ATTENTIONAL STYLE, PACE MONITORING, AND THEIR EFFECTS ON RATE OF PERCEIVED EXERTION AND RUN PERFORMANCE

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Abstract: Run-tracking devices are used by athletes and exercisers to monitor various metrics of human locomotion such as pace and distance. The purpose of this study was to determine the effects of pace monitoring via a run-tracking device on run performance and rate of perceived exertion (RPE). Subjects were 41 recreationally fit runners (17 male, 24 female) age 19-40 years (M = 22.4, SD = 4.4). The current study showed significant differences in completion times of two 1-mile time trials between two attentional focus conditions in both attentional focus groups: externalizers and internalizers. Subjects completed a Test of Attentional and Interpersonal Style (TAIS) to determine individual attentional focus. Subjects then completed an associative condition (AC) 1-mile time trial and a dissociative condition (DC) 1-mile time trial 24-36 hours apart. Individual, independent t-tests were run comparing completion time means between conditions. The internalizers group performed significantly faster in the associative condition (M = 496.10, SD = 105.05 seconds) than in the dissociative condition (M = 525.00, SD = 109.67 seconds), $t(20) = 5.79$, $p < .001$. The externalizers group performed significantly faster in the dissociative condition (M = 522.70, SD = 97.37 seconds) than in the associative condition (M = 556.90, SD = 116.62), $t(19) = -4.92$, $p < .001$. Results confirm the use of pace monitoring in accordance with TAIS scores to maximize run performance. While the study showed no significant difference in RPE scores between conditions, there may be practical implications of similar RPE scores when accompanied by significant changes in performance.

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CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

For decades, running has been at the forefront of the sports community (Jacobson, 2015). From 1990 to 2013, there was a 300% growth in the number of road race finishers for a total of over 19 million in the United States alone. The ease of participation and the minimal financial investment make it a popular option for individuals seeking to improve physical condition or competing at an elite level. There is, however, a segment of runners who are willing to spend large sums of money on the best training aids available: shoes, clothes, energy supplements, and run trackers (LaMagna, 2016). Run trackers are computer-based programs or devices that can monitor various factors such as steps, speed, distance, calories-burned and elevation change (Fritz, Huang, Murphy, & Zimmerman, 2014). Run trackers have grown in popularity in recent years with the development of dozens of smart phone applications to track runs (Fritz et al., 2014). Similarly, many of the major fitness apparel companies are now producing wearable fitness trackers. Whether using an app on a smart phone or a dedicated fitness watch, a person can monitor everything from energy expenditure to distance traveled.

The run-monitoring functions on these devices often rely on a global positioning system (GPS) to give real-time feedback of distance, pace, elevation change, split times, and much more

(Smith, Moran, & Foley, 2013). If an individual prefers to train indoors on a treadmill then these devices can often “pair” with the computer on the treadmill to share information (Fritz et al., 2014). Even without a wearable device or smart phone app, the treadmill display can reveal several different metrics in real-time. The use of a run tracker to monitor pace and progress of a run is becoming more prevalent (Whitehead, 2016). However, the effect of usage and the degree of those effects is still somewhat unknown.

Pacing is one of the key skills necessary for any runner to develop. Young (2007) defines pacing, or pace control, as the capability to produce a certain speeded variation of a continuous motor behavior from memory accurately and/or consistently over time. If pacing is a necessary skill for a runner, then it should be examined whether using a run tracker enhances or degrades this skill. Before the arrival of run tracking devices, and in some segments still, pace monitoring or “pacing” was done by sense of feel (Young, 2007). Also according to Young (2007) as people ran mile after mile, they would begin to have a sixth sense of how certain paces felt. Factors such as heart rate, respiration, knee-drive, and effort are just some of the factors that helped to fine tune this pacing sixth sense. The more people ran the more they would be able to set a pace in their mind and know that their body would respond accordingly (Fitzgerald, 2014). There is still a significant population of runners who rely on feel to determine pace rather than computer programs (Rodriquez, 2015). However, the use of run-tracking devices is trending upward while running by feel is becoming an idea of the past.

Run Tracking and Pacing

With so many run-tracking options available to athletes, it is unclear if monitoring pace so closely is beneficial to performance. Does the constant knowledge of speed improve or hinder running performance? Does the feedback on distance covered/remaining help or harm effort levels? Does the knowledge of run progress encourage complacency or challenge improvement? Overall, does real-time visual feedback of run pace and progress have a positive or negative effect on running performance?

Understanding the importance of pace control is vital to any runner, beginner or experienced (Young, 2007). However, even the most seasoned runners can make errors when it comes to pace-control. Pace is a vital component to both a training run and a competition. According to Smith, Moran, and Foley (2013), a pace that is off by even a few seconds can greatly affect the outcome of a run by causing a person to hit the lactate threshold too soon. Runners who do not have a honed sense of pace-setting either begin the race too fast and become fatigued before completion or go much slower than the desired pace. For most seasoned runners, who have completed hundreds of training runs and competed in numerous competitions, the skill of pace-monitoring has become like a sixth sense (Whitehead, 2016; Young, 2007). They can monitor the pace just by how it feels. However, novice runners do not have the experience level typically required to do this. For them, the use of a run tracker is beneficial for keeping track of pace as well as progress. If a few seconds off of goal pace can be detrimental to the outcome of a run, then it is vital for a runner to be able to maintain a desired pace.

Most experienced runners know the maximum pace that they can run for a given distance (Young, 2007). However, novice runners may only have an idea of what their maximum pace is for a given distance. They are in a developmental stage of training and their pace should be consistently improving (Moore, Jones, & Dixon, 2012). Therefore, it is possible that using a run-tracking device could be counter-productive to progress. That is, if they are constantly relying on an app, watch, or treadmill to tell them how fast they are running, then they may not ever push themselves to new boundaries (Smith, Moran, & Foley, 2013). Many beginning runners have an idea of the fastest pace they can maintain when their bodies are actually capable of running faster. Conversely, it is possible a runner that relies on “feel” to set their speed could see marked improvements from one run to the next because they are not handicapped by a perceived maximum pace.

Run Tracking and Attentional Focus

Another factor that needs consideration when deciding the effects of run tracking on an individual’s run performance is identifying preferred attentional focus. This refers to the use of an associative or dissociative focus (A/D). Association was first monitored and discussed by Morgan and Pollock (1977). According to Morgan and Pollock, association refers to the way runners monitor sensory input, and adjust their pace accordingly, with the goal of avoiding pain. Over the decades, the definition of association has evolved (Brick, MacIntyre, & Campbell, 2014). While it is often linked with a hyper focus on body mechanics and the corresponding body feedback, association is often synonymous with general internal focus and also faster speeds (Schucker, Hagemann, Strauss, & Volker, 2009). Like its counterpart, dissociation has developed a much broader meaning than its original definition. Dissociation often refers to focusing on “task irrelevant cues including problem-solving, or listening to music, and distracting from the sensory information stemming from the body” and is linked with lower exertion levels (Garcia, Razon, Hristovski, & Balague, 2015, p. 302). No matter how the definition reads, the common thread over the years has been the use of some external stimuli to distract an individual from the body’s mechanics and corresponding sensory feedback.

Run Tracking and GPS

There is very limited research on the effectiveness of run-tracker use on pace-setting as it relates to maximum run performance. The research that has been conducted focuses mainly on the accuracy of GPS-guided run tracking systems, the use of GPS systems to coach pace, and the use of GPS systems to monitor training loads (Karboviak, 2005; Terrier, Ladetto, Merminod, & Schutz, 2000; Terrier, Turner, & Schutz, 2005). However, these were descriptive studies so no empirical conclusions can be drawn. There are also narratives available on the difference between running with a GPS system and with running by feel (Fitzgerald, 2014; Rodriquez, 2015; Whitehead, 2016). No research could be found that directly measured the effects of visual pace and distance feedback on running performance.

In recent years, GPS has been used in many different studies to measure human motion. GPS-guided devices have become more cost effective and even more accurate (Terrier et al., 2000). Some studies have used the devices to measure movements of human locomotion as small as stride frequency and length (Terrier et al., 2005). Others have used GPS technology to measure factors such as training intensity, volume, and speed (Karboviak, 2005). The result on GPS device research has suggested that they are reliable and accurate when measuring pace and progress in sub-maximal intensities. The primary sources of any errors came from high-velocity running or rapid changes in direction (Terrier et al., 2000). When it comes to running at slower speeds than maximum sprinting, GPS run-tracking devices can be relied on to monitor pace and progress with great precision. Though the devices can be relied on does not necessarily mean that they should be if the goal is maximum performance.

