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ORIGINAL RESEARCH

The Effects of an Associative, Dissociative, Internal, and External Focus of Attention on Running Economy

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Much research has been executed to investigate how altering focus of attention impacts performance and feelings of fatigue. Using a within-participant design, the present study examined how an associative and dissociative attentional in addition to an internal and external attentional dimension influenced the running economy of nonprofessional runners. Twelve women (aged 18–30 years old) ran on a treadmill at 70% of their predetermined maximum velocity. Participants ran in four counter-balanced conditions (dissociative-external, dissociative-internal, associative-external, and associative-internal). Average oxygen volume, respiration volume and breathing frequency, heart rate, blood lactate level, and Borg rating of perceived exertion were measured. Our findings revealed when participants adopted a dissociative-external focus of attention, they consumed less oxygen, had lower blood lactate, and a lower rating of perceived exertion compared with trials completed using an associative attention strategy. The findings of this study demonstrate that running economy is improved and feelings of fatigue are lowest when using a combination of a dissociative-external focus of attention.

***Keywords**:* blood lactate, oxygen consumption, Borg scale, treadmill, fatigue

When running recreationally for pleasure or in a competitive context, we have countless options regarding how to focus our conscious attention. Previous research has reported that common thoughts that occur during running are related to pain, distance traveled, running time, cadence, and focusing on objects in the environment (Samson et al., 2017). Studies have revealed that directing attention externally toward the environment, or simply away from the performance of the task, has a positive effect on endurance performance and economy (Schücker et al., 2013, 2015). Running economy has been defined as the amount of oxygen consumed ($\dot{V}O_2$) or heart rate level when running at a submaximal velocity (Jones & Carter, 2000; Saunders et al., 2004). Interestingly, Masters and Ogles (1998) propose that using the

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equivalent of an internal or external focus of attention does not reflect a runner's mental action accurately, whereas others have suggested a classification with multiple dimensions of attention with the goal of capturing the nuanced ways one can allocate attention (Gose & Abraham, 2021). In addition to the internal or external adoption of attention, a mover can also utilize an associative or dissociative attention allocation strategy. When a mover adopts an associative attention policy, they are focusing on bodily function or sensations (e.g., muscle contractions, breathing), in contrast, when a dissociation strategy is used, the mover blocks out sensory perception by directing attention to a distracting task (e.g., watching a video) (Masters & Ogles, 1998; Neumann & Brown, 2013; Stevinson & Biddle, 1999).

Brick et al. (2014) proposed a two-dimensional model regarding how attentional focus affects endurance performance. According to this model, the combination of the previously mentioned dimensions creates the following four possible ways to focus attention: associative-external attention (e.g., pacing); associative-internal attention (e.g., muscle action); dissociative-external attention (e.g., watching a sporting event); and dissociative-internal attention (e.g., solving a mental puzzle). Previous research investigating the various forms of attentional focus when performing endurance activities have produced mixed results (Brick et al., 2014; Lind et al., 2009; Schücker et al., 2014, 2016; Terry et al., 2012). For example, Terry et al. (2012) revealed when an athlete listened to music, running economy was better than when using other attention allocation strategies. In addition, Schücker et al. (2016) implemented an experimental design in which participants ran at a predetermined running pace while adopting differing attention allocation strategies (e.g., watching a video, focus on breathing, focus on running movement, no instruction). Compatible with the results reported by Terry et al. (2012), the findings reported by Schücker et al. (2016) demonstrated that the best running economy (i.e., lowest oxygen consumption) occurred when participants watched a video. In another study by Schücker et al. (2009), participants ran at 75% of their maximal $\dot{V}O_2$ consumption. Results revealed that the external focus of attention condition (focus on a video while running) resulted in the best economy (lower $\dot{V}O_2$). Interestingly, these studies (Schücker et al., 2009, 2013; Schücker et al., 2014) did not report any significant differences on the rate of perceived exertion (RPE).

In a related line of research, Neumann and Piercy (2013) used regular exercisers to investigate alterations in associative attentional focus. Participants ran on a treadmill at 75% of their maximum treadmill speed. Runners were instructed to focus their attention on their breathing while running, running movements, or the amount of distance they had traveled. Those conditions were then compared with a control measure in which no attention focusing instructions were provided. Results revealed participants had the best economy when they were instructed to direct their attention toward running movements.

