. The sensations that arise from placing these physiological systems under near maximal strain may be perceived as unpleasant in nature resulting in high ratings of exertion[13]. Therefore, in physically similar individuals, it is the extent to which a performer can resist these inhibitory signals to maintain or increase their power output that may demark the success of a TT effort and this ability could be considered as primarily psychological in nature. This interplay may represent the balance point between afferent feedback and motor drive to generate muscular force[14].

The balance point for the regulation of pacing strategy has been suggested to take place in the form of a conscious or sub-conscious internal negotiation[4] or a continual internal dialogue[15,16] allowing for the regulation of power output[17]. This internal negotiation is thought to be normalized to the expected rating of perceived exertion (RPE) at a given point in the race[4]. A discrepancy between the expected RPE and the sensation of physical exertion would theoretically culminate in a reduction in power output making RPE and power output integral[4]. In turn, self-talk, broadly defined as a dialogue in which an individual interprets feelings and perceptions, regulates and changes evaluations and convictions, and gives himself/herself instructions and reinforcement[19], may occur concurrent with the generation of a perceived exertion rating. It is logical to suggest that the conscious component of any internal negotiation includes a verbal component. Indeed, it has been suggested that self-talk is crucial for self-awareness during exercise, by creating a time or distance ‘wedge’ between the ‘self’ and the mental and physical activities that the ‘self’ is currently experiencing[19]. On this basis it seems that structured self-talk could be one means of altering pacing strategy and influencing RPE during endurance exercise.

Despite a theoretical link between self-talk, RPE and pacing strategy, no studies have specifically examined this relationship. This is surprising given the evidence that, particularly in the case of motivational (positive) self-talk, the content of self-talk statements seems to influence gross motor tasks in a beneficial and directional manner[20,21,22]. Recently Blanchfield and colleagues[23] showed that a motivational self-talk (M-ST) intervention enhanced endurance performance and lowered ‘iso time’ (equivalent time in post-test trial *vs* pre-test) RPE during a time trial to exhaustion (TTE) exercise bout. Blanchfield et al[23] demonstrated M-ST enhanced performance (baseline TTE 637 ± 210 s *vs* post-test TTE 751 ± 295 s) in contrast to a control group who received no intervention and consequently did not improve (487 ± 157 s *vs* 475 ± 169 s). Therefore, M-ST appears to be one viable means of influencing fixed intensity exercise performance.

In the context of pacing, a TTE at a pre-set power output threshold does not enable the evaluation of the conscious regulation of power output. Moreover, a TTE allows for the assessment of endurance performance but cannot inform the likely ergogenic effect of M-ST in a conventional TT; a test which is a regular part of track and road cycling events[1,3]. Similarly, studies that do not use a ‘sham controlled’ control group when cognitive interventions are delivered do not account for the possibility that the improvement in performance is due to a placebo effect. In such studies it is possible that participants in a structured self-talk group exerted greater effort because the experimental team simply spent more time with the participants culminating in confounding by social facilitation[24]. Collectively these previous study limitations require clarification to substantiate the potential effects of M-ST.

Accordingly, the present study will examine the effect of an M-ST intervention on the performance of an ecologically valid endurance exercise task, namely TT cycling, in contrast to a neutral self-talk (N-ST) intervention. We hypothesised that M-ST would enhance TT performance and alter pacing (H_1), particularly at high levels of exertion during a TT[16] when the occurrence of negative self-talk statements may also be increasing.

Method

Experimental Design

The protocol was approved by the local ethics committee. The study used a within participant and between group, repeated measures design in which participants completed a 10 km TT on four separate occasions. They initially completed two familiarisation trials to establish a stable pacing template[2]. They were then matched and allocated to one of two self-talk intervention groups. They then completed a pre-intervention 10 km TT (TT3) followed by a) a neutral self-talk intervention (N-ST) or b) a motivational self-talk intervention (M-ST) and a final 10 km TT (TT4). Tests took place at the same time of day (± 1 hour) with a minimum of 48 hours between tests.

Participants

Participants provided written informed consent and completed medical screening. Fourteen males were recruited (age 19 [1] years; height 1.82 [0.12]m; mass 76.2 [8.9]kg). The participants were recreationally active and accustomed to maximal, non-cycling, exercise.