PURPOSE

The purpose of this study was to determine the effect of pace monitoring on run performance. Run trackers are growing in popularity and are being worn in recreational and competitive settings. However, it is possible that monitoring pace in real-time during a run may not be beneficial if the goal is maximum performance. According to research on attentional focus, the use of a run tracker may be advantageous for some people while detrimental to others (Morgan & Pollock, 1977). It is hypothesized that pace monitoring via a run tracker is advantageous for individuals with an associative preference of attentional focus and detrimental for individuals with a dissociative preference of attentional focus.

RESEARCH QUESTIONS

1. Will internalizers' 1-mile completion time be significantly lower when running with pace monitoring available compared to running without monitoring?
2. Will externalizers' 1-mile completion time be significantly lower when running without pace monitoring available compared to running with monitoring?
3. Will internalizers' rating of perceived exertion (RPE) be significantly different when running a 1-mile time trial with pace monitoring available compared to running without monitoring?
4. Will externalizers' rating of perceived exertion (RPE) be significantly different, when running a 1-mile time trial without pace monitoring available compared to running with monitoring?

HYPOTHESES

Null Hypotheses

1. Internalizers’ completion time will not be different between conditions.
2. Externalizers’ completion time will not be different between conditions.
3. Internalizers’ average RPE will not be different between conditions.
4. Externalizers’ average RPE will not be different between conditions.

Alternate Hypotheses

1. Internalizers’ completion time will be significantly faster in the associative condition.
2. Externalizers’ completion time will be significantly faster in the dissociative condition.
3. Internalizers’ average RPE will be significantly lower in the associative condition.
4. Externalizers’ average RPE will be significantly lower in the dissociative condition.

SIGNIFICANCE OF STUDY

Running is both a major sport and a major part of training for other sports. The use of run-tracking devices is becoming more common in many sports, especially running. Previous research suggested that run trackers are accurate in their measurements of factors such as pace and distance. However, the effectiveness of run trackers on performance remains unknown. It is possible that people wear a run tracker under a false assumption that it is benefitting their performance. Using a run tracker may be more beneficial for an individual who prefers association while being detrimental for an individual who prefers dissociation. The information gathered through this study can help to runners decide whether or not to use a run tracker based on their preference of association or dissociation. Understanding the situations where pace monitoring is beneficial and when it is detrimental could help an individual achieve greater success in or enjoyment of the sport of running.

DELIMITATIONS

1. Subjects were recreationally fit male and female runners.
2. The age of subjects was limited to 19-40 years.
3. For the purposes of this research, recreationally fit was defined as being able to run 2 miles without walking.
4. Subjects ran a 1-mile maximal effort run on a treadmill.
5. The trials were conducted in an indoor environment.
6. Speed of the treadmill was self-regulated by the subject.
7. Subjects were asked to restrict heavy exercise, alcohol consumption, or caffeine consumption 24 hours in advance of the trials.

LIMITATIONS

1. Subject diet (including caffeine, alcohol consumption, and hydration) was not controlled during data collection other than the request to restrict alcohol and caffeine consumption 24 hours in advance of the trials.
2. Subjects' quantity of physical activity was not controlled during data collection, other than the request to restrict heavy exercise 24 hours in advance of the trials.
3. Run pace was not controlled by the primary investigator (PI) because the pace was self-selected by the subject.

ASSUMPTIONS

1. Subjects ran the protocol at maximal intensity.
2. The pace and progress monitoring functions of the treadmill were accurate, valid, and reliable.
3. Subjects followed the study instructions and refrained from alcohol, caffeine, or heavy lifting 24-hours prior to testing.
4. Subjects were in the same physical condition during both trials.

OPERATIONAL DEFINITIONS

1. Rating of perceived exertion (RPE)- an individual's subjective rating of the amount of energy being exerted to complete a task/exercise (Borg, 2005)
2. Pace- a runner's time measured in minutes·mile
3. Progress- a runner's distance covered as it relates to the goal distance
4. Time trial- a test of the subject's speed over a set distance
5. Maximal intensity- at the subject's maximal capacity
6. Submaximal intensity- below the subject's maximal intensity
7. Association- monitoring sensory input, and adjusting pace accordingly, with the goal of avoiding pain and maximizing performance (Morgan & Pollock, 1977)
8. Dissociation- concentrating away from sensory input with the goal of ignoring pain and maximizing performance (Morgan & Pollock, 1977)
9. Attentional focus- a runner's preferred cognitive strategy: association or dissociation
10. Physical Activity Readiness Questionnaire- (PAR-Q) An inventory of questions designed to determine a subject's readiness for physical activity based on current health and fitness levels as well disclosure of any chronic or acute injuries/conditions
11. Hitting the wall- "refers to the time during a race when glycogen stores have been depleted and energy must be converted from fat." (Stevinson & Biddle, 1998, p. 229)

CHAPTER II

REVIEW OF LITERATURE

The review of literature is organized in a study-by-study manner with 4 subsections. The article summaries are listed in chronological order within each subsection. Each subsection concludes with a brief summary of the literature related to that component.

RUN TRACKING AND ATTENTIONAL FOCUS

Nideffer, 1976

The Test of Attentional and Interpersonal Style (TAIS) is an inventory of questions that produce quantifiable measures of 17 basic personality traits. Nideffer suggests the TAIS as a means to determine an individual's performance across a variety of life situations. Since its development, the TAIS has been used for research studies, psychological testing, and many other purposes. Objective third-party reviews have been conducted to test the reliability and validity of the test. The results concluded the TAIS has good test-retest reliability as well as some construct and predictive validity. For the purpose of this study, only a portion of the TAIS was used to determine scores across four of the seventeen categories the full test evaluates. According to the author, "it is hard to imagine a variable more central to performance than the ability to direct and control one's attention" (p. 395). The author suggests that attention can be measured in two dimensions: breadth of focus and direction. Breadth of focus is measured on a scale from narrow to broad regarding the amount of stimuli an individual can focus on at one time. Direction is measured on a scale between external and internal. Table 1 shows a brief description of the directions of focus taken from Nideffer's "Theoretical consequences of particular attentional styles" (p. 396).

Table 1
Description of Directions of Attentional Focus

External	- Preoccupied with environmental stimuli - Responses occur without reflection - Reinforcement comes from the environment - Behavior is stimulus-response
Internal	- May be withdrawn - Cognitive reinforcers are most potent - May tune out environment - May have difficulty expressing affect

Morgan and Pollock, 1977

Association and dissociation were first discussed and defined by Morgan and Pollock (1977). Through an interview process with a group of 27 elite middle-distance runners, Morgan and Pollock identified two common cognitive strategies used by the runners. These cognitive strategies were based on two directions of attention focus. The first, association, refers to the way runners "monitor sensory input, and adjust their pace accordingly, with the end result that pain is avoided" (p. 390). The second common strategy noted was dissociation, which refers to "focusing away from the painful sensory input" (p. 390). Morgan and Pollock's study was groundbreaking and foundational in the development of association and dissociation as viable cognitive strategies for athletes across sport.

Fillingim and Fine, 1986

The purpose of this study was to determine the effects of attentional focus on reported symptomatology. The authors hypothesized that maintaining an external, or dissociative, focus while running would yield a lesser degree of symptomatology than running the same distance in an internal, or associative, condition. It was also hypothesized that if subjects paced themselves based on RPE then the dissociative condition would yield faster run pace than the associative condition. For the study, 15 subjects were recruited to run 1-mile under three different conditions. For the associative condition, the subjects were instructed to focus on their attention only on what their body was doing with an emphasis on monitoring breathing and heart rate. For the dissociative condition, subjects were instructed to listen to a tape played through headphones. Fifteen monosyllabic words were repeated and subjects were told to count the number of times the word "dog" was said and then report the number post-test. The third condition was a control run with no experimental conditions. The results showed significantly lower symptomatology during the dissociative condition than the control or associative. Additionally, the completion times were faster during the associative run than during the dissociative or control conditions. These results are in agreement with other research that suggests association is beneficial for greater performance and dissociation is beneficial if the goal is a more relaxed experience (Morgan & Pollock, 1977).