The constrained action hypothesis can explain improved running economy during an external over an internal focus of attention (Wulf et al., 2001) in that individuals using an internal focus of attention attempted to control their movements consciously. Conscious control of motor behavior likely disrupted the automatic control processes in the motor system resulting in depressed motor performance. Schücker et al. (2014) summarized that directing attention internally to a specific body action (i.e., muscle contraction or breathing) was detrimental to running economy, whereas focusing on the body sensation was not comparatively

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detrimental (Schücker et al., 2014). It is worth noting that the constrained action hypothesis does not make specific predictions about the potentially enhancing or depressing effects of an associative or dissociative focus of attention.

The work of Schücker et al. (2009, 2013) has reported clear advantages to directing attention externally when performing endurance activities. However, a study conducted by Ziv et al. (2012) did not find differences in running economy when focus of attention was directed toward the movement (internal) or a video (external). It is important to note in the Ziv et al. (2012) study, participants were well-conditioned basketball players, not experienced distance runners, and when participants ran on a treadmill in the Ziv study, they watched a basketball game rather than a nature-based running scene like the observed video in the Schücker et al. (2009, 2013) studies. These methodological differences may explain the different results reported by Ziv et al. (2012) and Schücker and colleagues.

During endurance running, little is known regarding the associative and dissociative factors related to tasks with internal and external dimensions, and they impact running performance. Morgan and Pollock (1977) reported that expert and inexperienced runners use two different attention allocation strategies. Experts typically use an associative strategy while running, choosing to monitor sensory information, and adjust their pace based on factors such as muscular tension, breathing rate, and fatigue. In contrast, a dissociative strategy is commonly used by nonexpert runners. That is, nonexpert runners preferred to direct attention toward a distraction, so they would spend minimal time thinking about pain or physical exertion caused by the running activity. Similar findings have been reported in multiple studies examining trained endurance runners (Brick et al., 2014; Gill et al., 2017). It is also important to note participants in the research conducted by Schücker et al. (2014) who directed their attention toward a video compared with focusing their attention on movements or breathing consumed less oxygen. Therefore, it is not yet clear whether nonprofessional runners use the same strategy as highly trained athletes and if these results can be generalized to runners whom recently began participation in an endurance activity for recreation or exercise. It is presently unclear how an internal or external focus of attention coupled with an associative or dissociative strategy influences running economy in nonprofessional runners. Considering the previously mentioned contradictory results in the field of endurance activity, the present research aimed to investigate an attention allocation method that could be adopted by recreational runners to facilitate movement economy and lower perceived fatigue. We were interested in the effects of combining an internal or external focus of attention with associative and dissociative attention allocation strategies. Based on previous findings, we predicted that participants would display more efficient running economy (e.g., lower oxygen consumption and lower blood lactate level) and lower perceived exertion when using an external-dissociative attention strategy compared with other attention allocation schemes.

Method

Participants

A total of 25 females volunteered to participate in the current study. Participants were students enrolled in a general university physical education course. Following

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the explanation of the experimental protocol, eight participants dropped out of the study as they were worried about having their blood drawn. In addition, three participants were eliminated from the study because a proper vessel to draw blood could not be found, and an additional two participants voluntarily withdrew from the study because they felt dizzy during testing. As a result, 12 females (aged 18–30 years; $M_{age} = 23.45$, $SD = 3.61$, height = 150–170 cm; $M_{Height} = 161.82$ cm, $SD = 6.13$, weight range 43–77.95 kg; $M_{weight} = 59.99$ kg, $SD = 9.41$, body mass index 18.99–35.41; $M_{body\ mass\ index} = 22.77$, $SD = 3.81$) completed participation in the present study. A power analysis conducted using G*Power revealed that an estimated sample size of 14 should be sufficient to detect statistical significant group differences at the recommended .80 level (Beck, 2013; Schweizer & Furley, 2016). All participants reported the total amount of time they spent exercising (e.g., walking, swimming, jogging, cycling, aerobics, weight training) each week (Neumann & Piercy, 2013). The times weekly physical activity reported varied from <2 (31% of participants), 2–4 (57% of participants), and 4–6 hr (12% of participants) (M_{weekly} activity = 1.27 hr, $SD = 1.42$). All participants received a verbal explanation of the experimental procedures and gave their written informed consent before participating. A university ethics committee approved the study protocol. As the study focused on runners, who were not highly trained, inclusion criteria which was based on how long and how fast participants had been running prior to their enrollment in the study was determined. Specifically, in order for a participant to qualify for participation in the study, they acknowledged they briskly walked or jogged for less than a total of 4 hr a week for the prior year. As noted previously, the average weekly level of physical activity for the pool of participants was 1.27 hr. Based on these criteria, we considered our participants to not be professional runners. Specific to the task used in the present study, we considered the volunteers to have a low level of experience at the motor skill of running on a treadmill. In addition, participants reported not having any physical (e.g., cardiovascular diseases) or mental disorders at the time of their participation. After providing consent, all volunteers were familiarized with the testing methodology and their physical activity was documented.