Procedures – Time Trials

The participant wore the same light athletic clothing in each TT. All tests were conducted in an air-conditioned laboratory (20 [1.0] °C) on the same calibrated Velotron Dynafit Pro cycle ergometer (Racermate Inc, Seattle, WA, USA). Following TT1, the cycle ergometer set-up was replicated (within-participant). Before each TT, the participant initially completed a standardised 5-minute warm up (70 $rev \cdot min^{-1}$ power output 150 W).

Following the warm up period the participant re-mounted the cycle ergometer and they were instructed that they should exert a maximal effort to complete the upcoming TT as quickly as possible. Each TT was completed on a software generated flat, straight 10 km TT course. They then commenced cycling and had exclusive control of their pace and work intensity. During the TT a computerized image of a cyclist was projected on a screen positioned in front of them showing their progress. Participants received only feedback of distance covered; other variables of interest (time elapsed and power output) were not displayed but were recorded for later analysis. Participants received no verbal encouragement during the TT. On the completion of each kilometre participants provided a rating of perceived exertion using the 15-point likert scale (RPE[25]); participants were familiarised with the scale before the first TT.

During the TT the participant wore an oronasal mask to enable the measurement of oxygen uptake (VO_2), breath-by-breath using an online gas analyser (Cosmed, Quark B2, Rome Italy). Data were later converted to second by second by spreadsheet interpolation. The gas analyser and flow turbine were calibrated to certified gases (BOC gases 5.05 % CO_2 & 15.00 % O_2; and room air) and to a 3000 mL syringe (3000 mL Syringe, Harvard Instruments, Harvard, USA) respectively.

Following completion of TT2, matching and allocation was conducted generating two equal groups of seven participants; M-ST group, (age 19 [1] years, height 1.85 [0.10]m, mass 75.9 [9.0]kg) and the N-ST group (age 19 [1] years, height 1.79 [0.12]m, mass 76.7 [8.3]kg). Participants were matched and paired on the basis of their best TT completion times from TT2. After matching, the average TT2 completion times were M-ST: 1112 [106] s and N-ST: 1122 [103] s. Participants then completed a further two TTs and received a self-talk intervention between TT3 and TT4. Participants were initially naïve to the self-talk interventions.

Motivational Self-Talk Intervention

M-ST participants completed a 1-hour classroom session, on a separate day, where M-ST was defined and developed using a structured booklet[27], similar to previous investigations[28]. Briefly, participants were asked to identify a) if negative self-talk statements arose (participants reported they frequently did) prior to or during the previous TTs and the consequences of these statements and b) were asked to write counter-active positive, motivational statements to deploy when these negative statements arose subsequently. Participants were instructed to write one negative and one motivational statement for the start of the TT and for completion of each 2 km section. For example, for the 4 km point one participant wrote (negative statement) “I’ve worked too hard” and changed this to (positive statement) “I can manage my energy until the end”. Participants self-selected the M-ST statements, in accordance with self determination theory[28], in order to maximise perceived control over their performance environment and consequently to increase their intrinsic motivation throughout the TT. Previous investigations have provided evidence[15] and the theoretical underpinning[19] for this approach. Once participants had constructed their M-ST statements the list was laminated and the participant was asked to mentally rehearse them in the days preceding, and immediately prior to, the final TT; although the statements were not visible during the TT.

Neutral Self-Talk Intervention

In contrast to the M-ST intervention and also in accordance with self-determination theory[28], the N-ST intervention was structured to remove control and autonomy over the list of self-talk statements. Previous studies have suggested that assigned ST statements reduce self-determined control over the internal self-talk dialogue which reduces any positive influence the statements may have[29]. Participants were provided with a list of neutral, non-performance related statements to deploy in response to their negative self statements prior to and on every 2 km of the TT. For example, at 2 km one participant wrote (negative statement) “my legs hurt” and this was changed to (neutral statement) “my favourite colour is green”. These sessions lasted the same duration as the M-ST sessions.

Statistical Analysis

Test duration and power output were measured and recorded at a frequency to the nearest second using the Computrainer ® recording software (Computrainer Racemate, Seattle, USA). Mean [SD] were calculated for the following variables over each 1 km of the TTs: split time [absolute time], power output, VO_2, and RPE (the latter on completion of each km). Inter-trial coefficient of variation (CV) was calculated within each group between TT2 to TT3 and overall.

