THE EFFECTIVENESS OF ATTENTIONAL INSTRUCTIONS ON RUNNING ECONOMY AT A SUBMAXIMAL VELOCITY

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Abstract:

The purpose of this study was to examine the effectiveness of external and internal focus of attention instructions on running economy at a submaximal velocity. Twenty-four male physical education students ran on a treadmill at a velocity of 9.6 km·hr^{-1} in two 10-minute counterbalanced conditions: external focus (watching a video of running from the runner's perspective), and internal focus (focusing on the movement of their legs). The external focus of attention provided visual feedback of the running velocity to the participants and was shown during the internal focus condition as well. No differences in physiological responses, running economy, or rating of perceived exertion were found between the two conditions. Based on the data of the current study, it was concluded that attentional focus does not affect running economy or physiological responses when running at submaximal velocities.

Key words: *attentional focus instructions, running economy, visual feedback, exercise test*

Introduction

Evidence in the literature has shown that an external focus of attention can lead to improved learning and performance of motor skills compared with an internal focus of attention (see Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002; Jackson & Holmes, 2011; Lidor & Yanovitz, 2005; Southard, 2011; Wulf, 2007a, 2007b, 2013; Wulf, Lauterbach, & Toole, 1999; Wulf, McNevin, Fuchs, Ritter, & Toole, 2000; Wulf & Su, 2007; Zachry, Wulf, Mercer, & Bezodis, 2005). An external focus of attention leads one's attention to the movement effects, while an internal focus of attention leads one's attention to the movements themselves (Wulf & Dufek, 2009). One possible explanation for the advantage of the external focus of attention is that the external focus allows for automatic movement control, while the internal focus constrains the motor system by intervening with automatic processes (Wulf, 2007b, 2013). This explanation is supported by the findings of studies using electromyography (EMG), showing that reduced muscle activation accompanies the improved performance when using external focus in dart throwing (Lohse, Sherwood, & Healy, 2010) and vertical jump (Wulf, Dufek, Lozano, & Pettigrew, 2010). Reduced muscle activation accompanying improved performance suggests that coordination within the muscle is being optimized under external attention allocation (Wulf, et al., 2010).

Although the benefits of an external focus of attention are quite consistent for learning a new motor skill, particularly discrete closed-motor skills (see, for example, Wulf, 2007a, 2007b, 2013), the relationship between attentional focus and endurance activities was found to be inconsistent (Masters & Ogles, 1998). A number of studies suggested that an external focus might be beneficial to endurance athletes (e.g. Gill & Strom, 1985; Morgan, Horstman, Cymerman, & Stokes, 1983; Pennebaker & Lightner, 1980). For example, in one study (Gill & Strom, 1985), participants performed more repetitions in a leg extension endurance task under an external focus condition (i.e. looking at a collage) when compared to an internal focus condition (i.e. focusing on feelings in the legs). In contrast, other attentional studies suggested that an internal focus might have greater benefits (e.g. Connolly & Janelle, 2003; LaCaille, Masters, & Heath, 2004). For example, female varsity rowers performed better on a rowing ergometer (i.e. rowed for a longer distance) under internal focus conditions (i.e. focusing on breathing and on the body) than under external focus conditions (i.e. focusing on collages and answering general questions about them; Connolly & Janelle, 2003).

Based on the studies examining the effectiveness of internal and external attentional instructions, it can be observed that in most of these studies performance variables were measured. These include accuracy variables (e.g. variable error, absolute error), speed variables, and time variables. When measuring performance, a number of intervening factors can affect results, among them the level of motivation of a participant, his or her level of fatigue, and nutrition. It is less known whether attentional focus affects physiological responses to submaximal exercise, in which the performance of the task does not rely on psychological (e.g. motivation) or physiological (e.g. maximal aerobic capacity) variables. An important physiological variable that characterizes the quality of performance of a submaximal velocity running task is oxygen consumption, representing the running economy at that specific velocity (Saunders, Pyne, Telford, & Hawley, 2004).

Up to now, only two studies have examined the effects of attentional focus on running economy. One study found no benefits of either external or internal focus of attention in adolescent basketball players running at 60% of their heart rate reserve (Ziv, Meckel, Lidor, & Rotstein, 2012). In this study the participants watched a video of a basketball game during the external focus condition, and during the internal focus condition the video was turned off and the participants were instructed to focus on the movement of their legs. Oxygen consumption was similar in both conditions. In contrast, a study by Schücker, Hagemann, Strauss, and Völker (2009) found improved running economy during the external focus condition. The external focus of attention was a film showing an urban running setting from a runner's perspective at a velocity similar to that of the treadmill. During the internal focus condition, no film was shown and the participants were instructed to focus on their legs and on their running motion.