Task and Apparatus

Each volunteer performed a maximum speed test on the treadmill following the warm-up. Previous research (Neumann & Piercy, 2013) reported that the maximum speed on treadmill test is a valid predictor of running performance. To measure the maximum speed on treadmill of participants, the test began at a 6 km/hr treadmill speed and increased by 2 km/hr each minute. This process was continued up to emerging voluntary fatigue (Neumann & Piercy, 2013). The information on the treadmill monitor (e.g., speed, distance, and slope) was covered by a solid piece of material during the maximum speed on treadmill test to ensure the participant was not aware of the actual performance conditions. Consistent with previous research, over four continuous days, each participant ran on the treadmill at a velocity of 70% of her maximum speed on treadmill for 6 min (Neumann & Piercy, 2013). Participants were asked to look forward while running on the treadmill and to direct their attention on the provided instructions. Instructions were repeated every 30 s verbally during the trial in an attempt to ensure that

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participants paid attention to the guidelines. Prior to testing each day, participants were informed they would run for six continuous minutes. This study utilized a counterbalanced within-participant design, with participants experiencing a different experimental condition (i.e., four focus of attention conditions) during each of their 4 days of participation in the study. The four attention strategies were adopted from Neumann and Brown (2013) and were as follows:

(a) An associative-external attention was prompted by repeatedly instructing the participant to "count your steps" while running.

(b) To create an associative-internal focus of attention, the examiner repeated the phrase "Focus on the muscles in your feet" during the running action.

(c) Participants viewed a video clip of a basketball game on a monitor placed at eye level while in the dissociative-external condition.

(d) An dissociative-internal attention was prompted by asking each participant to perform mental calculations during the trial. This was done by providing each volunteer with a unique number and then instructing them to continuously subtract by three while running. The researcher asked the participant to verbally report the currently calculated number every 30 s.

Level of exertion was evaluated using the Borg RPE scale ranging from 6 to 20 (Borg, 1998) at the end of every 1-min running duration. Through a gas analyzer (R2 metallized model 3B; Cortex Corporation) and a Polar heart rate monitor, oxygen consumption and heart rate were recorded continually during running on the treadmill each testing session. Immediately following each testing session, blood samples were taken from an artery in the right arm by blood transfusion. Blood samples were then immediately transferred to tubes containing an anticoagulant and shaken 5–10 times. Tubes containing blood samples were then placed in a refrigerated centrifuge machine (German U320 model) for 10 min with a temperature of 4 °C and were spun at 200 revolution per minute. Blood and plasma were separated, and the plasma was poured into a microtube and stored in a freezer at −20 °C. Samples were transferred to the lab within 24 hr to determine blood lactate level.

Procedures

The procedures of this experiment required participants to run on a treadmill in a climate-controlled research laboratory. The only persons present during testing were the participant and members of the research team. Each testing session lasted approximately 11 min. Before running began for each testing session, each participant warmed-up for 4 min by walking at a self-selected pace on the treadmill. The treadmill speed during the warm-up was held constant within each participant across the four days of testing. Treadmill speed was adjusted during each testing session for each individual based on the results of the maximum speed on treadmill test. For the cooldown, speed decreased till the speed reached 0 km/hr in 1 min. The temperature and humidity of the testing room were also controlled and remained constant across all testing sessions for all participants. The research design is described in Table 1.