Nideffer, 1990

This second article by Nideffer served as a review of and rebuttal to fifteen years of criticism towards his Test of Attentional and Interpersonal Style. Since its development, the author stated that the TAIS had come under scrutiny with many reviews and studies conducted to dismiss it as a credible source in the evaluation of performance. In response to his critics, Nideffer published this study to address and refute the primary concerns surrounding the reliability of the TAIS. After a study conducted with over 1,000 subjects all completing the TAIS, Nideffer concluded with statistical evidence that the test is a viable resource to consider when determining the effects of attentional focus on performance. Specifically, Nideffer noted the effectiveness of the individual subset scores of the TAIS as being reliable indicators of success within different sports. Nideffer suggested the use of the TAIS to determine areas of individual strength and encourages athletes to focus their time on sports that best suit strengths. Nideffer recommended the abandonment of blanket training strategies for the use of individualized strategies.

Laasch, 1995

The purpose of this study was to determine the process runners go through when determining a cognitive strategy (attentional focus). Laasch discussed the pervasive suggestion in research set forth by Morgan and Pollock (1977) that association and dissociation are not mutually exclusive depending on experience level. Laasch suggested that the existing dichotomy is far too simple a description of the cognitive strategies of runners. Laasch then discussed the different advantages and disadvantages of association versus dissociation specifically while running. In conclusion, Laasch proposed the idea that different attentional focuses are less experience driven and more situation-dependent meaning a runner can move seamlessly in and out of association to dissociate when the need arises.

Stevinson and Biddle, 1998

In an effort to expand upon the initial research performed by Morgan and Pollock in 1977, the authors interviewed 66 non-elite runners immediately after completing the 1996 London marathon. Specifically, the study aimed to determine if runners' "hitting the wall" was related to their cognitive strategy during the race. "The wall" refers to the time during a race when glycogen stores have been depleted and energy must be converted from fat. According to the authors, "hitting the wall" is an unpleasant experience "with symptoms including a lack of physical coordination, dehydration, paraesthesia (tingling or numbness in the toes of fingers), nausea, muscle spasms, dizziness, an inability to think clearly, and extreme physical weakness" (p. 299). The authors discuss the original research by Morgan and Pollock that suggested "hitting the wall" is most commonly associated with a dissociative thought process. That is, focusing away from the sensory input of the body during a run can lead to injury or fatigue more easily than if a runner is focusing on the input from their body.

Instead of the two-category system used by Morgan and Pollock, association (internal) and dissociation (external), to compartmentalize attentional focus, Stevinson and Biddle developed a four-category system. Inward monitoring (inward association) was described as focusing on task relevant thoughts such as bodily sensations. Inward distraction (inward dissociation) was described as focusing on task irrelevant thoughts such as daydreams. Outward monitoring (outward association) was described as focusing on task relevant external factors such as split times. Outward distraction (outward dissociation) was described as focusing on task irrelevant cues such scenery.

The authors found that the most popular focus of attention during the marathon was inward monitoring. Within each category, association and dissociation, inward focus was more commonly used than external focus. According to the authors, avoiding "hitting the wall" is a vital component of completion of and maximized performance during a run. They determined that "hitting the wall" is most closely associated with internal dissociation.

Johnson and Siegel, 2008

In a study of forty-four college females, the authors sought to determine the effects of association and dissociation on perceived exertion. The subjects took part in three separate cycle ergometer tests: control, association and dissociation. At the conclusion of the 15-minute tests, subjects rated their perceived exertion on Borg's RPE scale. The results of the study showed significantly higher rating of perceived exertion in the associative condition with no difference in heart rate. This conclusion was in agreement with previous research suggesting dissociation as the better attentional focus for lower perceived exertion levels.

Schucker et al., 2009

In this article the authors sought to determine the effect of attentional focus on running economy (oxygen consumption) during three separate conditions. Twenty-four trained runners were recruited for participation in the study. They ran three 10-minute trials consecutively. They were instructed to focus on a different aspect during each trial: the running movement, their breathing, and their surroundings. Oxygen consumption levels were measured during all three trials. The external (dissociative) condition showed significantly lower oxygen consumption than the other two conditions supporting research that links dissociation with lower physiological exertion levels.

Brick et al., 2014

This review was intended to compile 35 years of research on the topics of association and dissociation to clear some confusion surrounding the terms as they relate to endurance activity. Since the initial study by Morgan and Pollock on association and dissociation, several different definitions have been suggested for the terms. Application of the terms and methodology in research on the terms have failed to reach a consensus. Thus, Brick et al. compiled decades of data to develop a new system that may more adequately categorize the cognitive processes. The authors agreed "the associative/dissociative framework may be limited in its ability to capture the dynamic complexities of thought processes" (p. 108). Continuing the thought process of a potentially flawed qualification system, Brick et al proposed that instead of developing new terminology, research should focus on extending and adding to the existing framework of association and dissociation.

They suggested extensions to both the associative categories as well as the dissociative categories. Relative to the internal association classification system, Brick et al. added the categories internal sensory monitoring and active self-regulation. With breathing or thirst being examples of internal sensory monitoring and technique or cadence being examples of active self-regulation. To the external association system, they added the category of outward monitoring. The examples of outward monitoring in the association focus could be other competitors, mile markers or split times. Additionally, Brick et al. suggested extensions to the dissociative classification system put forth by Stevinson and Biddle. Relative to the internal dissociation category, active distraction was added as a subcategory with an example being attention-demanding tasks like puzzles. External dissociation was also further clarified by adding the subcategory of involuntary distraction.

Garcia et al., 2015

In their study, Garcia et al. investigated the effects stability of attentional focus during maximal running. Fourteen trained runners were recruited for participation. During three separate running trials, subjects were asked to run to failure. Each test had the subjects start running on the treadmill with the speed set at 5km/h. The speed was increased 1 km/h every minute and subjects instructed to run until they could no longer keep up with the pace. Subjects reported their attentional focus at regular intervals: task related (associative) or task unrelated (dissociative). The results were graphed to show the dynamic nature of their thought process as the intensity of the run increased. During the early stages of the run, subjects reported a primarily dissociative attentional focus. The middle stages of the run showed a back and forth transition from associative to dissociative at random intervals. Toward the end of the run, as the intensity neared maximal efforts, subjects reported a primarily associative attentional focus. The authors concluded that the attentional focus process if very fluid and dynamic in nature allowing runners to use both associative and dissociative strategies as they needed to.

Summary of Run Tracking and Attentional Focus

Decades of research have concluded that association and dissociation play a large role in performance. Some researchers would suggest that association is reserved for elite athletes and not possible for novice athletes to utilize (Stevinson & Biddle, 1998). Likewise, some researchers would suggest that dissociation is reserved for novice athletes and does not benefit the elite athlete when it comes to achieving maximum performance. Other researchers have concluded association is directly linked to higher levels of performance while dissociation is linked to lower exertion levels (Schucker et al., 2009). The most recent research suggests a dynamic relationship between association and dissociation to performance levels. The dynamic nature allows an individual to move seamlessly between an associative and a dissociative focus of attention. According to Nideffer and the TAIS, certain individuals are more likely to perform well in an associative condition while others will more likely succeed in a dissociative condition. Pace monitoring during a run is a function of association. The constant, real-time feedback of pace and distance is information that contributes to an associative condition while running. However, according to research, an individual who thrives in a dissociative condition may not perform as well when they have the constant feedback available.

RUN TRACKING AND PERCEIVED EXERTION

Ceci and Hassmen, 1990

The purpose of this study was to determine the difference in running on a treadmill and running outside. Eleven healthy male participants performed identical protocols in both the treadmill and outdoor conditions. The protocol instructed the subjects to run at three distinct RPE levels for a pre-determined time limit. Self-regulation and self-monitoring in exercise is determined by how well an individual can adjust effort intensity levels to successfully reach a given goal such as total time, distance, or calories burned. Ceci and Hassmen (1991) found the following:

> Subjectively adjusting the exercise intensity can be seen as a continuous, as well as simultaneous, process involving monitoring of internal cues (e.g., perceived exertion, proprioception, and respiration) as well as external cues (e.g., velocity, and wind resistance). (p. 732)

The authors also discussed the various commands or goals that RPE corresponds to. For example, the command to go for a slow jog is often synonymous with running at a low RPE while the command to finish a given distance as fast as possible is linked to a higher RPE.

