The effect of different attentional strategies on physiological and psychological states during running

David L. Neumann[a,b] & Amy Piercy[a]

[a]School of Applied Psychology, Griffith University

[b]Behavioural Basis of Health, Griffith Health Institute

Number of words: 6436

Acknowledgements

This research was supported under Australian Research Council's Discovery Projects funding scheme (project number DP110103223). The assistance of Miriam Emad in preparing this manuscript is acknowledged.

Please direct correspondence to:

David Neumann: School of Applied Psychology, Gold Coast Campus, Griffith University, QLD 4222, Australia. E-mail: D.Neumann@griffithuni.edu.au. Facsimile: +61(0)7 5552 8291, Telephone: +61(0)7 5552 8052.

Abstract

The attentional focus of an athlete or recreational exerciser may influence performance outcomes during running. The present study used an experimental approach to manipulate the associative attentional focus of regular exercisers (*N* = 21) as they ran on a treadmill at 75% of V_{max}. Participants focused their attention on their breathing, running movements, the distance travelled, or under no specific instructions (control). A focus on distance travelled produced the lowest respiration frequency and a focus on running movements produced the lowest VO_2 consumption. The distance focus was also rated as one of the least difficult and most preferred strategies. Mood states and enjoyment of exercise did not differ across the conditions. The results suggest that the attentional focus an individual adopts can improve physiological performance outcomes during running without any negative psychological cost. The attentional focus may thus be an important factor in advice psychologists give to competitive athletes and recreational exercisers.

Keywords: attention, exercise, running, exercise psychology, sport psychology

The effect of different attentional strategies on physiological and psychological states during running

The way individuals focus their attention during endurance sports such as running is of interest to psychologists for several reasons. First, psychological strategies may influence athletes' performance during competitive races (Patrick & Hrycaiko, 1998; Schomer, 1990; Vealy, 2007). The strategies may also influence the effectiveness of athletes' training programs in the lead up to competition. Second, at a broader population level, psychological strategies used by recreational exercisers may influence the physical effort that they exert or feel during exercise. Changes in exertion or feeling states may, in turn, influence enjoyment and adherence to exercise (Lind, Welch, & Ekkekakis, 2009). The need for psychologists to develop strategies to assist recreational exercisers is particularly acute given that approximately 70% of the Australian population are deemed sedentary or active at a low exercise level (Australian Government, 2010). Moreover, the percentage of Australians participating in moderate physical exercise on a daily basis has decreased (Dale, Dollman, & Lewis, 2007; Lee & Stubbs, 2004). Using appropriate attentional strategies may be one means by which individuals can enhance their performance and influence their psychological states during exercise or competition.

In a recent review, Lind et al. (2009) distinguished between association and dissociation as two broad attentional strategies that can be adopted during exercise. Association refers to focussing on aspects relevant to the exercise, for example, bodily sensations and muscular fatigue (Morgan, 1978). Dissociation, by contrast, involves focussing on other things in a way that helps to block out the exercise (e.g., look at scenery). In past research, the classification of attentional focus as associative or dissociative has varied and there may be overlap between the two (e.g., focussing on running technique may also serve to distract from the pain of exertion; Stevinson & Biddle, 1998). Nevertheless, research has generally shown that an association focus leads to better performance, but at a psychological cost. La Caille, Masters, and Heath (2004), for example, asked regular exercisers to adopt an association focus (monitor their heart rate) or a dissociation focus (listen to music). The association focus resulted in faster running, but lower levels of positive affect than the dissociation focus. Other researchers have also reported better performance by athletes with an association focus in the sports of rowing (Connolly & Janelle, 2003) and swimming (Couture, Jerome, & Tihanyi, 1999). However, there have also been contrary findings (e.g. Morgan, Horstman, Cymerman, & Stokes, 1983). Nevertheless, association may be more appropriate for performance enhancement because it better enables a regulation of effort, particularly at high exercise intensities (Lind et al., 2009; Masters & Ogles, 1998).

Individuals may adopt an association focus in different ways. Concentrating on breathing, movements of the body, and pace and rhythm are among the possible approaches during running. One way to categorise the various approaches is according to the direction of attention (i.e., internal or external) the individual adopts (Stevinson & Biddle, 1998; Wulf, 2007a,b). The notion of an internal and external focus of attention has also been applied in research on skill-based sports (see Wulf, 2007a,b). In this work, an internal focus is described as attending to one’s body and actions during the execution of a skill, whereas an external focus is described as attending to the effects of the body movements on the environment. Research using skill-based tasks such as balancing on a stabilometer, putting, and dart throwing has shown that an external focus results in more effective learning and performance than an internal focus or giving no instructions (e.g., Shea & Wulf, 1999; Radlo et al., 1999; Wulf, Sheah, & Park, 2001).

The distinction between an internal and external focus has been investigated in the exercise of lifting weights. Vance et al. (2004) asked participants to do bicep curls with a weighted dumbbell. Electromyographic (EMG) activity was lower (i.e., there was less recruitment of muscle fibres to lift the weight) and movements were performed faster when participants focussed on the movement of a dumbbell (external focus) than when participants focussed on the feeling of the biceps muscle (internal focus). Furthermore, when movement speed was controlled, the external focus still resulted in lower EMG activity. Marchant et al. (2008) extended these findings by adding a no instruction condition as a control. Electromyographic activity was lower during the external focus than both the internal focus and control conditions, thus suggesting that an external focus produced a relative reduction in EMG activity.

To explain the findings resulting from the benefits of an external focus of attention in sport and exercise, Wulf and colleagues proposed the constrained action hypothesis (Vance et al., 2004; Wulf, 2007a,b; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). The hypothesis states that when individuals adopt an internal focus of attention they will attempt to consciously control their movements. The conscious processing of movements will constrain the motor system and disrupt the automatic control processes that would otherwise be operating. As a result, movements are less fluid and performance suffers. In contrast, an external focus on movement effects will let the automatic control processes operate without interference and produce better performance. Moreover, an external focus results in less attentional demands to perform the task even though movements are faster and more refined (Wulf et al., 2001).