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Table 1 Research Design

Test session	Procedure	Duration
First test session	Activity-level questionnaire	
	Warm-up 4 km/hr	4 min
	Max speed on treadmill test 6 km/hr	Max time defined 5 min and speed increased 2 km/hr per minute
	Cooldown	3 min
Other test session	Warm-up with 4 km/hr	4 min
	Running at 70% maximum speed on treadmill while giving attentional instruction per 30 s	6 min
	Cooldown	3 min
	Blood sample	1 min
	Centrifuge machine	10 min

Statistical Analysis

Separate repeated-measures analyses of variance were conducted on each dependent variable (average $\dot{V}O_2$, respiration volume and breathing frequency, heart rate, blood lactate, and Borg RPE). Alpha level was set at $p < .05$ for all statistical tests. Partial eta squared (η_p^2) was calculated to determine effect sizes for each statistical comparison. For post hoc tests, we used pairwise comparisons with the least significant differences (Bonferroni) adjustments of the alpha level. Data analyses were conducted using SPSS (version 22.0).

Results

To analyze the effect of attentional focus on running performance within nonprofessional runners, average $\dot{V}O_2$ was calculated for each attentional condition from four to 11 min (the first 4 min included the warm-up and the last 1 min was the cooldown). The results of the repeated-measure analysis of variance showed significant difference among the conditions in terms of oxygen consumption, $F(3, 36) = 9.41$; $p = .001$; $\eta_p^2 = .44$. The paired comparisons indicated that the associative-internal condition generated the highest average oxygen consumption (i.e., worst economy; $M = 27.01$ ml/kg/min, $SD = 2.19$), followed by the associative-external ($M = 26.98$ ml/min/kg, $SD = 2.79$), and then the dissociative-internal group ($M = 26.27$ ml/min/kg, $SD = 2.04$). The best economy, on average, occurred when participants were in the dissociative-external condition ($M = 25.98$ ml/min/kg, $SD = 2.38$). The Bonferroni analysis revealed that the two associative conditions were not significantly different from each other, $F(3, 36) = 0.48$; $p = .16$; $\eta_p^2 = .07$. Similarly, the two dissociative conditions were not significantly different from one another, $F(3, 36) = 1.03$; $p = .09$; $\eta_p^2 = .13$. However, our post hoc analysis revealed that the two associative conditions were significantly different

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than the two dissociative conditions. The average oxygen consumption for each condition and significant differences are reported in Figure 1. Cohen's effect sizes (*d*) indicated large effects for differences in oxygen consumption (dissociative external vs. dissociative internal, $d = 0.14$; dissociative external vs. associative external, $d = 39$; dissociative external vs. associative internal, $d = 0.45$; dissociative internal vs. associative external: 0.29; dissociative internal vs. associative internal, $d = 0.35$; associative external vs. associative internal, $d = 0.01$).

For a more differentiated picture of the breathing pattern, the results of the descriptive and repeated-measures analyses of variance showed there were no significant differences in breathing frequency (in breath per minute) among the groups, $F(3, 36) = 1.11$; $p = .36$; $\eta_p^2 = .08$. Also, there were no significant heart rate differences between the different conditions, $F(3, 36) = 2.003$; $p = .11$; $\eta_p^2 = .14$, nor were there differences in breathing volume, $F(3, 36) = 2.31$; $p = .07$; $\eta_p^2 = .16$. The average values for each dependent measure are displayed in Table 2.

The results of our analysis indicated there was a significant main effect for blood lactate level, $F(3, 36) = 79.46$; $p = .001$; $\eta_p^2 = .87$. Post hoc testing indicated that all four conditions were significantly different from each other with the highest average blood lactate (i.e., worst economy) being observed in the associative-internal condition ($M = 3.01$ mmol/L, $SD = 1.41$); followed by the associative-external ($M = 2.83$ mmol/L, $SD = 0.71$); and then the dissociative-internal condition ($M = 2.35$ mmol/L, $SD = 1.61$); and finally, the dissociative-external condition had the lowest blood lactate (i.e., best economy) ($M = 1.96$ mmol/L, $SD = 0.91$). Average blood lactate levels are reported in Table 2 and Figure 2. Cohen's effect sizes (*d*) showed large effects for differences in blood lactate levels (dissociative external vs. dissociative internal, $d = 0.30$; dissociative external vs. associative external, $d = 1.06$; dissociative external vs. associative internal, $d = 0.88$;