The results of the study found that RPE accurately reflected the physiological changes that occur during running at the assigned intensities. Blood lactate levels, heart rate, and velocity were all measured in each test at regular intervals. Each variable increased proportionally with the rise in RPE in both the treadmill and outdoor tests. The authors concluded that RPE functions well as a means of monitoring and regulating exercise intensity.

Baden et al., 2004

The purpose of this study was to determine the effect anticipated running distance on perceived exertion levels and direction of attentional focus. Two separate studies were performed. In the first, 22 runners participated in a short (8-mile) and long (10-mile) run. During both runs, subjects reported the direction of their focus (associative or dissociative) and their rate of perceived exertion at regular intervals. In the second study, 40 participants ran two separate time trials on a treadmill. The first trial had them run at a steady pace for an expected short time (10 minutes). The second trial had them run for an expected long time (20 minutes), however, the second run was unexpectedly cut short at the 10-minute mark. Both studies produced comparable results of lower RPE during the long run condition and a higher prevalence of dissociative thoughts during the long run condition. Additionally, the authors noted that lower heart rates were recorded during the longer conditions and attributed the difference to changes in attentional focus. It was the conclusion of the authors that dissociation and RPE have a negative relationship. As dissociative thoughts increased, RPE decreased at equal effort levels.

Tucker, 2009

In his review, Tucker proposed a model of regulating performance based on RPE. The review discussed how the brain regulates work rate by processing multiple internal and external factors. The brain processes the input and determines an appropriate work rate based on the expected duration of activity. Figure 1 shows the proposed model of performance regulation using RPE.

Figure 1. Tucker's Proposed Model of Performance Regulation.

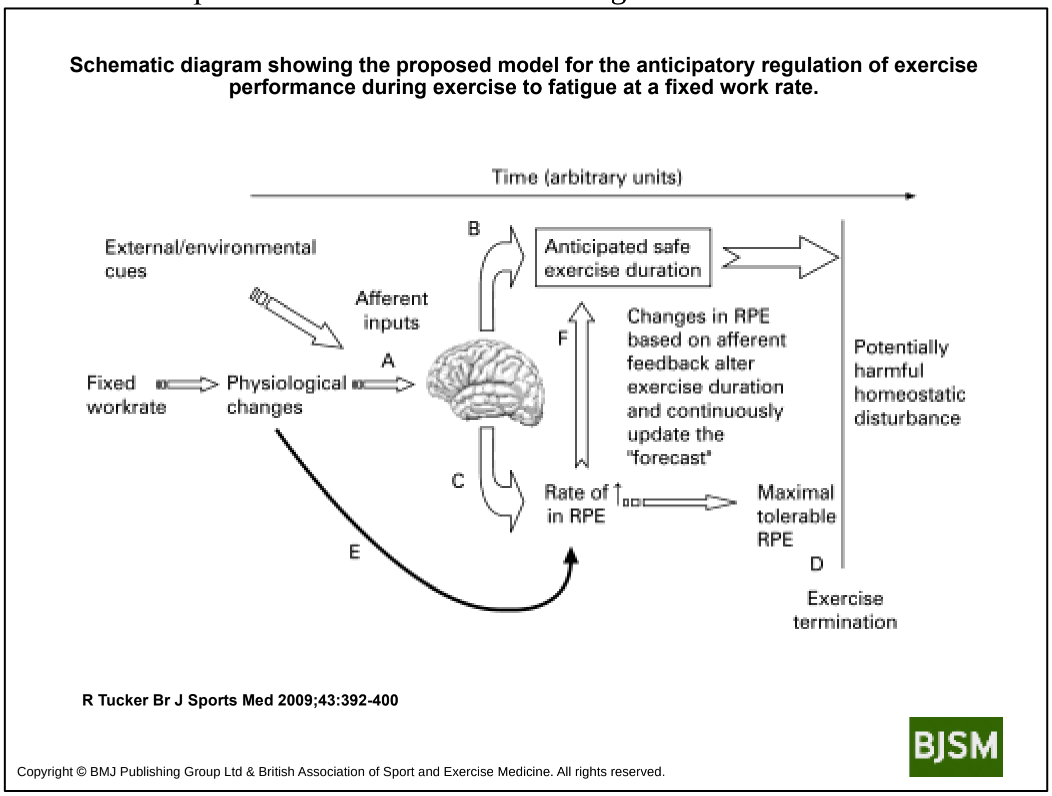


Figure 1. At the onset of exercise, afferent information from various physiological systems and external/environmental cues (A) is used by the brain to forecast the duration of exercise that can be safely completed without causing harmful homeostatic derangements (B). The afferent feedback from physiological systems depends on the exercise intensity and environmental conditions, including factors such as temperature and the partial pressure of oxygen of the inspired air. Simultaneously, the initial rate of increase in RPE is set as a consequence of a subconscious anticipatory calculation of the safe exercise duration (C). The initial "setting" of exercise duration and the rate of increase in RPE represent the anticipatory component of the model. Because exercise terminates when the maximal tolerable RPE is attained (D), the time to

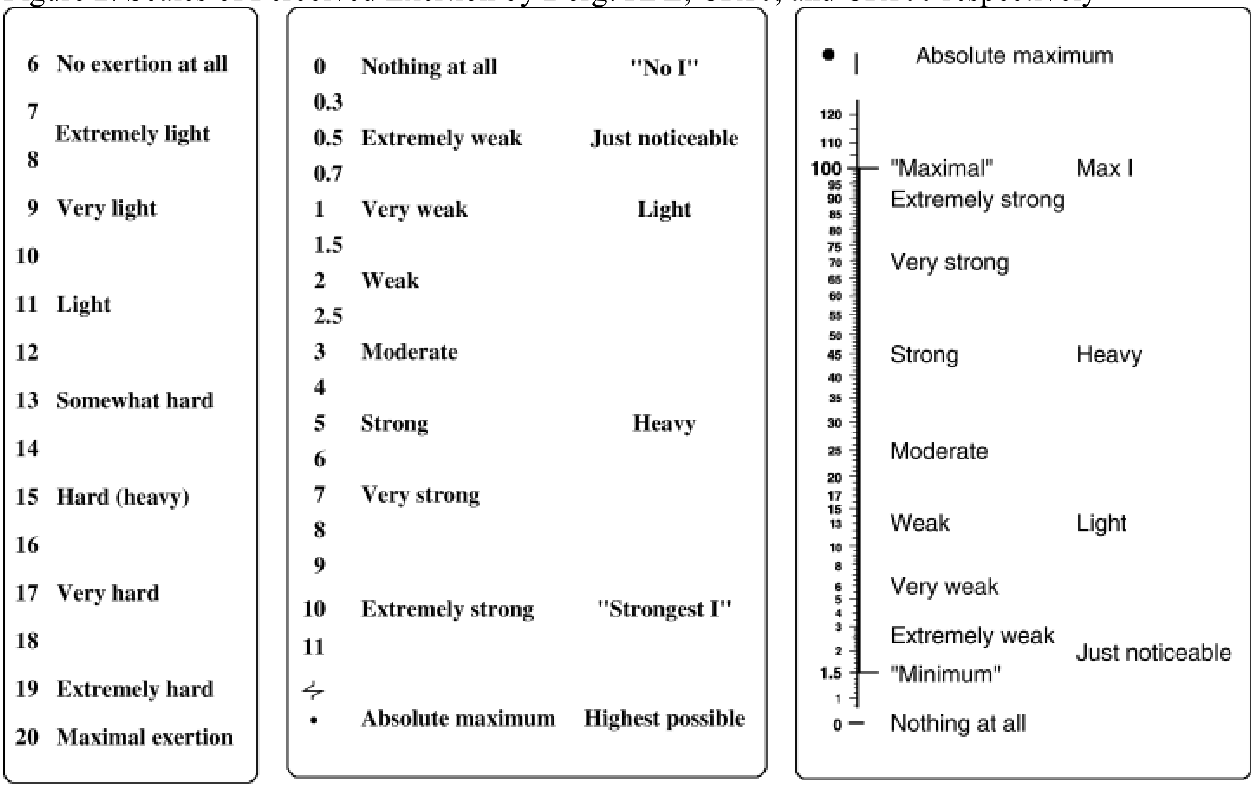
exhaustion is determined by the rate of increase in RPE, which is continuously modified based on the regular integration of afferent feedback signals from numerous physiological systems, including those described previously (E). The "safe" exercise duration is thus determined by a combination of anticipatory forecasting and afferent feedback as a result of the physiological changes occurring during exercise. The maximal tolerable RPE (D) occurs before harmful changes to homeostasis can occur. Such changes include, for example, the attainment of a critically high core temperature. The high core temperature thus acts as an "off-switch", mediated, importantly, by the RPE. Adapted from "The anticipatory regulation of performance: the physiological basis for pacing strategies and the development of a perception-based model for exercise performance," by R.Tucker, 2009, *British Journal of Sports Medicine*, *43*(6), p. 394.