The effect of an internal and external focus remains to be fully explored with endurance exercises such as running. Although there have been descriptive and qualitative studies (e.g., Stevinson & Biddle, 1998), experimental approaches have been uncommon. Schücker, Hagemann, Strauss, and Vökler (2009) applied the notion of an internal and external attentional focus during a treadmill running task. Importantly, the investigators kept the demands of the task constant (i.e., speed and distance run) so that the effects of different types of attentional focus on running economy could be investigated. Running economy may be defined in terms of heart rate or oxygen consumption when running below maximal pace (Franch, Madsen, Djurhuus, & Pedersen, 1998; Johnes & Carter, 2000). In the experiment, trained runners had lower oxygen consumption when they attended to a video than when they focussed their attention on their breathing or on their movements. The video was argued to promote an external focus because it was taken from the perspective of someone moving through an urban running course (the video was taken by a camera fixed on a bicycle travelling 12 km/hr). However, the video may have also contained some elements of dissociation because it depicted a different environment to the testing context and the speed was unrelated to the movement of the treadmill.

More recently, Ziv, Meckel, Lidor, and Rotstein (2012) compared an internal focus of attention on the legs and running movement with an external focus of attention on a video. No differences between conditions were found in oxygen consumption or heart rate. However, the external condition used in this study may also be questioned. The video showed a basketball game. Although the participants were elite youth basketball players, the video of the basketball game was not related to the effects of the participant’s running movement on the environment. As a consequence, the video would have induced a dissociation focus of attention away from the running task.

The present experiment aimed to extend prior research on the effects of different associative strategies during a running exercise. Unlike Schücker et al. (2011) and Ziv et al. (2012) who both used a video recording to induce an external focus, the present experiment used a manipulation that required participants to concentrate on the distance travelled. This type of focus is linked to the speed of the running action and thus ensures that the external focus is associative in nature. In addition, a second condition required a focus on breathing and a third condition required a focus on the running movement. A fourth control condition that involved no specific attentional focus instruction was also added. Measures of physiological performance (oxygen consumption, breathing rate, heart rate, muscle activity) and psychological states (mood states, enjoyment, perceived exertion, attentional focus preference) were taken. Based on prior research on motor skill learning (Wulf, 2007a,b) and the exercises of weight lifting and running (Marchant et al., 2008; Schücker et al., 2009; Vance et al., 2004) it was hypothesised that a focus on the distance travelled would produce the highest running economy (e.g., reduced oxygen consumption, reduced breathing rate) when compared to the other conditions.

Method

Participants

Twenty-two first year psychology students participated in exchange for partial course credit. Prior to participation, the participants were screened using the Sports Medicine Australia Pre-Exercise Screening System (Sports Medicine Australia, 2005) to establish any health-related concerns that may preclude safe participation in the experiment (e.g., cardiovascular disease). No participants were excluded on this basis. The data from one female participant were excluded due to problems with the physiological recording equipment. The final sample consisted of 12 females and 9 males with a mean age of 24.52 years (*SD* = 11.27, range = 17 to 63) and mean body mass index of 22.64 (*SD* = 3.21, range = 18.93 to 33.31). All but one participant reported exercising each week with the total typical time of exercise across the week varying through <2 hours (19%), 2-4 hours (37%), and 4-6 hours (44%). Ten participants reported running as a form of exercise on either 1 (60%), 2 (10%), 3 (10%), 4 (10%), or 6 (10%) days a week for a duration of 10 to 40 minutes each session (*M* = 26.0, *SD* = 11.74). All participants provided informed consent to a protocol granted ethical approval from the institutional review board.

Apparatus

Participants completed the running task on a Marquee Fitness MT80 treadmill set at a grade of 6%, which corresponds to an angle of 3.43°. The treadmill speed was set at an individual level based on the results obtained from the initial testing phase using a maximum velocity test. A wireless weather station (ATECH WS303-G) was also used to record temperature and humidity within the laboratory.

Physiological measures were acquired with a 8/35 PowerLab (ADInstruments, Sydney) data acquisition system. The system was connected to a Dual BIO Amp/Stimulator (ADInstruments ML408), a BIO Amp (ADInstruments ML132), a Gas Analyzer (ADInstruments ML206), and a Gas Mixing Chamber (ADInstruments MLA246), to record EMG activity, electrocardiogram (ECG), and gas exchange, respectively, using a sampling rate of 1000 Hz. A Thermistor Temperature Sensor (ADInstruments MLT415/M) was also used and attached to a Thermistor Pod (ADInstruments ML309) to measure air temperature from the gas mixing chamber. The EMG recordings were obtained via surface-mounted disposable Ag/AgCl electrodes (Ambu T-sensor, Denmark) placed over the gastrocnemius muscle (calf) and vastus lateralis muscle (outer quadriceps) muscles of the right leg (the ground electrode was placed on the outside of the knee joint). The ECG recordings were also obtained using Ag/AgCl electrodes that were attached to manubrium and xiphoid process of the chest region, with the ground electrode placed over a lower right rib bone. Participants wore a medium sized face mask (ADInstruments MLA1029) that separated inspired and expired air prior to gas exchange analysis.

Subjective measures were obtained with four separate scales that were compiled into one questionnaire. The Borg Perceived Exertion Scale (Borg, 1998), which has been shown to be positively linearly correlated with heart rate during exercise (Russell & Weeks, 1994), required participants to rate their level of exertion during the task using a single item rating scale from 6 to 20. Exercise satisfaction was also measured because prior research has shown that cognitive strategies and exercise setting can influence satisfaction with exercise (Harte & Eifert, 1995; from LaCaille, Masters, & Heath, 2004). A single item Exercise Satisfaction Scale (adapted from LaCaille et al., 2004) asked participant's to rate their level of satisfaction with their effort on a 5-point scale (1 = *very low,* 3 = *moderate,* 5 = *high*). The Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991) was used to measure enjoyment through a series of 16 statements that participants responded on a 5-point Likert scale (1 = *strongly disagree,* 5 = *strongly agree*). The Cronbach's α of the PACES was .91. The Profile of Mood States short form (POMS; McNair, Lorr, & Droppleman, 1981) was also used to measure the six mood states of tension, depression, anger, vigour, fatigue, and confusion. Participants are given a score for each state as well as a total mood disturbance score. The POMS showed adequate reliability with Cronbach's α values from .69 to .95 across the subscales. Finally, two questions were developed for completion at the end of the experiment in which participants ranked the most difficult and most preferred attentional focus condition. The response options for each question were presented in counterbalanced order across participants.