One possible explanation for the different results of the studies by Ziv et al. (2012) and by Schücker et al. (2009) is that the external focus condition in the latter study included a visual feedback of the running velocity, while in the study by Ziv et al. (2012) no visual feedback of the running velocity was provided to the participants during the external focus condition. It has already been shown that visual feedback of running velocity can affect gait and locomotion (e.g. Mohler, Thompson, Creem-Regehr, Pick, & Warren, 2007; Prokop, Schubert, & Berger, 1997). In the study by Schücker et al. (2009), the film that was shown during the external focus condition was not shown during the internal focus condition. Therefore, it is possible that it was the presence of the visual feedback during the external focus condition, rather than the external or internal focus *per se*, that led to an improved running economy in that study.

An attempt was made in the current study to further examine the effectiveness of internal and external focus of attention instructions on running economy when feedback on running velocity is provided during both the external and internal focus conditions. These findings may help to increase our understanding of the contribution (as reported in the study by Schücker, et al., 2009), or lack of contribution (as reported in the study by Ziv, et al., 2012), of attentional instructions to running economy at a submaximal velocity. In addition, the findings of this study may benefit coaches by providing instructional tips on how to teach their athletes to be focused when running at a submaximal velocity.

Methods

Participants

Twenty-four male physical education students (mean age = 26.5±4.04 years) were recruited for this study. The participants' mean body height was 174.58±6.23 cm, their mean body mass was 73.98±8.54 kg, and their mean percent of body fat was 10.52±3.67%. The study was approved by the Ethics Committee of the Zinman College of Physical Education and Sport Sciences, Wingate Institute, Israel.

Procedure

Upon arrival at the Exercise Physiology Laboratory, the participants' body mass and height were measured and recorded using an electronic scale and a stadiometer (Seca Deutschland, Hamburg, Germany), respectively. Two-compartment body composition (fat mass and fat-free mass) was estimated using the sum of three skinfolds (triceps, subscapular, and chest) using a Lafayette skinfold caliper (Lafayette Instrument Company, Lafayette, IN, USA).

After the measurements of body mass, body height, and body composition were completed, each participant performed a warm-up session composed of an 8-min run at 8.5 $km \cdot hr^{1}$ and five minutes of stretching exercises. The participants were then connected to a metabolic cart (K4, Cosmed, Rome, Italy) and a heart rate (HR) monitor, and began an experimental run which lasted 20 minutes at 9.6 $km \cdot hr^{1}$ – ten minutes with internal focus instructions and ten minutes with external focus instructions. The internal and external focus conditions were counterbalanced. Under both conditions, a video of a trail in New York's Central Park, videotaped from the runner's perspective, was shown to the participants on a computer screen placed in front of them at eye level (Outside Interactive, MA, USA). The running velocity in the video matched that of the treadmill (i.e. 9.6 $km \cdot hr^{1}$). However, different audio instructions were presented to the participants under each condition. Under the internal focus condition, the participants were instructed to focus on their moving legs and feet, whereas under the external focus condition they were told to focus on the video. The instructions regarding the focus of attention were recorded on a CD and were repeated every 15 seconds throughout the relevant condition. During the internal focus condition, the statements *"Focus on the running motion"* and *"Focus on the movement of your legs"* were spoken and alternated every 15 seconds. During the external focus condition, the statements *"Focus on the video"* and *"Focus on the trail"* were spoken and also alternated every 15 seconds.

Throughout the 20-min run the participants were connected to the metabolic cart, and breath-by-breath physiological measurements were recorded. In the last seven minutes under each condition, the mean of the following variables was used for further analysis: oxygen consumption (VO_2), ventilation (Ve), respiratory rate (RR), and respiratory exchange ratio (RER). The rate of perceived exertion (RPE) on a 1-10 scale (Borg, 1982) was recorded in the last minute of each condition. At the completion of the 20-min run, each participant completed an open-ended strategy-check questionnaire in order to assess whether the attentional focus instructions were actually followed.

Statistical analyses

Descriptive statistics are presented as means±SDs. Paired *t*-tests were performed to assess differences between the physiological variables in the two running conditions. The statistical significance level for all the analyses was set at alpha = .05.

Results

The physiological responses and RPE of the participants across the internal and external focusing attention conditions are presented in Table 1. The oxygen consumption during running under the internal and external focus conditions is presented in Figure 1. The data analyses revealed no significant differences in any of the physiological variables between the internal and the external focus condition.

An analysis of the strategy-check questionnaire indicated that the attentional focus instructions were followed 78% of the time, on average. For example, one participant reported that he used the instructions 50% of the time, and one 40% of the time. Six participants reported that they followed the instructions for over 90% of the duration of the run.