Tucker's development of this model is predominantly founded on the suggestions by Borg that RPE is the "single best indicator of physical strain," and "integrates various information, including many signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions, and from the central nervous system" (p. 396). According to Tucker, the link between subjective feelings of effort and the discrete physiological changes that occur during work is of vital importance. Those subjective feelings of effort, or RPE, directly affect the level of performance in exercise.

Borg and Kaijser, 2005

The purpose of this study was to determine the effectiveness of the three different scales developed by Borg. Forty participants performed a step test while heart rate, blood lactate, and exertion levels were collected at regular intervals. The relationship between heart rate and blood lactate levels to exertion levels were comparable across all three scales. The figures accompanying each scale (RPE, CR10, and CR100 respectively) are pictured in Figure 2. The result of the comparison study showed all three scales to be reliable in estimating exertion levels but recommends the CR scales.

Figure 2. Scales of Perceived Exertion by Borg: RPE, CR10, and CR100 respectively



Summary of Perceived Exertion

Borg's scales are among the most commonly recognized and used to measure rate of perceived exertion (Borg & Kaijser, 2005; Tucker, 2009). Several studies have been conducted to confirm the reliability of RPE as a measure of exercise intensity (Baden et al., 2004; Ceci & Hassmen, 1990). As it relates to this study, perceived exertion is closely linked to attentional focus and pacing. Therefore, an understanding of how to measure RPE is vital to the discussion of pace monitoring for maximum run performance.

RUN TRACKING AND PACING

Silva and Applebaum, 1989

This study investigated the effects of A/D during running on elite runners at the United States Olympic Marathon trials. The authors investigated if elite athletes use different cognitive strategies compared to novice athletes through a pre-race interview and questionnaire paired with post race analysis. After the conclusion of the race, Silva and Applebaum concluded that the top 50 finishers alternated between association and dissociation during the early stages of the marathon. After the early stages, the top finishers used association predominantly and only switched to dissociation when pain was felt. One of the main focuses of their associative focus was "marking" other key racers to monitor pace and placement. All three of those attentional focus strategies were more prevalent among the top 50 finishers than among the lower finishers. Therefore, the authors concluded that an attentional focus strategy that hinges on flexibility to the situation is the best practice for maximum pace and performance.

Masters and Ogles, 1998

A comprehensive review of the literature was performed by Masters and Ogles to determine the best strategy for attentional focus as it relates to many factors including pace. In their study, the authors concluded that regardless of skill level, runners generally prefer dissociation during training runs and association during competitive runs. Additionally, Masters and Ogles determined that training runs are typically performed at a slower pace that allows the athlete to dissociate easier.

Baghurst et al., 2004

A study performed with university students on an indoor rowing machine provides evidence for the positive effect of attentional focus on pace. The study involved a group of students completing the Test of Attentional and Interpersonal Style to help identify his or her preferred attentional style. After the results were tallied, the participants were split into two groups; internalizers and externalizers. Internalizers were those who preferred an internal or associative focus while externalizers were those who preferred an external or dissociative focus. Both groups then took part in two timed rowing tests. Test 1 had the participants row for 15 minutes with the goal of accumulating the greatest distance possible. They did not have access to the digital display but were informed at 5, 10, 12, and 14 minutes so that they had the opportunity to self-regulate pace for completion. For the duration of the time trial, the participants were required to answer basic multiplication questions creating a dissociative environment that prevented them from internalizing their thoughts.

The second test featured the same testing protocols as Test 1 in regards to time and goal. The difference was that in Test 2 the participants were instructed to maintain focus on the digital display that showed time, distance, pace, and 500m split time. For the entire duration of the test, participants were required to report the total distance covered every 15 seconds therefore creating an associative attentional focus. The results showed that when the internalizers were allowed to maintain an associative attentional focus, they rowed 155 meters further than when they were forced to maintain a dissociative attentional focus. Likewise, the group of externalizers rowed 275 meters further when they were allowed to maintain a dissociative attentional focus than when they were forced to maintain an associative attentional focus. Therefore, the conclusion was made that when an individual was allowed to perform within their preferred attentional style they maintained a faster pace over the same amount of time.

Young, 2007

Young begins the article by defining pacing, or pace control, as the capability to produce a certain speeded variation of a continuous motor behavior from memory accurately and/or consistently over time. He also discussed that pace could also be interpreted as how accurately one interprets whether the speeded variation of a continuous motor behavior matches some criterion variation such as target pace. Young points out the importance of pacing in a competition by referencing the hiring of "rabbits" to run a certain pace for the first portion of a before stepping off of the course. Regarding the importance of pacing as a trained skill in runners, the author stated:

> "In order to make accurate pace decisions while running, an athlete must keenly perceive how their 'own body feels,' retrieve a solution in memory for what the 'goal pace should feel like' and then make the appropriate comparisons between these 'feelings' in order to slow down or speed up. The importance of pacing presumably becomes more pronounced for longer race distances, especially when athletes are denied regular split-time feedback (with a stopwatch over measured distances), and where the duration of the race is sufficient for early-race pacing mistakes to bring about physiological consequences later on (e.g., 'hitting the wall'). If one recognizes the importance of such a skill, the questions is: how could coaches go about training pace in runners?" (p. 211)

Regarding training the pacing ability, Young discussed the plans available to coaches and athletes. For novice runners, a blocked schedule of running a target pace, or a few different target paces, repetitively produces the greatest results. The repetition allows the runner to feel how their body responds at certain effort levels and commit those feelings to memory. For experienced runners, a non-repetitive schedule produces the greatest results as it keeps them from becoming cognitively lazy while running the same pace over and over.

Summary of Run Tracking and Pacing

The skill of pacing is vital to running performance at any skill level. It is crucial to the athlete who is racing to win as it helps dictate maximum performance without hitting the wall too early in a race (Silva & Applebaum, 1989). It is equally vital to the runner on a recovery run or recreational run for pleasure as it is related to rate of perceived exertion (Masters & Ogles, 1998). In order to train the pacing skill, repetitive runs at specified paces are required (Young, 2007). The more a runner becomes familiar with the sensory input and body mechanics of certain paces, the more they will be able to replicate that pace when needed. Regularly monitoring pace via a run tracker can handicap the development of the pacing ability. The constant visual feedback of pace can cause a runner to dissociate from the sensory input and body mechanics occurring at a given pace. In short, reliance on a run tracker can negatively influence the development of the pacing ability. However, constantly monitoring pace can also serve as a method of association that usually corresponds to increased performance.

LIMITATIONS OF THESE STUDIES

Several limitations exist in the available research of pace tracking during running. Those limitations are understandable given the small number of studies that have been conducted on run trackers in general. The limitations can be categorized by demographic, technological, and metric.

Demographic Limitations

One of the main issues lacking in current research is the presence of the general population (non-collegiate athlete) demographic. The largest age segment represented in the running community is 25-44 with over 53% of the finishers in road races (Jacobson, 2015).

Furthermore, research shows that runners are greatly influenced by the physical community of their surroundings. Specifically, runners are as diverse in race, age, and socio-economic standing as the cities in the United States (Ferstle, 2012). If the largest participant group in running is non-college aged and the running community as a whole is incredibly diverse, then the research on run trackers and running should be comparable. Yet, in many of these studies, the participants were college-aged students or student athletes.