Procedure

Following informed consent, participants completed the Sports Medicine Australia Pre-Exercise Screening System (Sports Medicine Australia, 2005). Demographic information and exercise practice information were collected. Participants next completed a maximum velocity (V_{max}) test on the treadmill to determine the speed to be used for the experimental conditions for each participant. The V_{max} test has been shown to be at least as good or a better predictor of running performance than other test measures (e.g., VO_2max; Noakes, Myburgh, & Schall, 1990). The V_{max} test also provided a means to standardise the exercise intensity across participants and the test can be performed in the same session as the experimental conditions. The V_{max} test was based on 1 min effort stages beginning at 8 km/hr, with increments of 2 km/hr until volitional exhaustion (Noakes, Myburgh, Schall, 1990). V_{max} was taken as the final speed the individual could maintain for at least one minute. During the V_{max} test, all information on the treadmill display (e.g., speed, distance, incline setting) was covered. Participants attained a mean V_{max} speed of 9.6 km/hr (*SD* = 1.50). The speed used in each experimental condition was 70% of the individual's own speed (which corresponds to a mean of 6.7km/hr across the entire sample). In this way, the exercise intensity was standardised to be moderately challenging at a jogging/running pace.

On completion of the V_{max} test, participants were given a 5 min rest break. During this time, the breathing mask and electrodes were attached. In addition, participants reported what they focussed their attention on during the V_{max} test. Next, participants were required to complete four 6 min running blocks, each separated by a 5 min break. Gas exchange, EMG, and ECG were recorded for the duration of each 6 minute trial and participants completed the questionnaires following each trial. The participants were asked to look straight ahead and to concentrate and carry out the specific directions given at the beginning of each condition. These instructions were also repeated every 30 s to ensure that the participants maintained their focus as instructed. Four attentional focus conditions were used and these were completed in a counterbalanced order across participants using a Latin square design. In the Distance focus condition, participants were instructed to "concentrate on the distance screen" and "pay attention to the increase in kilometres travelled". For the Distance focus condition, the section of the treadmill display screen that showed the distance travelled was revealed to participants. All other information on the treadmill display (e.g., time elapsed, incline level) was covered by a black card. In all other conditions in the experiment, the entire treadmill display screen was covered. In the Movement focus condition, participants were instructed to "concentrate on your running movement" and "pay attention to the steps and forward movement of your legs". In the Breathing focus condition, participants were instructed to "concentrate on your breathing" and "pay attention to breathing in and out". In the Control condition, the participants were reminded of what they had focussed on during the Vmax test. Participants were instructed to use this same focus of attention during the control condition. This procedure was implemented to ensure that the participants did not adopt one of the instructed attentional focus conditions based on their experiences with it in a prior condition. In this way, this condition better served as a control against the three instructed conditions. After completing all conditions, participants ranked the relative difficulty of adopting each attentional focus and ranked their preference of each focus.

Scoring and statistical analysis

Following the methods of Schücker et al. (2009), only physiological data following the starting phase of each running condition were used for analyses. Accordingly, the first 60 seconds of each trial were excluded to result in minutes 2 to 6 being used for the analysis of all physiological measures. Further, this time period was divided into 30 s epochs to examine the time course of the measures across each condition.

The physiological measures were scored using the Chart Pro (ADInstruments, Sydney) software. Spiroergometry measures were scored to obtain measures of oxygen consumption, respiration frequency, ventilation exchange ratio, respiration exchange ratio, and the production of oxygen and carbon dioxide. A 2 point calibration was applied to oxygen consumption and carbon dioxide production, with means calculated within each 30 second epoch. Respiration frequency was determined using a preset air flow detection setting with a 0.5 SD threshold. Participants' gender, age, weight, and height were taking into account when calculating mean scores for each epoch. Muscle activity was scored from the EMG recordings separately for each recording site (Lipp, Neumann, & McHugh, 2003). Initially, a 30 to 500 bandpass filter was applied to the signal and the resulting waveform was rectified prior to calculating the mean within each 30 s epoch. Heart rate was scored using the

ECG signal (see Neumann & Thomas, 2009, 2011). The signal was initially screened for artifacts due to movement or poor electrode contact. The R-waves in the ECG signal were identified using the built-in algorithm in the ChartPro program, set to detect human ECG activity with a 2 SD threshold. Ectopic artifacts were manually detected and corrected for prior to calculation of the mean within each 30 second epoch.

Statistical analyses employed repeated measures ANOVAs or MANOVAs to test for differences between the four attentional focus conditions. Because the physiological dependent variables had been scored in 30 s epochs, the factor of Epoch was also included as within-subjects independent variable. For this reason, the physiological dependent variables were analysed with 4 x 10 (Condition x Epoch) factorial ANOVAs. The remaining dependent variables were analysed with one-way repeated measures ANOVAs or MANOVAs. The dependent variables were checked against the assumptions of the planned statistical analyses. The only adjustment required for violations of the assumptions was to evaluate statistical significance against the Greenhouse-Geisser adjusted *p*-value in cases where the sphericity assumption was violated. Follow up analyses were conducted using *t*-tests that used the Holm multistage adjustment for inflated Type I error. The familywise α level was set at .05.

Results

Physiological measures

The physiological dependent measures (VO_2, VCO_2, respiration frequency, ventilation exchange, respiratory exchange ratio, heart rate, and EMG activity) were analysed with separate 4 x 10 (Condition x Epoch) ANOVAs. As shown in Figure 1, respiration rate increased across the session, main effect for Epoch, $F(9, 180) = 28.38$, $p < .001$, $\eta_p^2 = .59$. Although the Condition x Epoch interaction approached significance, $F(27, 540) = 1.79$, $p = .09$, $\eta_p^2 = .08$, the main effect for Condition was highly significant, $F(3, 60) = 9.72$, $p = .001$, $\eta_p^2 = .33$. Follow up analyses showed that respiration rate was lower with a distance focus than with a breathing focus, movement focus, and the control condition, all $t(20) > 3.34$, $p < .003$, $d > 0.57$. No other comparisons across conditions were significant, all $t(20) < 1.52$, $p > .14$.