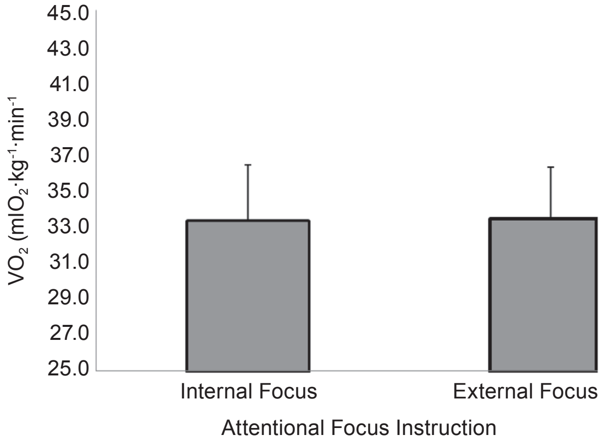

Figure 1. Oxygen consumption during running under the internal and external focus conditions. Error bars represent standard deviations

Discussion and conclusions

The main finding of the current study is that neither external nor internal attentional focus instructions affect running economy when running at a comfortable sub-maximal running speed. In the current study, we measured physiological responses and running economy at a fixed submaximal running speed. As indicated before, the actual compliance with the required task in this study was not limited by the maximal psychological or physiological capacities of the participants. More specifically, the 20-min run at 9.6 $km{\cdot}hr^1$ was an easy effort for our participants, as shown by the very low RPE (~ 2.0) that was reported throughout the run. It was demonstrated that during such a task the submaximal psychological and physiological responses are not affected by the provision of focusing attention instructions.

The benefits of external focus of attention in the motor learning literature were observed particularly during the performance of discrete closed-motor skills, where specific performance outcomes were measured (see Jackson & Holmes, 2011; Wulf,

Table 1. The physiological and RPE responses of the physical education students to the two experimental conditions (means±SDs)

Variable	Internal Focus	External Focus	Significance
VO_2 ($mlO_2{\cdot}kg^{-1}{\cdot}min^{-1}$)	33.29±3.14	33.41±2.89	$t_{(23)}$=0.395, p=.696, ES=.04
Ventilation (L·min-1)	68.20±11.26	66.49±12.18	$t_{(23)}$=-1.003, p=.327, ES=.15
Respiratory rate (breaths·min^{-1})	36.84±8.49	36.40±8.40	$t_{(23)}$=-0.626, p=.537, ES=.05
HR (beats·min^{-1})	149±20	150±21	$t_{(23)}$=0.133, p=.895, ES=.05
Respiratory exchange ratio	.96±.07	.96±.07	$t_{(23)}$=-1.973, p=.061, ES=0
RPE	2.01±1.28	2.17±1.19	$t_{(23)}$=0.806, p=.429, ES=.13

2013; Wulf, et al., 1999; Wulf, et al., 2000; Wulf & Su, 2007; Zachry, et al., 2005). It is possible that maximal running speed or running duration can be influenced by a number of psychological factors, such as the motivation level, anxiety level, and mood state of the participant. External focus of attention can benefit performance by directing one's attention away from psychologically unfavorable internal dialogues (e.g. negative thoughts). However, under submaximal conditions the effects of these psychological factors may be minimal, and therefore a significant effect of attentional focus on physiological responses or RPE under these conditions was not observed.

Our present findings seem to be in disagreement with the findings of the study by Schücker et al. (2009), who reported an improved running economy with an external focus of attention. However, in that study visual feedback on running velocity was provided during the external focus condition, but not during the internal focus condition. Therefore, it is possible that it was the presence of visual velocity feedback rather than the external focus *per se* that led to the improved running economy.

It has been shown that changes in the visual flow of information can influence the perception of locomotion and lead to changes in the preferred transition speed from walking to running (Mohler, et al., 2007), as well as to changes in self-chosen walking velocities (Prokop, et al., 1997). Since it appears that visual flow information is related to changes in gait (e.g. stride length, arm swing, shoulder rotation) and locomotion, and since changes in gait can lead to changes in running economy (Anderson, 1996), it is possible that the presence of visual flow information can affect physiological responses to running at submaximal velocities. It should be noted that when running outdoors, where the terrain keeps changing, the visual velocity feedback is constantly available regardless of the attentional focus. Hence, our present protocol was closer to the conditions observed during actual outdoor running.

In the current study the video was running during both internal and external focus conditions. While the instructions under the internal condition clearly emphasized focusing on the participants' moving legs, the information from the video (i.e. the changing scenery of Central Park in New York filmed from the runner's perspective) was still present. No differences in running economy were found under the two conditions.

Three other possible explanations of the differences between the findings that emerged from the study by Schücker et al. (2009) and those from Ziv et al. (2012) are further proposed.