Technological Limitations

Myriad fitness companies make some type of fitness tracker, many of which have some type of run tracking capabilities. With so many tracking options on the market, the products used for testing in the available research were on the high end financially, and thus not necessarily accessible to all people. Likewise, no research was found using the display and monitoring capabilities of treadmills. However, treadmills are a mainstay in the run-training programs of many athletes.

Metric Limitations

One of the main goals for any runner is to run a given distance in the fastest time possible. However, none of the research that was found measured how run tracking devices affected run performance. The studies focused on the reliability of GPS or how GPS can be used to measure pace, progress, and volume in training or competition.

CHAPTER III

METHODOLOGY

PARTICIPANTS

For this study, 59 individuals were recruited. The criteria for inclusion in the study were two-fold. Subjects must have been able to run 2 miles without stopping and had to be clearly identified as an externalizer or an internalizer according to their score on the Test of Attentional and Interpersonal Style. Eighteen of the individuals recruited did not meet the inclusion criteria and were eliminated from the study. Subjects included were 41 recreationally fit runners (17 men, 24 women) between the ages of 19 and 40 years (*M* = 22.4, *SD* = 4.4). Basic demographic data of subjects is listed in Table 2. For the purpose of this study, to ensure that participants would be able to successfully complete the one-mile trials, recreationally fit was defined as the ability to complete a two-mile run without stopping. Subjects were split into two groups, internalizers and externalizers, based on their score on the Test of Attentional and Interpersonal Style (Nideffer, 1976).

Table 2.
Demographic data of subjects

	Age[1]	**Height[2]**	**Weight[3]**
Mean	22.4	1.72	71.30
Standard Deviation	± 4.4	± .11	± 14.29

Note. [1] years, [2] meters, [3] kilograms

RECRUITMENT

Subjects were recruited through several methods. Approved flyers were distributed around the campus of a local university, in-class announcements were made to Health and Human Performance classes, and several subjects were recruited by the primary investigator (word of mouth). Institutional Review Board approval (see Appendix E) was granted before the commencement of the study.

APPARATUS AND INSTRUMENTATION

The warm-up, experimental trials, and cool-down were conducted on a Trackmaster (Full Vision Inc, Newton, KS) treadmill in the Applied Neuromuscular Physiology Laboratory located in the Colvin Recreation Center at Oklahoma State University. The on-board time and distance functions on the treadmill were used to monitor pace and progress. Rate of Perceived Exertion was measured using the Borg CR10 scale of perceived exertion (Borg, 1998).

TESTING PROCEDURE AND DATA COLLECTION

Prior to the experimental trials being conducted, subjects filled out a Physical Activity Readiness Questionnaire (PAR-Q) as well as an Informed Consent Form. The PAR-Q served as an opportunity to determine the subject's readiness for physical activity and also disclose any injuries or conditions that may have limited their ability to complete the testing protocol. Additionally, subjects filled out the Test of Attentional and Interpersonal Style (TAIS) to determine their preferred attentional focus: association or dissociation. The questionnaire is shown in Appendix A. Grading of the questionnaire generated scores in four separate categories: broad external, overload external, broad internal, and overload internal. Table 3 shows a brief description of each category according to Nideffer (1976, p. 397).

Table 3.
Description of TAIS categories

BET- Broad External Focus	High scores on this scale are obtained by individuals who describe themselves as being able to effectively integrate many external stimuli at one time.
OET- Overloaded by External Stimuli	The higher the score, the more individuals make mistakes because they become confused and overloaded with external stimuli.
BIT- Broad Internal Focus	High scores indicate that individuals see themselves as able to effectively integrate ideas and information from several different areas. They see themselves as analytical and philosophical.
OIT- Overloaded by Internal Stimuli	The higher the score, the more mistakes individuals make because they confuse themselves by thinking about too many things at once.

The results of the individual TAIS questions were compiled to determine means and standard deviations. Each subject's scores were compared to the standardized means established by Nideffer (1976) to identify which group they would be assigned. Table 4 shows the breakdown of means for each of the four TAIS categories.

Table 4.
Means and standard deviations of TAIS scores for internalizers and externalizers

	BET	**OET**	**BIT**	**OIT**
Externalizers	18.9 ± 2.2	12.6 ± 3.5	16.05 ± 2.1	12.9 ± 5.1
Internalizers	14.0 ± 3.3	17.7 ± 4.6	20.7 ± 2.3	12.7 ± 3.9

Note: BET: Broad External Test Score, OET: Overload External Test Score, BIT: Broad Internal Test Score, OIT: Overload Internal Test Score

The criteria for inclusion in either the internalizer group or the externalizer group were three-fold. For inclusion in the internalizer group, an individual had to score above the standardized mean (BIT = 18) in the BIT category (Nideffer, 1976). Additionally, their BIT score had to be greater than their BET score as well as their OIT score. Likewise, for inclusion in the externalizers group, an individual had to score above the standardized mean (BET = 14) in the BET category (Nideffer, 1980). Additionally, their BET score had to be greater than their

BIT score as well as their OET score. The 41 qualifying subjects were assigned to groups but not told which group they belonged to until after the completion of the second time trial. The groups were split into 21 internalizers (10 men, 11 women) and 20 externalizers (7 men, 13 women).

The experimental trials were conducted as a randomized, repeated-measures design. A minimum of two days and no more than three days was required between the subject's first and second trials. Order of testing with pace monitoring (associative condition) or without pace monitoring (dissociative condition) was randomized for each subject. The order of testing is shown in Appendix B. Upon arrival, subjects completed the PAR-Q, Informed Consent, and Test of Attentional and Interpersonal Style. The PAR-Q form is shown in Appendix C and the Informed Consent form is shown in Appendix D. Subjects were assigned a de-identified number for record keeping.

For the warm-up, the subjects walked at a self-selected comfortable pace for three to five minutes to allow for gradual warm-up and familiarization with the treadmill. Then the subject's slowly increased the speed of the treadmill until they were running at an easy jog for three to five minutes. The subjects were allowed to manipulate the speed controls of the treadmill during the full time of the warm-up to familiarize themselves with the operational controls. At the completion of the ten-minute warm-up period, subjects were given the opportunity to go through their normal pre-run stretching routine for three minutes. They were not, however, required to complete a stretching routine if that was not their normal practice. All subjects were instructed to use the same pre-run stretching or no stretching routine before both time trials.

Upon completion of the warm-up and stretching, subjects returned to the treadmill to begin the time trial. Prior to both treatments, subjects were given the goal of running one mile as fast as possible. For the associative condition (AC), the speed display was left uncovered to enable pace monitoring. For the dissociative condition (DC), the speed display was covered to prevent the subject from being able to view their pace. During both conditions, subjects maintained full responsibility of manipulating their pace with the on-board speed controls. Also, during both treatments, the time display was covered so that the subject was unaware of the elapsed time or completion times of each trial until after completion of the study.

The subjects were instructed by the primary investigator to start the trial with the following prompt. "When you are ready, start the treadmill by pressing the up arrow. As soon as you press the button the band on the treadmill will begin moving and I will start the stopwatch. Increase the speed of the treadmill as fast as you feel comfortable with to reach your desired running pace. You will have full control of the speed for the duration of the trial to increase or decrease your speed as you desire. Try to run at the highest intensity possible without hitting the wall too early causing you to slow down. You will be able to monitor the distance display for the duration of the test. I will ask you every quarter of a mile how hard you feel like you are working on a scale of 1-10 with one being easiest and ten being hardest. Your goal is to run one mile as fast as you are able to."

During both trials, the distance display was visible. At each quarter of a mile interval, the subjects were asked to report their rate of perceived exertion on a scale of 1-10 and their cumulative elapsed time was recorded. Immediately upon completion of one mile, subjects were asked their final RPE and instructed to press the Cool Down button on the treadmill. Participants were instructed to follow the programmed cool down protocol of the treadmill which progressively decreases the speed of the belt over three minutes.

Table 5.
Order of procedure for data collection.