Insert Figure 1 and 2 about here

The VO_2 consumption is shown in Figure 2. As can be seen, consumption increased over the exercise session, as confirmed by a main effect for Epoch, $F(9, 180) = 17.03$, $p < .001$, $\eta_p^2 = .46$. Importantly, consumption differed as a function of attentional focus, main effect for Condition, $F(3, 60) = 3.06$, $p = .03$, $\eta_p^2 = .13$, but there was no significant Condition x Epoch interaction, $F < 1$. Further analyses to compare across the attentional focus conditions showed that VO_2 was lower with a movement focus than a breathing, $t(20) = 2.76$, $p = .012$, $d = 0.61$, and distance focus, $t(20) = 2.44$, $p = .024$, $d = 0.41$, but not the control condition, $t(20) = 0.99$, $p = .09$, $d = 0.31$. No other comparisons between the conditions were significant, all *t*s < 1.00, $p > .05$.

The remaining cardiovascular measures showed the expected changes across epoch. As reflected in a main effect for epoch, ventilation exchange volume, $F(9, 180) = 59.14$, $p < .001$, $\eta_p^2 = .75$, VCO_2, $F(9, 180) = 80.82$, $p < .001$, $\eta_p^2 = .80$, respiratory exchange ratio, $F(9, 180) = 130.38$, $p < .001$, $\eta_p^2 = .87$, and heart rate, $F(9, 180) = 3.69$, $p < .001$, $\eta_p^2 = .16$, all increased across epochs. However, none of these measures yielded a significant main effect for condition or interaction between condition and epoch, all *p'*s > .05. The statistical analyses for EMG activity of the leg muscles did not yield any significant effects, all *p'*s > .05.

Psychological measures

An examination of the self-report of attentional focus during the intial V_{max} test indicated that there was no consistent cue that participants attended to. The most common cues reported by participants were breathing (*n* = 4), the treadmill (e.g., noise, speed; *n* = 7), sounds in the room (e.g., of footsteps; *n* = 3), balance (*n* = 2), speed (*n* = 4), and feet (*n* = 5). Moreover, many participants reported multiple attentional focus cues that changed over the test (e.g., breathing and running speed).

During the experimental conditions, the percentage of participants who reported which attentional focus condition was the least difficult and most preferred are shown in Table 1. The distance focus condition was highly ranked by a large percentage of participants on both dimensions. A large percentage of participants also reported that a focus on running movement was the least difficult condition. A chi-square analysis confirmed that rankings of the least difficult condition differed across the attentional focus conditions, $\chi^2(21) = 14.24$, $p = .003$. For the rating of the most preferred strategy, the distance focus and breathing focus were ranked highest with just less than half the participants preferring each of these strategies. The difference in preferences across the attentional focus conditions were confirmed by a significant chi-square statistic, $\chi^2(21) = 11.57$, $p = .009$.

Insert Table 1 about here

Subjective ratings for the perceived exertion, satisfaction, and total PACES score were examined with separate repeated measures ANOVAs. The grand mean (averaged across all conditions) were 13.91 (*SD* = 1.96), 3.42 (*SD* = 0.45), 55.33 (*SD* = 7.71), and 4.08 (*SD* = 0.61), respectively. These ratings indicated that participants perceived the exercise to be somewhat hard, they were moderately satisfied with their effort, and it was moderately enjoyable. No significant differences across conditions were found for any measures, all *p*'s > .05. Due to the correlations among subscale scores (mean r = .39, range = .08 to .93), a MANOVA was used to examine the ratings on the tension-anxiety, depression-dejection, anger-hostility, vigour-activity, fatigue-inertia, and confusion-bewilderment POMS subscales. The multivariate effect was not significant, F (18, 156) = 1.24, p = .23, η_p^2 = .16. Similarly, a repeated measures ANOVA on POMS total mood disturbance score was not significant, F (3, 60) = 0.33, p = .81, η_p^2 = .02.

Discussion

The results of the present experiment indicated that instructing exercisers on a treadmill to focus their attention on the distance run and running movements had benefits over focussing on breathing and no explicit instructions. A focus on the distance being run resulted in a lowered breathing rate. Moreover, the lowered breathing rate occurred without any change in the volume of air breathed, as reflected in no significant differences across conditions in ventilation exchange. A focus on the running movements on the treadmill produced a lower consumption of oxygen than a focus on breathing or distance. The differences observed between the conditions were highly statistically significant (p < .001) and had moderate to large effect sizes to suggest that they represent real and important effects of the attentional strategy. A focus on distance and running movements were also ranked as the least difficult conditions and a focus on distance and breathing were ranked as the most preferred strategies. It is noteworthy that a large number of participants rated the focus on breathing as a preferred focus, even though this focus produced relatively higher breathing rate and oxygen consumption. No differences across the attentional focus conditions were found in subjective ratings of exercise enjoyment, perceived exertion, or mood states. Taken together, the results provide partial support for the hypothesis that an external focus of attention will benefit exercise economy when compared to a focus on the body or no explicit focus instructions.

When running on a treadmill, the participant remains relatively stationary in space. This presents a challenge to develop an attentional focus strategy that is directed external to the effects of the movement. Schücker et al. (2009) used a video showing the perspective of a runner moving through a pre-recorded scene. To more closely link the movement to the actual speed that the participant was travelling, the participants in the present experiment were instructed to focus on the distance travelled. This attentional focus resulted in a lowered breathing rate for the same work output (the distance travelled was the same in all conditions) and it was perceived to be the least difficult and equally with a breathing focus as the most preferred strategy. Indicators showing the distance travelled are common on commercial treadmills. Therefore, psychologists could recommend that exercisers adopt this form of attentional focus for its apparent benefits on respiratory exertion and perceived difficulty of the exercise. A similar external focus can be adopted when running outdoors if exercisers are instructed to focus on landmarks that they pass along a road or the number of laps completed. However, it may be doubtful that exercisers could maintain their focus of attention on a single cue for an extended period. For this reason, it may be useful for exercisers to switch their attentional focus from time to time. The present results suggested that switching between distance travelled and the running movement would generally result in the lowest physiological effort being exerted.