First, Schücker et al. (2009) used a running velocity corresponding to 75% of VO_{2max}. In contrast, Ziv et al. (2012) used a lower velocity, corresponding to approximately 60% of VO_{2max}. It is possible that since running at 75% of VO_{2max} was more demanding than running at 60% of VO_{2max}, external focus of attention would be more beneficial, as it distracts the participants from any feelings of discomfort in their body. The similar findings obtained in the current study and those that emerged from the study by Ziv et al. (2012) may be due to the relatively small physiological loads placed on the participants during the submaximal run. Under such conditions, it is likely that focus of attention was not of importance, since the running activity did not require a special effort, and was perceived as easy by the participants (RPE of approximately two in the current study and less than four in the study by Ziv, et al.). Unfortunately, these values are difficult to compare to the ones in the study by Schücker et al. (2009), as the subjective rating of exertion used in the latter study was on the scale of one (easiest) to three (most difficult). Still, under the two internal running conditions a subjective rating of difficulty from 2.17 to 2.41 was reported. These values appear to represent a much higher difficulty than the values reported in the current study and in the study by Ziv et al. (2012). As mentioned earlier, it is possible that an external focus of attention would be beneficial under more difficult conditions. Indeed, in the study by Schücker et al. (2009), a subjective difficulty rating of 1.38 was reported under the external focus condition.

Second, participants who took part in the previously mentioned studies were at different ability/skill levels: trained runners who ran an average of 59 km per week participated in the study by Schücker et al. (2009), youth basketball players participated in the study by Ziv et al. (2012), and physical education students served as participants in the current study. While all the participants were supposed to be proficient at running, it is still possible that attentional focus instructions have a different effect on various populations with different levels of ability and skill, as well as different backgrounds in sport or physical activity.

Third, since attentional focus cannot be measured directly, it is possible that the participants in the study by Schücker et al. (2009), the study by Ziv et al. (2012), and the current study followed the attentional focus instructions differently, and therefore the results of each study were biased based on how the participants (and how many of them) actually used the given attentional focus instructions. The results from the strategy-check questionnaire in the current study suggest that the attentional focus instructions were for the most part followed (an average of 78%, as reported by the participants). These results are in line with data of previous research: in one study (Singer, Cauraugh, Murphey, Chen, & Lidor, 1991), the strategy-check questionnaire revealed that 76% of the participants who received attentional instructions reported that they used the attentional instructions throughout the experiment. In another study (Singer, Lidor, & Cauraugh, 1993), 85% of the participants who received learning strategy instructions reported that they used the instructions throughout the experiment. In the studies by Schücker et al. (2009) and Ziv et al. (2012), strategy-check questionnaires were not administered to the participants.

The results of the current study suggest that attentional focus instructions do not affect running economy in submaximal velocities when visual feedback is presented to the runners. The visual feedback in the present study under both attentional focus conditions represented conditions of natural outdoor running. However, future research should examine these issues when running in field conditions rather than in a laboratory. In addition, if running velocities are increased, it is possible that the attentional focus instructions will have an effect on running economy and other physiological variables. This should be further examined in future research as well.

Coaches who aim at teaching their athletes how to focus attention during running at a submaximal velocity should consider the use of both internal and external instructions. Since some kind of focusing attention level is required in any given task performed by athletes, both internal and external focus attention instructions can be used in running tasks performed at a submaximal velocity.

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UTJECAJ UPUTA ZA FOKUS PAŽNJE NA EKONOMIČNOST TRČANJA SUBMAKSIMALNIM BRZINAMA

Cilj je ovog istraživanja bio ispitati koliko instrukcije za (vanjski i unutarnji) fokus pažnje utječu na ekonomičnost trčanja submaksimalnim brzinama. Dvadeset i četiri studenta (muškarca) kineziologije trčala su po deset minuta na pokretnoj traci brzinom od 9,6 km/h provodeći dva različita eksperimentalna protokola usmjeravanja pažnje: vanjski fokus (gledanje videa snimljenoga iz perspektive trkača) i unutarnji fokus (pažnja na kretnje vlastitih nogu). Vanjski fokus pažnje omogućio je ispitanicima vizualnu povratnu informaciju o brzini trčanja, a video snimka je prikazana i u uvjetima unutarnjeg fokusa pažnje. Nisu zabilježene značajne razlike u fiziološkim odgovorima, ekonomičnosti trčanja ili subjektivnoj procjeni opterećenja između dva eksperimentalna protokola. Na temelju podataka istraživanja zaključeno je da fokus pažnje ne utječe na ekonomičnost trčanja ni fiziološke reakcije prilikom trčanja submaksimalnim brzinama.

Ključne riječi: *upute za fokus pažnje, ekonomičnost trčanja, vizualna povratna informacija, testiranje*