Change in performance between TT3 and TT4 and absolute data were compared between and within group, using mixed model repeated measures analysis of variance (ANOVA) with a Bonferroni correction. Sphericity was checked using Mauchley’s test and, where necessary, a Greenhouse-Geisser adjustment was applied. The direction of statistically significant effects were determined using a *post-hoc* pair-wise comparisons procedure. For all statistical tests initial α level was set at 0.05. Data are presented as mean [SD] where possible. All statistical tests were conducted using SPSS version 18 (Chicago, IL, USA). Confidence intervals were also calculated to a 95% level for the performance time data in order to discern the likely true population effect of the respective self-talk interventions.

Results

TT Completion Time

Consistent with the idea that participants in the study had achieved a stable pacing strategy and profile, the inter-trial (*n*=14) CV between TT2 and TT3 was 1.9 [1.7] %. When examined in their respective groups the CV was 2.4 [1.9] % and 1.5 [1.6] % for the N-ST and M-ST respectively. TT3 completion time was 1150 [110] s and 1120 [112] s and was not different ($F_{(1,12)}$ = .150, p = .706).

In TT4, the performance of the N-ST remained unchanged (p = .312) whereas the M-ST improved their TT performance (p = .009) relative to TT3 ($F_{(2,24)}$ = 7.948, p = .002). This change in performance was sufficient to produce between group differences ($F_{(1,12)}$ = 5.805, p = .033) with an interaction between group and distance ($F_{(9,108)}$ = 5.795, p = .006). Post-hoc analysis showed the M-ST completed TT4 faster than the N-ST, by an average of 77 [53] seconds. The interaction effect showed that as the time trial ensued the difference in performance split time grew between groups being consistently faster in the M-ST from the 7th to the 10th kilometre (p = .050, .030, .016, .004; km 7-10) by an average difference of 55 [17] seconds across this 3 km section. TT completion time data are shown in figure 1.

The 95% CI indicated the likely true performance effect of the respective interventions (between trial). In the M-ST this was between 13 to 71 s quicker in TT4 relative to TT3. In the N-ST the CI range was between 44 s slower to 15 s quicker reflective of the null effect. Between group the M-ST intervention enabled 3 to 60 s faster TT performance.

INSERT FIGURE 1 NEAR HERE

Pacing and Power Output

In both TT3 and TT4 participants in the N-ST and M-ST produced similar pacing profiles (within group); figure 2 panel A for N-ST and panel B for M-ST. This profile was characterised by a high to moderate initial power output (relative to the mean) followed by a gradual decline but culminating in an increased power output in the form of an end-spurt.

TT3 mean power output was 205 [17] and 213 [17] W in the N-ST and M-ST respectively which were not different ($F_{(1,12)}$ = .502, p = .492). Thereafter, the statistical differences mirrored those of the TT completion time data and showed higher power output in the M-ST in TT4 relative to TT3 (p = .006) and unchanged power output in the N-ST group relative to TT3 (p = .573). The change in power output as a consequence of the respective interventions was different between groups being higher in the M-ST relative to the N-ST ($F_{(1,12)}$ = 5.575, p = .018). Mean [SD] power output across TT4 was 248 [17] W in the M-ST and 204 [11] in the N-ST. An interaction effect across TT4 was also evident ($F_{(9,108)}$ = 1.986, p = .001) with the differences between the group power outputs being significant at the 6th kilometre and maintained, with the exception of the 8th kilometre point ($p = .056$), thereafter ($p = .011, .006, .002, .001$; km 6-7 & 9-10). Power output data are shown in figure 2.

INSERT FIGURE 2 NEAR HERE

VO_2

The VO_2 data indicated that the higher power output in TT4, relative to TT3, was matched by a higher oxygen uptake ($F_{(1,12)} = 7.636$, $p = .017$) by an average difference of 218 [56] mL in the M-ST group. In TT3 oxygen uptake was similar in each group (N-ST: 2644 [147] mL & M-ST: 2651 [239] mL; $F_{(1,12)} = 0.202$, $p = .661$) but were once again different between group in TT4 after the respective interventions (N-ST: 2639 [91] mL & M-ST: 2869 [256] mL) which induced a change in VO_2 in the M-ST group ($F_{(1,12)} = 5.575$, $p = .018$). Once again, as the TT ensued the extent of the differences ($F_{(9,108)} = 2.435$, $p = .015$) became and remained significant, consistently so from the 6th kilometre; see figure 3.