Research has not always observed effects of attentional focus on oxygen consumption (e.g., Hatfield et al., 1992; Morgan et al., 1983; Smith et al., 1995; Ziv et al., 2012). However, in the present experiment a focus on the running movement produced the lowest oxygen consumption. Perhaps for this reason of increased exercise economy, it was also rated by many participants as the least difficult condition. The movement focus condition required participants to concentrate on their running movement and forward steps of their legs. Although these instructions would be expected to produce an internal focus on the body, it may also have induced some element of an external focus on the movements relative to the treadmill. Running on a treadmill requires some degree of balance and coordination with the treadmill, which are factors likely to be made more salient by a focus on the feet and running movements.

As shown by the running movement condition, in many cases it may be overly simplistic to presume that manipulations of attentional focus will induce an attentional focus that is either purely internal or external. Instead, it may be more productive to adopt a processing resources model of attention. In this approach, an individual's attentional capacity may be split across various internal or external cues across the duration of the running session. The classification of an individual's focus of attention may thus be made according to the relative amounts of each type of focus. Such an approach is adopted by Wininger and Gieske (2010) in their Measure of Attentional Focus. In this self-report scale, participants report the relative percentage of time that they focussed their attention on task-relevant and task-irrelevant internal and external cues (e.g., bodily sensations, task-relevant thoughts). Based on the percentages reported, it is possible to classify attentional focus in a more subtle way than offered by a mutually exclusive categorical approach.

While defining the types of attentional focus used in a more quantitative way may prove useful, it is equally important for researchers to provide precise operational definitions for an internal or external attentional focus. There has been variability in the ways an external focus of attention has been induced in experimental research on running to date. Schücker et al. (2009) operationalised an external focus as attending to a video showing the movement through a course from the perspective of the runner. Ziv et al. (2012) used a video showing a basketball game. The present study required participants to attend to the distance being run.

These three approaches differ in the extent to which they might induce a dissociation focus. Dissociation would appear to be greatest in the method used by Ziv et al. (2012) because the video was unrelated to the actual task of treadmill running. The method of Schücker et al. (2009) may have induced both dissociation and association. These considerations highlight the importance of using manipulations that are defined in relation to both the internal/external dimension and the association/dissociation dimension (Stevinson & Biddle, 1998). Wulf (2007) offers one potential source for researchers in which she has provided example instructional manipulations for various sports and exercises that will induce an internal association and external association focus of attention.

Schücker et al. (2009) did not find any significant difference in oxygen consumption between a focus on running movement and a focus on breathing. The same instructions were used in the present study as those used by Schücker et al. (2009) yet differences were found. The contrasting in results may reflect differences in the participants or the running task across the two experiments. The present experiment used a sample of young recreational exercisers who ran in 5 minute trials at a speed of 70% V_{max} with rest periods in between. In contrast, Schücker et al. (2009) used older trained runners who ran in continuous trials of 10 minutes at 75% V_{max} and with no rest period between trials. The mean age of participants in the present experiment was 22.6 years whereas in Schücker et al. (2009) the mean age of participants was 30.8 years (it should also be noted that the mean age of the present sample was inflated due to the inclusion of one 63 year old participant). The participants in the present sample were also recreational exercisers, whereas the participants in Schücker et al. (2009) were trained runners. It may be the relatively inexperienced and lower fitness level of the participant sample or the lower exercise intensity that resulted in a greater benefit of a focus on running movement than on breathing. For example, a slower speed of the treadmill may make it easier to run with a smooth and efficient movement because the stresses on the body caused by a high intensity exercise do not reach a great enough level to demand attention. However, definitive conclusions would require that an experiment manipulate the experience or fitness level of the participant and the intensity of the exercise to determine if these factors are important.

Unlike the experiment reported by Schücker et al. (2009), the present experiment included a no instruction control condition. The control condition had the advantage of showing that a focus on the distance travelled and the running movement produced a relative reduction in breathing rate and oxygen consumption, respectively. Likewise, a focus on breathing did not significantly impair the physiological indices of exercise economy, although it clearly was not of any benefit. The control condition in this and other studies of attentional focus on exercise (e.g., Marchant et al., 2009; Neumann & Heng, 2011) should not be interpreted as the absence of any attentional focus. Participants reported what they had focussed on when running under no explicit instructions during the V_{max} test. The participants reported that they attended to various cues during the test and that these cues changed over the trial (e.g., breathing and running speed). A "no instruction" control condition is thus best interpreted as non-structured condition that could be highly variable in terms of the cues on which participants focus their attention.

The present findings of an effect of attentional focus on running economy and subjective difficulty ratings may be interpreted within the theoretical framework of the constrained action hypothesis (Vance et al., 2004; Wulf, 2007a,b; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). According to this hypothesis, the external focus of attention on the distance travelled facilitated automatic control processes associated with running and produced more efficient performance. In contrast, an internal focus of attention disrupts the automatic control processes and results in less fluid and efficient performance.

As a result, breathing rate was lower with a focus on distance covered than in the control, breathing focus, and running movement focus conditions.

The focus on running movements yielded lower VO_2 than the breathing focus and distance focus conditions. As noted earlier, a focus on running movements is interpreted as requiring both an internal and external focus of attention. The increased automaticity as a result of some external attentional focus can explain the difference in VO_2 between the running movement focus and breathing focus conditions. However, the observation of a difference in VO_2 between the running movement focus and distance focus conditions is less easy to explain within the constrained action hypothesis because both involved an external focus of attention. The exact nature of the external focus was different in the two conditions. Wulf (2007a) has reviewed research showing that the benefits of an external focus of attention on motor skill learning can differ according to specific way in which the external focus is operationalised. For example, learning is enhanced as the focus of attention becomes more distal to the body. Further research is required to more systematically examine the differences in the attentional focus between different types of external attentional focus when treadmill running.

The attentional focus conditions had relatively little effect on subjective ratings of mood states and enjoyment. Future research could use alternative measures, such as the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1998). The PANAS may be more appropriate than the POMS because it measures affective states rather than mood states, which are considered less transient than emotions (Beedie, Terry, & Lane, 2005). Nevertheless, the lack of an effect of attentional focus on psychological states in the present experiment has two main implications. First, the increased running economy that resulted from a focus on the distance travelled and running movement did not come at a cost or benefit to the participants' psychological state. These attentional focus manipulations may thus be interpreted as being mood neutral in its effects. Second, alternative strategies may be required to induce an increase in positive moods or emotions. For example, different motivational primes have recently been shown to influence ratings of enjoyment and perceived exertion in a 30 minute self-paced cycling task (Banting, Dimmock, & Grove, 2011). In addition, the application of music (Lane et al., 2011), imagery (Stanley & Cumming, 2010), and self-talk and coping strategies (Nicholls & Polman, 2007) are further means by which attentional focus may be manipulated in a way that may influence feeling states and perceived exertion during endurance exercises.