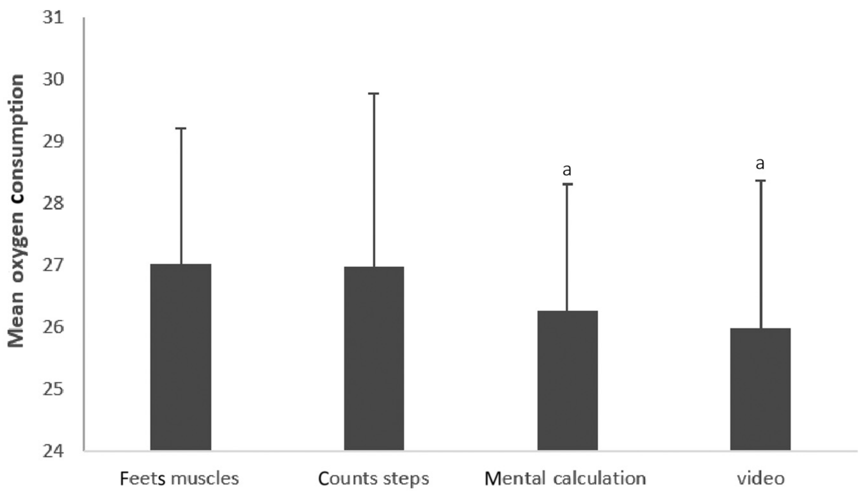

Figure 1 — Average oxygen consumption. The mental calculation condition and video conditions consumed significantly lower amount of oxygen compared with the two feet muscles and count step conditions. Error bars represent *SD*. [a]Significant differences.

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Table 2 Physiological and Psychological Parameters

Parameters conditions	Muscle	Count steps	Mental calculation	Video	*p*	η_p^2
Mean oxygen consumption (ml/min/kg)	27.01 ± 2.19	26.98 ± 2.79	26.27 ± 2.04	25.98 ± 2.38	.001	.44
Breathing frequency (breath/min)	31.86 ± 6.03	31.62 ± 6.12	31.33.6.02	31.27 ± 5.93	.36	.08
Heart rate (beats/min)	191 ± 16.47	188 ± 15.98	187 ± 15.18	183 ± 16.01	.11	.14
Breathing volume (l/breath)	2.04 ± 0.56	2.00 ± 0.41	1.95 ± 0.47	1.91 ± 0.36	.07	.16
Blood lactate (mmol/L)	3.01 ± 0.41	2.83 ± 0.71	2.35 ± 0.30	1.96 ± 0.91	.001	0.86
Mean RPE scale	15.01 ± 1.70	14.20 ± 1.23	13.47 ± 2.00	12.86 ± 1.47	.009	.24

Note. Mean values (*SD*) for the last 5 min of each 6-min block (excluding the starting phase). *p* values and effect sizes based on repeated-measures ANOVA. ANOVA = analysis of variance; RPE = rate of perceived exertion.

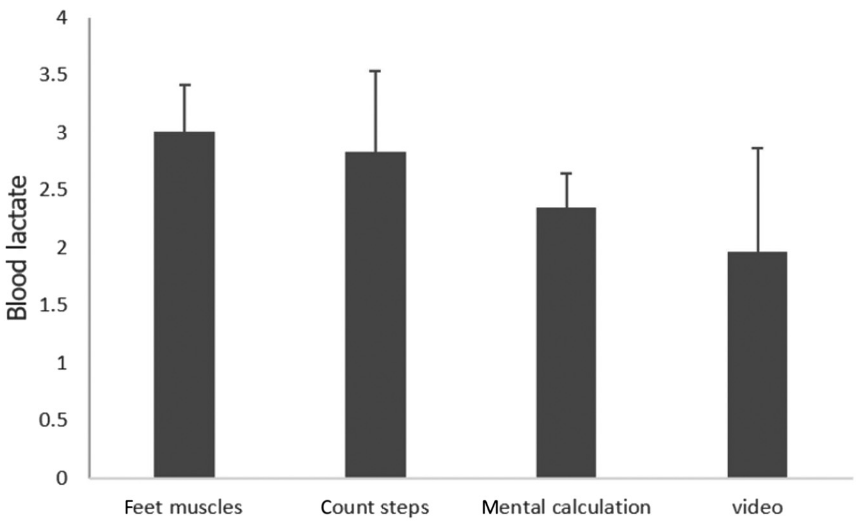

Figure 2 — Average blood lactate level for each experimental condition. All four groups were significantly different from each other. Error bars represents *SD*.