INSERT FIGURE 3 NEAR HERE

RPE

RPE increased linearly over the course of each TT, reaching a peak in both groups on completion of the 10th kilometre. There were no differences within or between group (Trial x Group: $F_{(1,12)} = .955$, $p = .348$) or between group (Group: $F_{(1,12)} = 1.556$, $p = .236$) in RPE at any stage between TTs. The mean [SD] RPE at halfway and the end of TT4 for each group was 14 [2] and 16 [2] in the N-ST and 14 [1] and 17 [1] in the M-ST; RPE data are shown in figure 4.

INSERT FIGURE 4 NEAR HERE

Discussion

This study examined the effect of motivational self-talk on the performance and pacing of an externally valid exercise task whilst controlling for the potential of a placebo effect by employing a neutral self-talk treatment group. Based on numerical evidence of enhanced power output at the start of exercise and statistical differences after 6km of a 10 km TT, we show that M-ST significantly improves performance (figure 1) and alters power output and therefore pacing (figure 2 panel B); VO_2, and therefore energy production by aerobic means, increased accordingly (figure 3, panel B). Consequently, the hypothesis can be accepted (H_1). By contrast, the neutral self-talk group showed no evidence of a performance change (figure 2, panel A). Within both groups the pacing profile appeared to be similar in shape (figure 2) although the M-ST clearly shifted toward a sustained higher power despite an unchanged RPE (figure 4). If we consider M-ST to be positive in nature, these contrasting responses give weight to the argument that the valence of the self-talk was an important component of this type of intervention.

Our experimental design also allowed us to control for a potential confounding effect by social facilitation[24] that is a legitimate criticism of previous studies that have used similar interventions[23,27]. We spent a similar amount of time with the N-ST group but delivered a sham intervention that N-ST group members were told could impact on their TT performance. Yet, the N-ST performance was unchanged whereas the M-ST improved significantly. Collectively these data show that it is the specific content of the M-ST intervention that is important in enhancing performance.

Our data build on, and are generally consistent with the findings of Blanchfield and colleagues[23] that showed evidence of performance enhancement following an M-ST intervention although the extent of the improvement is less substantial in the present study; 4 % quicker in TT4 than TT3 compared to 18% in the study of Blanchfield et al[23]. This could be accounted for by the difference in the exercise test selected in the respective studies with TTE, as selected by Blanchfield et al[23], thought to be more variable (i.e. up to 26.6 %), than a conventional TT[30] although both test formats have been suggested to be similarly sensitive[31]. Irrespective, it seems that M-ST enhances cycling performance and we speculate that it does so by improving the internal motivational environment for performance.[28]

The RPE data can be contextualised against that of Blanchfield et al[23] who found significantly lower RPE after M-ST at an equivalent time point during the post intervention TTE at a fixed power output. Our data, in a self-paced exercise test, showed no change in RPE despite higher power output of approximately 30 W and greater physiological strain after M-ST (i.e. higher VO_2); this also infers a perceptual benefit of M-ST and partly agrees with Blanchfield et al[23]. However, to be entirely consistent with the data of Blanchfield et al[23] we might have expected RPE to be lower in the M-ST than the N-ST in TT4 because of the directional effect of the M-ST intervention or lower within the M-ST group between TTs 3 and 4 due to the timing of the intervention between trials but this was not the case. It remains possible that the difference in power output after M-ST in our study was not large enough to stimulate changes in RPE; but there was no subjective evidence that RPE was even close to altering (see figure 4). It is also possible that the RPE scale was insufficiently sensitive to enable the difference to be detected or that statistical power was insufficient. We think this unlikely as Blanchfield et al[23] did see differences using a similar experimental design. The possibility remains that it is the nature of self-paced vs fixed intensity exercise that accounts for this discrepancy. Clearly, the RPE data require further clarification in the context of the psychobiological model and other models of pacing regulation[14].

This study is not without limitation. Indeed, the cohort of participants tested were recreationally active males and not trained *per se*. Consequently the findings are primarily applicable to a similar population rather than athletes or trained cyclists. The population we tested may also have been more likely to respond to this type of intervention given that the performance of a trained population tends to be more reproducible[33] and that trained participants may have already established their own M-ST strategies through competing[34]. Therefore the magnitude of effect may be lower in trained persons. Moreover, it would almost certainly have been useful to contextualise the fitness of the present cohort of participants by taking a peak oxygen uptake value (VO_{2peak}) from an incremental exercise test; available resource excluded this possibility. Establishing a VO_{2peak} would have helped establish the proportion to which oxygen uptake was higher after the M-ST intervention. Our data can only show that VO_2 was increased after M-ST relative to TT3. Ultimately our data include an indicator of performance of an ecologically valid task, which has also been quantified using confidence intervals, against which VO_{2max} would ultimately be compared.