It should be noted that the present findings may be limited to the particular experimental conditions that were used. In the Vmax test and control condition, the treadmill display was covered so that participants could not see exercise relevant information such as distance travelled and running speed. Although covering the display increased experimental control across conditions (the display was also covered in the focus on breathing and running movement conditions), it may limit the generalisability of the results to normal exercise situations. In addition, the exercise task was of relatively short duration (4 x 5 minute trials), at a speed set at a moderate intensity (70% of V_{max}), and running indoors on a treadmill. The subjective ratings indicated that the recreational exercisers who participated found the exercise intensity to be relatively moderate. Whether attentional focus will have different effects at a lower exercise intensity (e.g., walking) or higher exercise intensity or when exercising for a longer duration remains to be determined. The present participant sample was also limited in that it comprised largely of young adults (mean age of 24.52 years). The use of a broader age range to include adolescents and elderly individuals would show the extent to which the present findings generalise across the wider population.

In addition, the present experiment examined differences between attentional strategies across a group of participants as a whole. It should be acknowledged that individual differences and past exercise history may play an important role in the effects of any particularly type of attentional focus. Individual differences were evident in the present study in ratings of the most preferred strategy and ratings of the most difficult strategy. Preferences for a particular type of attentional focus may thus be an important variable to consider in future research. Past history was not investigated in the present study. However, it may be expected that individuals vary in whether they exercise predominantly on a treadmill or on tracks or roads outside. Individuals that exercise on a treadmill may have found the instruction to focus on the distance run to be highly familiar. These individuals may have responded differently to those for which a focus on distance run was more novel. Such aspects of familiarity may have influenced not only physiological performance outcomes, but also subjective ratings during the attentional focus conditions. It is recommended that future research take individual differences and past history into account when examining the effects of attentional focus instructions on performance and subjective ratings.

In conclusion, the present experiment has further confirmed the impact of internal and external attentional focus on physiological performance outcomes during physical exercise, such as weight training (e.g., Marchant et al., 2008; Neumann & Heng, 2011, Vance et al., 2004) and running (e.g., Schücker et al., 2009). This research is allowing psychologists to give evidence-based advice to athletes and recreational exercisers who wish to enhance their performance during training or competition. The present findings, for example, suggest that athletes could gain benefits in terms of exercise economy if they focus their attention on the distance travelled and their running movements during competitive races. Similar advice could also apply for athletes in other endurance sports, such as rowing, distance cycling, and distance swimming, although further research is required to determine whether the present findings do generalise to these other sports. Nevertheless, the direction of the attentional focus is clearly an important issue to consider in consultations with athletes or those wishing to exercise to improve their fitness.

Key Points

What is already known about this topic

- Psychological strategies can influence performance during sport and exercise
- Attention can be directed to different aspects of exercise tasks
- An external focus of attention may benefit exercise performance more than an internal focus

What this topic adds

- A focus on distance travelled reduced breathing frequency when running and was ranked as one of the least difficult and most preferred strategies
- A focus on body movements reduced oxygen consumption when running and was ranked as one of the least difficult strategies
- The physiological benefits of a distance or movement focus did not come at any psychological cost or benefit

References

Australian Government, Department of Health & Ageing. (2010). *Physical activity: Research & Statistics*. Retrieved March 10, 2011, from http://www.health.gov. au/internet/main/publishing.nsf/content/health-pubhlth-strateg-active-evidence.htm.

Banting, L. K., Dimmock, J. A., & Grove, J. R. (2011). The impact of automatically activated motivation on exercise-related outcomes. *Journal of Sport & Exercise Psychology, 33,* 569-585.

Beedie, C. J., Terry, P. C., & Lane, A. M. (2005). Distinctions between emotion and mood. *Cognition and Emotion, 19,* 847-878.

Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales*. United States: Human Kinetics.

Connolly, C. T., Janelle, C. M. (2003). Attentional strategies in rowing: performance, perceived exertion, and gender considerations. *Journal of Applied Sport Psychology, 15,* 195-212.

Couture, R.T., Jerome W., Tihanyi, J. (1999). Can associative and dissociative strategies affect the swimming performance of recreational swimmers? *The Sport Psychologist, 13,* 334-343.

Dale, M., Dollman, J., & Lewis, N. (2007). Trends in physical activity behaviours and attitudes among South Australian youth between 1985 and 2004. *Journal of Science and Medicine in Sport, 10,* 418-427.

Franch, J., Madsen, K., Djurhuus, M. S., & Pedersen, P. K. (1998). Improved running economy following intensified training correlates with reduced ventilatory demands. *Medicine and Science in Sports and Exercise, 30,* 1250–1256.

Harte, J. L., & Eifert, G. H. (1995). The effects of running, environment, and attentional focus on athletes' catecholamine and cortisol levels and mood. *Psychophysiology, 32,* 49–54.

Hatfield, B. D., Spalding, T. W., Mahon, A. D., Slater, B. A., Brody, E. B., & Vaccaro, P. (1992). The effect of psychological strategies upon cardiorespiratory and muscular activity during treadmill running. *Medicine and Science in Sports and Exercise, 24,* 218-225.

Jones, A. M., & Carter, H. (2000). The effect of endurance training on parameters of aerobic fitness. *Sports Medicine, 29,* 373–386.

Kendzierski, D., & DeCarlo, K. J. (1991). Physical activity enjoyment scale: Two validation studies. *Journal of Sport and Exercise Psychology*, *13,* 50-64.

LaCaille, R. A., Masters, K. S., & Heath, E. M. (2004). Effects of cognitive strategy and exercise setting on running performance, perceived exertion, affect, and satisfaction. *Psychology of Sport and Exercise*, *5*, 461-476.

Lane, A. M., Davis, P. A., & Devonport, T. J. (2011). Effects of music interventions on emotional states and running performance. *Journal of Sports Science and Medicine, 10,* 400-407.

Lee, A. J., & Stubbs, C. O. (2004). The obesity epidemic: Both energy intake and physical activity contribute. *Medical Journal of Australia*, *181*, 489-491.