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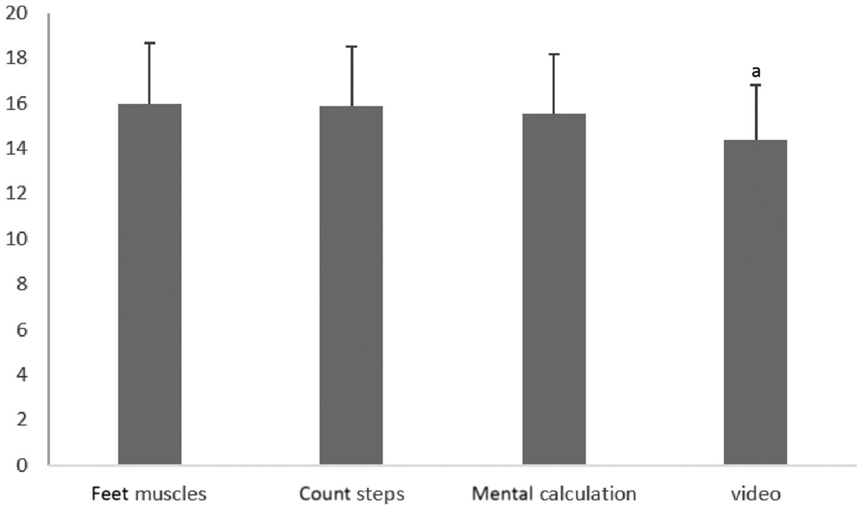

Figure 3 — Average Borg rate of perceived exertion scores. [a]The video condition was significantly lower than all other conditions. Error bars represent *SD*.

dissociative internal vs. associative external: 0.39; dissociative internal vs. associative internal, $d = 1.47$; associative external vs. associative internal, $d = 0.44$).

Finally, significant differences were observed on the Borg RPE scale, $F(3, 36) = 3.79$; $p = .009$; $\eta_p^2 = .24$. Post hoc testing showed the RPE scores in the dissociative-external condition were significantly lower than those in the associative-internal and associative-external conditions. No other differences were observed. Average Borg RPE scores for each condition are reported in Figure 3.

Discussion

The present study sought to investigate the effects of directing attention internally or externally while also adopting associative or dissociative strategies while performing an endurance task. We found participants had significantly lower oxygen consumption (i.e., best economy) when they were in the dissociative-external and dissociative-internal conditions relative to the associative-external and associative-internal conditions. In addition, we observed that blood lactate levels significantly increased as participants were tested in the dissociative-external, dissociative-internal, associative-external, and associative-internal conditions, respectively. To the best of our knowledge, the present study is the first to measure changes in blood lactate as a product of altering focus of attention. Finally, our findings revealed that RPE was significantly lower in the dissociative-external condition compared with the two associative conditions. When the results of the present study are collectively examined, they suggest that adopting an internal focus of attention or focusing on bodily sensations (i.e., associative-attention) decreased running economy and increases RPE. Our findings provide clear

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evidence of the delimiting effects of using an associative attention strategy, which results in focusing on performance-related bodily sensations.

In the study conducted by Schücker et al. (2016), they used a running video, which provided a viewpoint from the perspective of the runner. They concluded that a video displayed from this point of view facilitates feelings of natural running (Schücker et al., 2016). Despite that, in the present study, we used a video of a basketball game to create a clear external-dissociative attentional focus, and participants ran with greater economy. It seems that the type of video (i.e., basketball game or running scene) is less important. What does appear to be valuable is that the runner is using an external-dissociative focus of attention. Another reason for these results might be that in nonprofession runners, the running movement is less automated, and by focusing more internally or associatively, the mover is disrupting the automization of the task to a greater extent. Studies have shown that at the beginning of the learning process, focusing on the step-by-step implementation of the learned action might be helpful (Beilock et al., 2002). The participants in the present study were not highly skilled or highly conditioned runners, but they presumably already had some running experience, and therefore, a certain degree of automaticity had likely already been developed.