ORDER OF PROCEDURE FOR DATA COLLECTION	
1. IRB approval obtained	
2. Subjects recruited	
3. Preferred attentional method survey collected from subjects	
4. Study instructions communicated to subjects	
5. Subjects were alternated into associative condition (AC) or dissociative condition (DC) upon arrival to Trial 1 by the Primary Investigator (PI)	
AC TRIALS	**DC TRIALS**
8a. Informed consent collected	8b. Informed consent collected
9a. Prescribed warmup conducted	9b. Prescribed warmup conducted
10a. 3 minutes of optional stretching	10b. 3 minutes of optional stretching
11a. Treadmill and trial instructions explained to subject	11b. Treadmill and trial instructions explained to subject
12a. Subject moved to treadmill	12b. Subject moved to treadmill
13a. Treadmill started as PI gave verbal command to go	13b. Treadmill monitor blocked by cardboard
14a. Subject completed 1-mile trial at maximal intensity	14b. Treadmill started as PI gave verbal command to go
15a. Upon completion of trial, stopwatch stopped	15b. Subject completed 1-mile trial at maximal intensity
16a. Subject walked for 5 minute cool down	16b. Upon completion of trial, stopwatch stopped
	17b. Subject walked for 5 minute cool down

STATISTICAL ANALYSIS

Statistical analysis was conducted using Microsoft Excel, JMP Pro 13, and IBM SPSS. Rate of perceived exertion scores were examined using a 2 x 2 x 4 (Group [internalizer vs externalizer] x Condition [AC vs DC] x Time [.25 miles, .5 miles, .75 miles, & 1 mile]) analysis of variance (ANOVA). Post hoc Bonferroni pairwise comparisons were used to reveal differences between time points for RPE scores. Mean change in completion time between conditions for each group was examined using an independent t-test. Completion times were compared between conditions for each group using dependent t-tests. The alpha level for statistical analysis was set at $p < .05$.

CHAPTER IV

FINDINGS

RESULTS

Rate of perceived exertion (RPE) scores were examined using a 2 x 2 x 4 (Group [internalizer vs externalizer] x Condition [AC vs DC] x Time [.25 mile, .5 mile, .75 mile, & 1 mile]) analysis of variance (ANOVA). This ANOVA showed no significant interaction between groups and visits across times. Likewise, no significant interaction was found between time and group or visit and time. There was a significant main interaction in RPE scores across time with $p < .001$. Table 6 shows the means and standard deviations for each group according to condition across times. Post hoc Bonferroni pairwise comparisons revealed that each time point was significantly different than the other time points. Table 7 shows *p*-values for all six relationships between times.

Table 6.
Internalizer and externalizer RPE means and standard deviations across conditions and times.

Group	Condition	.25 miles	.5 miles	.75 miles	1 mile
Internalizers	DC	5.2 ± 1.3	6.5 ± 1.1	7.3 ± 1.1	8.3 ± 1.1
	AC	5.0 ± 1.4	6.2 ± 1.3	7.3 ± 1.5	8.4 ± 1.5
Externalizers	DC	5.5 ± 1.3	6.5 ± 1.4	7.3 ± 1.2	8.4 ± 0.9
	AC	5.6 ± 1.6	6.6 ± 0.8	7.5 ± 0.8	8.6 ± 0.9

Table 7.
Comparison of p-values across time points for RPE scores.

Times	**.25 miles**	**.5 miles**	**.75 miles**	**1 mile**
.25 miles	---	< .001	< .001	< .001
.5 miles	---	---	< .001	< .001
.75 miles	---	---	---	< .001

Change in completion time was factored by subtracting AC completion time from DC completion time. Mean change in completion time between conditions for each group was examined using an independent t-test. The t-test showed a significant difference between mean change in completion times between groups, $t(35) = 7.37$, $p < .001$. Table 8 shows the mean change in completion times between conditions for each group.

Table 8.
Change in time (in seconds) between conditions by group.

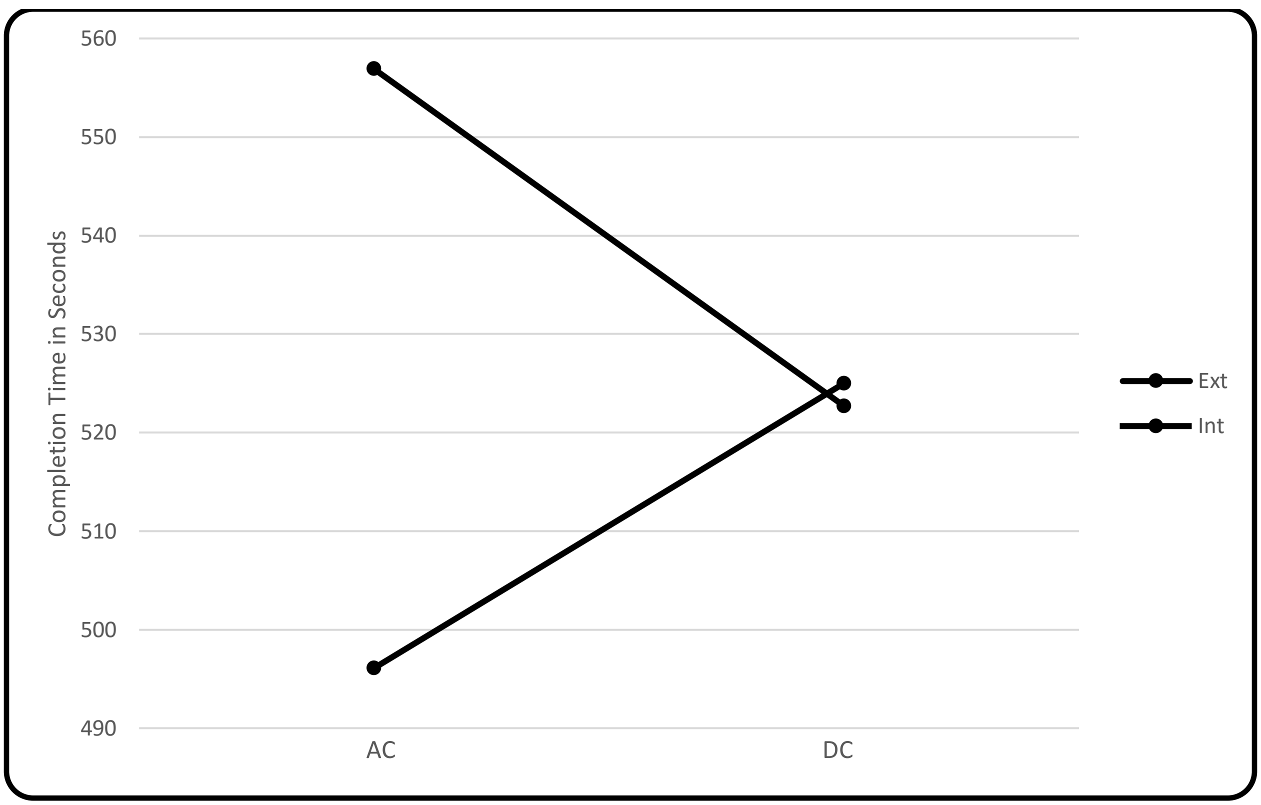
Group	*Mean*	*Standard Deviation*
Externalizers	-34.2	± 31.1
Internalizers	28.9	± 22.9

Data were then divided according to attentional focus group classification: internalizers or externalizers. Completion times were compared between conditions for each group using dependent t-tests. The internalizers group performed significantly faster in the associative condition ($M = 496.10$, $SD = 105.05$ seconds) than in the dissociative condition ($M = 525.00$, $SD = 109.67$ seconds), $t(20) = 5.79$, $p < .001$. The externalizers group performed significantly faster in the dissociative condition ($M = 522.70$, $SD = 97.37$ seconds) than in the associative condition ($M = 556.90$, $SD = 116.62$), $t(19) = -4.92$, $p < .001$. Table 9 shows the means and standard deviations of completion times (see also Figure 3).

Table 9.
Internalizers and externalizers completion time (in seconds) means and standard deviations (SD) in the associative and dissociative conditions.

Condition	Group	*Mean*	*SD*
Associative	Internalizers	496.10	± 105.05
	Externalizers	556.90	± 116.92
Dissociative	Internalizers	525.00	± 109.67
	Externalizers	522.70	± 97.37

Figure 3. Completion Time in Seconds of Internalizers and Externalizers Across Conditions.



Based on the results of the *t*-tests the following null hypotheses were accepted:

1. Internalizers' average RPE will not be different between conditions.
2. Externalizers' average RPE will not be different between conditions.