Practical Application and Conclusion

It is concluded that M-ST enhances performance and alters power output and therefore pacing during a simulated 10 km TT whereas an N-ST intervention does not alter power output, pacing or performance; these data suggest the content and valence of self-talk are influential and important. The change in performance was achieved by M-ST participants producing higher power output and oxygen consumption in the TT with no discernable change in RPE. M-ST is an effective intervention for a recreationally active population performing cycling exercise.

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Conflict of Interest
No funding was received for this work
There are no conflicts of interest to declare

References

1. Corbett J. An analysis of the pacing strategies adopted by elite athletes during track cycling. *Int J Sports Physiol Perform*, 2009, 4(2), 195-205.
2. Corbett J, Barwood MJ, Parkhouse K. Effect of task familiarization on distribution of energy during a 2000m cycling time trial. *Br J Sport Med*, 2009, 43, 770-774.
3. Foster C, Hoyos J, Earnest C, Lucia. Regulation of energy expenditure during prolonged athletic competition. *Med Sci Sport Exerc*, 2005, 670-675.
4. De Koning JJ, Foster C, Bakkum A, Kloppenburg S, Thiel C, Joseph T, Cohen J, Porcari JP. Regulation of pacing strategy during athletic competition. *PLoSONE 6*, 2011, 6,e15863.
5. Foster, C, Snyder AC, Thompson, NN, Green MA, Foley, M & Schrager M. Effect of pacing strategy on cycle time trial performance. *Med Sci Sport Exerc.* 1993, 25, 383-388.
6. Atkinson G, Brunskill A. Pacing strategies during a cycling time trial with simulated headwinds and tailwinds. *Ergon*, 2000, 43, 1449-60.
7. Barwood MJ, Corbett J, White D, James J. Early change in thermal perception is not a driver of anticipatory exercise pacing during exercise in the heat. *Br J Sport Med*, 2012, 46(13), 936-942.
8. Amann M, Venturelli M, Ives SJ, McDaniel J, Layec G, Rossman MJ, Richardson RS. Peripheral fatigue limits endurance exercise via a sensory feedback-mediated reduction in spinal motorneuronal output. *J Appl Physiol*, 2013, 115(3), 355-64.
9. Swart J, Lindsay T, Lambert MI, Brown J, Noakes TD. Perceptual cues in the regulation of exercise performance: physical sensations of exercise and awareness of effort interact as separate cues. *Br J Sports Med*, 2012, 46(1), 42-48.
10. Rauch HG, St Clair Gibson A, Lambert EV, Noakes TD. A signaling role for muscle glycogen in the regulation of pace during prolonged exercise. *Br J Sports Med*, 2005, 39(1), 34-38.
11. Jones AM, Wilkerson DP, DiMenna F, Fulford J, Poole DD. Muscle metabolic response to exercise above and below the ‘critical power’ assessed using 31P-MRS. *Am J Physiol: Integ, Compar, Physiol*, 2008, 204, R585-593.
12. Clark SA, Bourdon PC, Schmidt W, Singh B, Cable G, Onus KJ, Woolford SM, Stanef T, Gore CJ, Aughey RJ. The effect of acute simulated moderate altitude on power, performance and pacing strategies in well-trained cyclists. *Eur J Appl Physiol*, 2007, 102(1), 45-55.
13. St Clair Gibson A, Foster C. The role of self-talk in the awareness of physiological state and physical performance. *Sports Med*, 2007, 37, 1029-1044.
14. St Clair Gibson, Noakes TD. Evidence for complex system integration and dynamic neural regulation of skeletal muscle recruitment during exercise in humans. *Br J Sports Med*, 2004, 38, 797-806.
15. Schomer HH, Connolly MJ. Cognitive strategies used by marathoners during each quartile of a training run. *South Afr J Sport Res, Phys Ed Recr*, 2002, 24(1), 87-100.
16. St Clair Gibson A, Lambert EV, Rauch LHG, Tucker R, Baden DA,

Foster C, Noakes TD. The role of information processing between the brain and peripheral physiological systems in pacing and perception of effort. *Sports Med*, 2006, 36, 705-722.