Our findings provide minimal support for the predictions of the constrained action hypothesis (Wulf et al., 2001). Specifically, participants consistently displayed elevated performance when they directed their attention externally while also using a dissociation strategy. However, movement economy was lowered when an external focus was combined with an associative attention. In many of our measures, excluding blood lactate, the associative-internal and associative-external conditions were not significantly different from each other, suggesting that simply directing attention internally or externally was not enough to impact oxygen consumption or RPE. The focus of attention manipulation had to be coupled with a dissociative attention before beneficial results manifested in improved running economy and RPE. This finding suggest that directing attention away from the performance of the task (i.e., external-dissociative) had a greater impact on running economy compared with only focusing externally on the result of the movement. We take this finding to mean that automated movement processes are facilitated to a greater extent when using a dissociative allocation strategy compared with an external focus of attention.

Previous research suggested that an dissociative strategy can facilitate endurance performance (Gill et al., 2017; Morgan & Pollock, 1977). More recent findings proposed that a dissociative strategy optimizes muscular endurance (Birrer & Morgan, 2010). Gill and Strom (1985) provided initial supportive evidence of the effectiveness of using a dissociative attention compared with focusing attention on body sensations. Nevertheless, our findings were not in agreement with those of Connolly and Janelle (2003) and Schücker et al. (2013). Connolly and Janelle (2003) evaluated the effect of attentional strategy on performance, perceived exertion, and gender on individuals performing a rowing task. The results showed that participants of each age group had a faster performance under the associative strategy compared with dissociative and control conditions. The observed contradictory results could be due to measuring methods, tasks performed, and overall research design. Specifically, the rowing task used by Connolly and Janelle was self-paced and emphasized performance, whereas the

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present study had a constantly paced treadmill speed and evaluated running economy through a variety of physiological measures and RPE scores. This shows that the optimal attentional focus may well depend on the outcome that is desired rather than being generalized to endurance-based tasks at large. Clearly, more research is needed to more fully understand how focus of attention impacts tasks of varying endurance or constraining characteristics.

Moreover, some studies showed that associative thoughts tend to increase perceptions of effort and fatigue when compared with dissociative thoughts (Johnson & Siegel, 1992; Stanley et al., 2007). For example, Johnson and Siegel (1992) found that RPE was increased when performing a 15-min cycling ergometer test using an associative attention, while at the same time, RPE was decreased by using a dissociative attention. Similarly, Stanley et al. (2007) evaluated the effect of attentional coping strategies on perceived fatigue when performing a cycling task. The results indicated associative thoughts led to increased perceptions of effort and fatigue when compared with using an internal or external-dissociative focus of attention. Consistent with these findings, the results reported in the present study show that the amount of perceived exertion reported by participants in the associative-internal and external conditions were higher compared with conditions using a dissociative strategy. Other studies have also reported the benefit of adopting an dissociative attention during low-intensity activities (Morgan et al., 1987; Schomer & Connolly, 2002). To our knowledge, only one study (Delignières et al., 1994) has reported an increase in perceived exertion when using a dissociative strategy. Delignières et al. (1994) concluded that the information processing demands imposed on the participants in their study added extra stress, which likely increased their perceived exertion.

This research allows practitioners to provide evidence-based advice to recreational runners who wish to enhance their performance during training. For example, our findings suggest that the nonprofessional female runners tested in the present study improved their economy when directing their attention on dissociative factors. In addition, it is important to note that it appears there is virtually no benefit to encouraging runners similar to those used in the present study to use an associative attention strategy. Similar advice may also apply for recreational participants in other endurance sports such as rowing, distance cycling, and distance swimming, although further research is required to determine the generalizability of our findings. Nevertheless, the direction of the attentional focus is clearly an important issue to consider in consultations with athletes or recreational participants wishing to improve their cardiovascular endurance. Despite the previously mentioned studies, this study is of applied interest for nonprofessional athletes. In conclusion, according to the results of this study, recreational runners who wish to optimize their running in terms of movement economy should be encouraged to implement an external-dissociative focus of attention while running.

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