Lind, E., Welch, A. S., & Ekkekakis, P. (2009). Do ‘mind over muscle’ strategies work? Examining the effects of attentional association and dissociation on exertional, affective, and physiological responses to exercise. *Sports Medicine*, *30,* 743-764.

Lipp, O. V., Neumann, D. L., & McHugh, M. J. (2003). Lead stimulus modality change and the attentional modulation of the acoustic and electrical blink reflex. *Biological Psychology, 62,* 27-48.

Marchant, D., Greig, M., & Stott, C. (2008). Attentional focusing strategies influence muscle activity during isokinetic biceps curls. *Athletic Insight: The Online Journal of Sport*

Psychology, *10*. Retrieved from http://www.athleticinsight.com/Vol10Iss2/ MuscularActivity.htm.

Masters, K. S., & Ogles, B. M (1998). The relations of cognitive strategies with injury, motivation, and performance among marathon runners: results from two studies. *Journal of Applied Sport Psychology, 10,* 281-296.

McNair, P. M., Lorr, M., & Droppleman, L. F. (1981). *POMS Manual* (2nd ed.). San Diego: Educational and Industrial Testing Service.

Morgan, W. P. (1978). Mind of the marathoner. *Psychology Today, 11*, 38-49.

Morgan, W. P., Horstman, D. H., Cymerman, A., & Stokes, J. (1983). Facilitation of physical performance by means of cognitive strategy. *Cognitive Therapy and Research, 7,* 251-264.

Nicholls, A. R., & Polman, R. C. J. (2007). Coping in sport: A systematic review. *Journal of Sport Sciences, 25*, 11-31.

Neumann, D. L. & Heng, S. (2011). The effect of associative and dissociative attentional focus strategies on muscle activity and heart rate during a weight training exercise. *Journal of Psychophysiology, 25*, 1-8.

Neumann, D. L., & Thomas, P. R. (2011). Cardiac and respiratory activity and golf putting performance under attentional focus instructions. *Psychology of Sport and Exercise, 12,* 451-459.

Neumann, D. L., & Thomas, P. R. (2009). The relationship between skill level and patterns in cardiac and respiratory activity during golf putting. *International Journal of Psychophysiology, 72,* 276-282.

Noakes, T. D., Myburgh, K. H., & Schall, R. (1990). Peak treadmill running velocity during the VO_2max test predicts running performance. *Journal of Sports Sciences*, *8,* 35-45.

Patrick, T. D., & Hrycaiko, D. L. (1998). The effects of a mental training package on an endurance performance. *The Sport Psychologist, 12,* 283–299.

Radlo, S. J., Steinberg, G. M., Singer, R. N., Barba, D. A., & Melnikov, A. (2002). The influence of an attentional focus strategy on alpha brain wave activity, heart rate, and dartthrowing performance. *International Journal of Sport Psychology, 33*, 205–217.

Russel, W. D., & Weeks, D. L. (1994). Attentional style in ratings of perceived exertion during physical exercise. *Perceptual and Motor Skills*, *78*, 779-783.

Schomer, H. H. (1990). A cognitive strategy training programme for marathon runners: ten case studies. *South African Journal for Research in Sport, Physical Education &. Recreation, 134,* 47-78.

Schücker, L., Hagemann, N., Strauss, B., & Völker, K. (2009). The effect of attentional focus on running economy. *Journal of Sports Sciences, 27*, 1241-1248.

Shea, C. H., & Wulf, G. (1999). Enhancing motor learning through external-focus instructions and feedback. *Human Movement Science, 18*, 553-571.

Smith, A. L., Gill, D. L., Crews, D. J., Hopewell, D., & Morgan, D. W. (1995). Attentional strategy use by experienced long distance runners: physiological and psychological effects. *Research Quarterly for Exercise and Sport, 66,* 142-50.

Sports Medicine Australia (2005). *Sports Medicine Australia (SMA) pre-exercise screening system 2005*. Available at http://sma.org.au/wp-content/uploads/2009/05/new_pre_screening.pdf.

Stanley, D. M., & Cumming, J. (2010). Not just how one feels, but what one images? The effects of imagery use on affective responses to moderate exercise. *International Journal of Sport and Exercise Psychology, 8,* 343-359.

Stevinson, C. J., & Biddle, S. J. H. (1998). Cognitive orientations in marathon running and “hitting the wall”. *British Journal of Sports Medicine*, *32,* 229-235.

Vance, J., Wulf, G., Töllner, T., McNevin, N., & Mercer, J. (2004). EMG activity as a function of the performer's focus of attention. *Journal of Motor Behavior*, *36*, 450-459.

Vealy, R. S. (2007). Mental skills training in sport. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of sport psychology 3rd ed.* (pp. 287-209). Hoboken, NJ: John Wiley & Sons.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54,* 1063-1070.

Wininger, S.R., & Gieske, D. (2010). Measure of Attentional Focus: Cognitive Interviews and a Field Study. *Athletic Insight, 2,* 125-146.

Wulf, G. (2007a). *Attention and motor skill learning*. United States: Human Kinetics.

Wulf, G. (2007b). Attentional focus and motor learning: A review of 10 years of research. *E-Journal Bewegung und Training*, *1*, 4-14.

Wulf, G., Shea, C., & Park, J. (2001). Attention and motor performance: Preferences for and advantages of an external focus. *Research Quarterly for Exercise and Sport*, *72*, 335-344.

Wulf, G., McNevin, N., & Shea, C. H. (2001). The automaticity of complex motor skill learning as a function of attentional focus. *Quarterly Journal of Experimental Psychology*, *54A*, 1143-1154.

Ziv, G., Meckel, Y., Lidor, R., & Rotstein, A. (2012). The effects of external and internal focus of attention on physiological responses during running. *Journal of Human Sport & Exercise, 7,* 608-616.