17. Swart J, Lamberts RP, Lambert MI, Gibson ASC. Exercising with reserve: evidence that the central nervous system regulates prolonged exercise performance. *Br J Sports Med*, 2009, 43(10), 782-788.
18. Hackfort D, Schwenkmezger P. Anxiety. In: Singer RN, Murphey M, Tennant LK (eds.) Handbook of Research in Sports Psychology. New York, Macmillan 1993, 328-364 p.
19. Morin A. Possible links between self-awareness and inner speech: theoretical background, underlying mechanisms, and empirical evidence. *J Consc Stud*, 2005, 12, 115-34.
20. Hamilton RA, Scott D, MacDougall MP. Assessing the effectiveness of self-talk interventions on endurance performance. *J Appl Sport Psychol*, 2007, 19: 226-39.
21. Hatzigeorgiadis A, Theodorakis Y, Zourbanos N. Self-talk in the swimming pool: the effects of self-talk on thought content and performance on water polo tasks. *J Appl Sport Psychol*, 2004, 16:138-150.
22. Theodorakis Y, Weinburg R, Natsis P, Douma I, Kazakas P. The effects of motivational versus instructional self-talk on improving motor performance. *Sport Psychol*, 2000; 14, 253-272.
23. Blanchfield AW, Hardy J, de Morree, Staiano W, Marcora S. Talking yourself out of exhaustion: the effects of self talk on endurance performance. *Med Sci Sport Exerc*, 2013, [Oct 10, EPub ahead of print].
24. Rhea MR, Landers DM, Alvar BA, Arent SM. The effects of competition and the presence of an audience on weight lifting performance. *J Strength Cond Res*, 2003, 17(2), 303-306.
25. Borg GAV. Psychophysical basis of physical exertion. *Med Sci Sport Exerc*. 1982, 14, 377-381.
26. Thelwell RC, & Greenlees IA. The effects of a mental skills training package on gymnasium triathlon performance. *Sport Psychol*, 2001, 15:127-41.
27. Barwood MJ, Thelwell R, Tipton MJ. Psychological Skills Training improves exercise performance in the heat. *Med Sci Sport Exerc*, 2008, 40(2): 387-396.
28. Deci EL, Ryan RM. Conceptualisations of Intrinsic Motivation and Self Determination. In: Deci EL, Ryan RM. Intrinsic motivation and self-determination in human behavior. New York: Plenum Press, 1985, 11-39 p.
29. Weinburg R, Miller A, Horn T. The influence of a self-talk intervention on collegiate cross-country runners. *Int J Sport Exerc Psychol*, 2012, 10(2), 123-134.
30. Jeukendrup A, Saris WH, Brouns F, Kester AD. A new validated endurance performance test. *Med Sci Sport Exerc*, 1996, 28(2), 266-270.
31. Amann M, Hopkins WG, Marcora SM. Similar sensitivity of time to exhaustion and time-trial to changes in endurance. *Med Sci Sport Exerc*, 2007, 40(3), 574-578.
32. Marcora SM, Staiano W. The limit to exercise tolerance in humans: mind over muscle? *Eur J Appl Physiol*, 2010, 109(4), 763-70.
33. De Koning JJ, Bobbert MF, Foster C. Determination of optimal pacing during track cycling with an energy flow model. *J Sci Med Sport*,

1999, 2, 266-277.

34. Hardy J. Speaking clearly: A critical review of the self-talk literature. *Psych Sport Exerc*, 2006, 7, 1-17.

Figure Captions

Figure 1. Mean [SD] completion times in TT3 and TT4 in the N-ST (*n*=7) and M-ST (*n*=7); * denotes significant difference within groups between marked TTs; ♯ denotes significant difference between groups.

Figure 2. Mean [SD] power output (W) in TT3 and TT4 in the N-ST (panel A; Y_2, *n*=7) and M-ST (panel B; Y_1, *n*=7) across 1 km increments; * denotes significant difference within groups between TTs; ♯ denotes significant difference between groups in TT4.

Figure 3. Mean [SD] oxygen uptake (mL) in TT3 and TT4 in the N-ST (panel A; Y_2, *n*=7) and M-ST (panel B; Y_1, *n*=7) across 1 km increments; * denotes significant difference within groups between TTs; ♯ denotes significant difference between groups in TT4.

Figure 4. Mean [SD] RPE in TT3 and TT4 in the N-ST (panel A; Y_2, *n*=7) and M-ST (panel B; Y_1, *n*=7) across 1 km increments; * denotes significant difference within groups between TTs; ♯ denotes significant difference between groups in TT4.