Figures

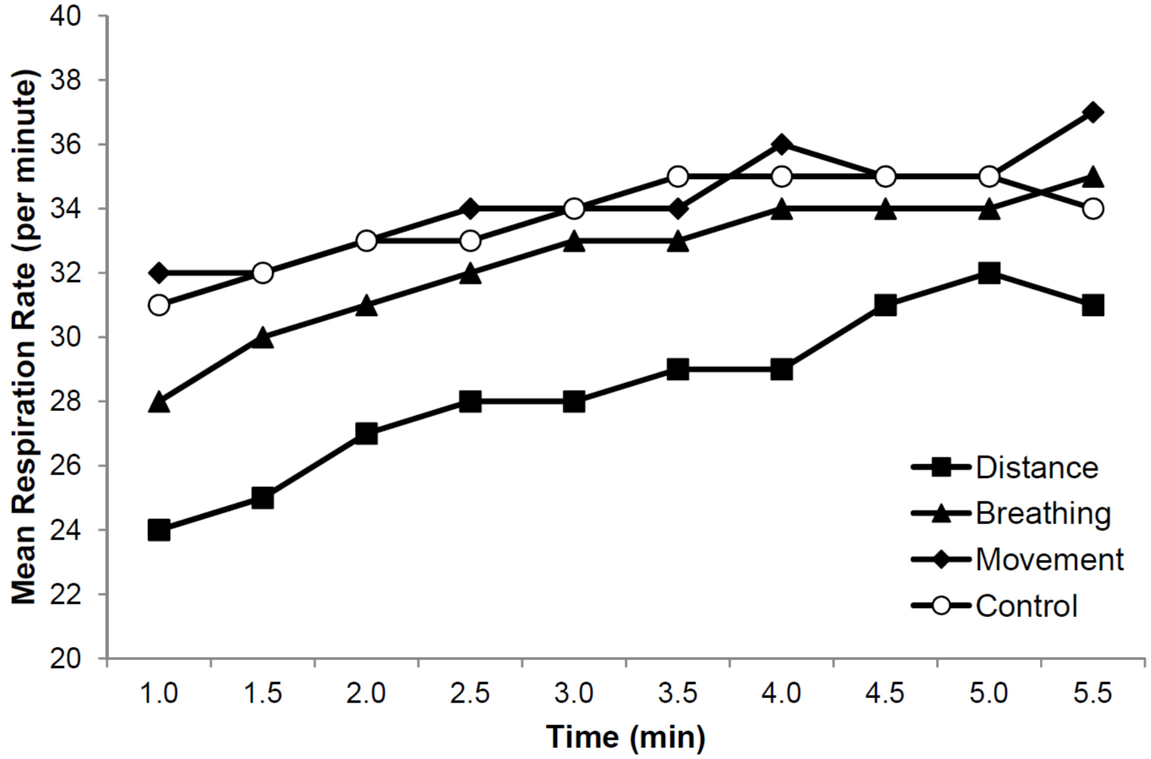
Figure 1. Mean respiration rate as a function of the attentional focus condition. The x-axis scale refers to the minute at which each 30 s epoch first began.

Figure 2. Mean VO_2 consumption as a function of the attentional focus condition. The x-axis scale refers to the minute at which each 30 s epoch first began.

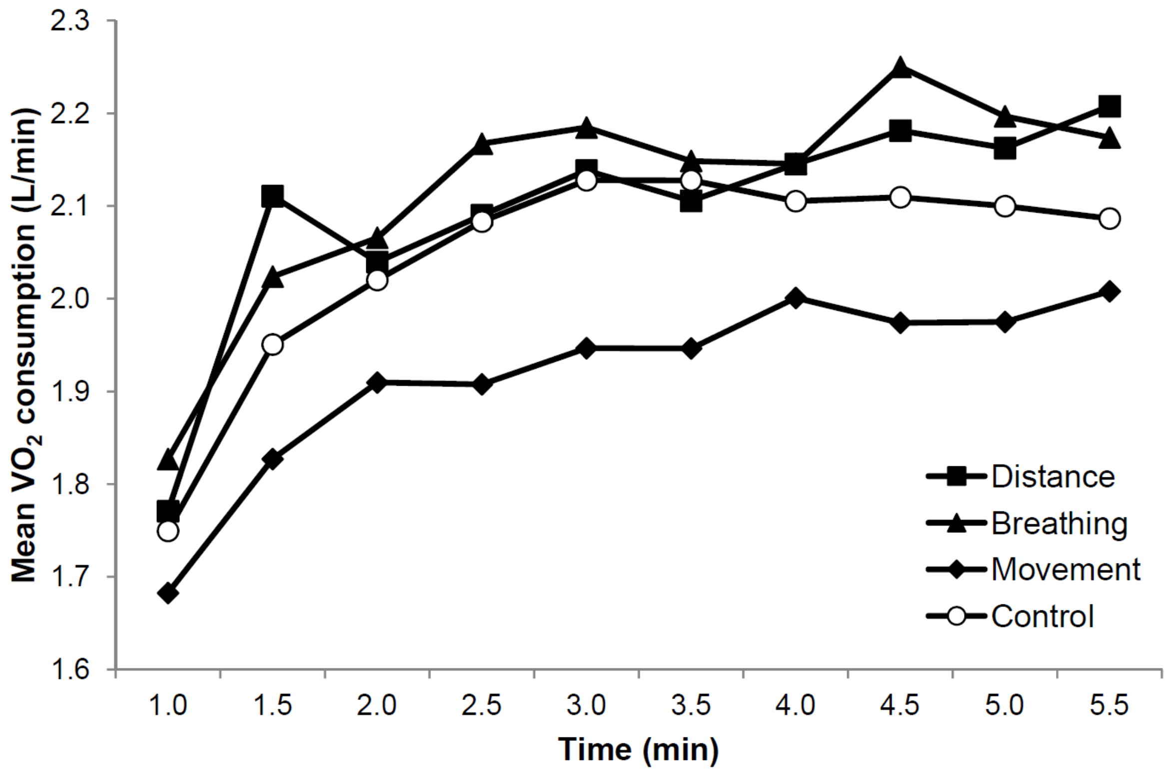
Table 1

Percentage of participants who reported the least difficult and most preferred attentional focus condition

Rating dimension	Attentional Focus Condition			
	Distance	Breathing	Movement	Control
Least difficult	47.6%	9.5%	42.9%	0.0%
Most preferred	42.9%	42.9%	14.2%	0.0%



Mean Respiration Rate (per minute)
40
38
36
34
32
30
28
26
24
22
20
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Time (min)
Distance
Breathing
Movement
Control



Mean VO2 consumption (L/min)
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Time (min)
Distance
Breathing
Movement
Control