Based on the results of the *t*-tests the following null hypotheses were rejected:

1. Internalizers' completion time will not be different between conditions.
2. Externalizers' completion time will not be different between conditions.

CHAPTER V

DISCUSSION

COMPLETION TIME

The purpose of this study was to determine how pace monitoring via a run tracking device might affect run performance. The two variables of run performance that were investigated were completion time of a 1-mile run and rate of perceived exertion (RPE) during the run. For this purpose, 41 recreationally fit runners ran 1-mile time trials in two conditions. A pace monitoring (associative) condition was achieved by having the pace visible on the treadmill display. The no-monitoring (dissociative) condition was achieved by covering the pace display on the treadmill to block visual feedback from the subject. Results indicate internalizers performed significantly better in the associative condition (M = 496.10, SD = 105.05 seconds) than in the dissociative condition (M = 525.00, SD = 109.67 seconds), $t(20) = 5.79$, $p < .001$. Likewise, externalizers performed significantly better in the dissociative condition (M = 522.70, SD = 97.37 seconds) than in the associative condition (M = 556.90, SD = 116.62), $t(19) = -4.92$, $p < .001$.

Subjects who were classified as externalizer prefer a dissociative attentional focus (Morgan & Pollock, 1977). For the purpose of this study, dissociation can be described as focusing on external stimuli to distract from sensory cues while running. Based on research by Baghurst et al. (2004) that showed increased performance when subjects were engaged in their preferred attentional style, it was hypothesized that subjects in this study would perform better in the NM condition. Not having their pace to focus on, subjects were forced to focus on any number of external stimuli. For individuals who scored high in externalization on Nideffer's (1976) Test of Attentional and Interpersonal Style, this condition was better suited for them to succeed. Many studies over the past 35 years have suggested that dissociation is more commonly associated with lower RPE levels and decreased performance (Brick et al., 2014; Fillingim & Fine, 1986; Laasch, 1995; Stevinson & Biddle, 1998). However, the results of this study suggest that if an individual prefers dissociation then they will perform better in a dissociative condition than an associative one. Subjects classified as internalizers performed significantly better in the associative condition than in the dissociative, which is supported by past research that found a positive relationship between association and increased performance (Baghurst et al., 2004; Young, 2007). Overall, the findings of this study suggest that personal preference for association or dissociation may dictate performance level.

RATE OF PERCEIVED EXERTION

According to previous research, the dissociative (DC) condition was expected to yield significantly lower RPE scores (Baden et al., 2004; Ceci & Hassmen, 1990; Tucker, 2009). In contrast to previous findings, the present study showed no significant difference in average RPE between conditions. Even the externalizers group reported a minimal difference in perceived exertion between conditions. This result may be due to the maximal effort goal, to run one mile as fast as possible, of both time trials.

Similar RPE scores across conditions contribute to the practical significance of the completion time results. The results showed significantly faster completion times within groups when subjects were allowed to perform in their preferred attentional style. The implication of being able to run a mile significantly faster with similar effort levels is profound. After all, a common goal among runners is to run a given distance as fast as possible with minimal perceived or actual exertion (Tucker, 2009). If simply shifting attentional focus can produce such significant differences in completion times, then the use of the TAIS to determine preferred style, and the application of the test's results, is a method of performance enhancement (Nideffer, 1990).

LIMITATIONS AND FUTURE STUDIES

The major limitation of this study was the limited maximum speed of the treadmill. One of the subjects maxed out the speed of the treadmill for a brief time. It is possible that the subject could have completed the time trial faster. Another limitation of the current study was the use of RPE as a measure of exertion. The RPE score is subjective in nature between individuals and between trials for each individual. However, despite it's subjectivity, past research supports the use of an RPE scale as a valid measure of exertion (Borg, 2005).

Despite the significant results of the current study, the findings may not be an accurate representation of the general population due to the small sample size. Future studies should consider testing more subjects with the same protocol. Similarly, while an effort was made to address the age-related limitation of previous research, the willingness of study participants over the age of 25 was minimal. The addition of a system of analysis to quantify some of the trends noted during post-test discussions could be a valuable modification to future study as well. Additionally, conducting the same testing protocol on a more homogenous sample in regards to experience level may be beneficial, as the current study did not differentiate between subjects with extensive or minimal running experience. Similarly, fitness level is another factor that should be considered for future studies. Lastly, changing from an indoor treadmill to an outdoor running trail, with established distance markers, may provide different results but would increase environment variability. To conduct a similar study that focuses on the effects of pace-monitoring on RPE exclusively, changing the goal of each time trial could suffice. Instructing subjects to run at a pre-determined pace rather than as fast as possible would help isolate RPE.

CONCLUSION

The current study showed significant differences in completion times of a 1-mile time trial between two attentional focus conditions. Results confirm the use of pace monitoring as a means of performance enhancement. Simply shifting to/away from or restricting a subject's ability to focus on their pace while running may be a viable method of manipulating performance. While the study showed no significant difference in RPE scores between conditions, there may be practical implications of similar RPE scores when accompanied by significant changes in performance. One conclusion that is in agreement with most research is the dynamic nature of attentional focus of runners (Brewer et al., 1996; Brick et al., 2014; Garcia et al., 2015). Certain situations may call for an associative focus while others may benefit from a dissociative focus. Viewing pace-monitoring during a run as a function of attentional focus can significantly benefit performance.

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APPENDICES

APPENDIX A

Test of Attentional and Interpersonal Style, (taken from Nideffer, 1976)

Test of Attentional and Interpersonal Style

Name: ________________________________

	Never	Rarely	Sometimes	Frequently	All the Time
1. When people talk to me I find myself distracted by the sights and sounds around me.	☐	☐	☐	☐	☐
2. When people talk to me I find myself distracted by my own thoughts and ideas.	☐	☐	☐	☐	☐
3. All I need is a little information and I can come up with a large number of ideas.	☐	☐	☐	☐	☐
4. I run back and forth from task to task.	☐	☐	☐	☐	☐
5. I seem to work in "fits and starts" or "bits and pieces".	☐	☐	☐	☐	☐
6. The work I do involves a wide variety of seemingly unrelated materials and ideas.	☐	☐	☐	☐	☐
7. My thoughts and associations come so rapidly I can't keep up with them.	☐	☐	☐	☐	☐
8. The world seems to be a booming buzzing brilliant flash of colour and confusion.	☐	☐	☐	☐	☐
9. When I make a mistake it is because I did not wait to get all the information.	☐	☐	☐	☐	☐
10. When I make a mistake it is because I waited too long and got too much information.	☐	☐	☐	☐	☐
11. In school I failed to wait for the teachers' instructions.	☐	☐	☐	☐	☐
12. I get caught up in my thoughts and become oblivious to what is going on around me.	☐	☐	☐	☐	☐
13. I theorize and philosophize.	☐	☐	☐	☐	☐
14. I enjoy, quiet thoughtful times.	☐	☐	☐	☐	☐
15. I would rather be feeling and experiencing the world than my own thoughts.	☐	☐	☐	☐	☐
16. My environment is exciting and keeps me involved.	☐	☐	☐	☐	☐
17. My interests are broader than most people's.	☐	☐	☐	☐	☐
18. Happenings or objects grab my attention.	☐	☐	☐	☐	☐
19. With so much going on around me, it's difficult for me to think about anything for any length of time.	☐	☐	☐	☐	☐
20. I'm good at quickly analyzing complex situations around me, such as how a play is developing in football or which of four or five kids started a fight.	☐	☐	☐	☐	☐
21. At stores I'm faced with so many choices I can't make up my mind.	☐	☐	☐	☐	☐
22. I spend a great deal of my time thinking about all kinds of ideas I have.	☐	☐	☐	☐	☐
23. I figure out how to respond to others by imagining myself in their situation.	☐	☐	☐	☐	☐
24. In school I would become distracted and didn't stick to the subject.	☐	☐	☐	☐	☐

TAIS (page 2)

	All the Time	Frequently	Sometimes	Rarely	Never
25. Even though I am not hungry, if something is placed in front of me, I'll eat it.	☐	☐	☐	☐	☐
26. I am more of a doing person than a thinking one.	☐	☐	☐	☐	☐
27. In a room filled with children or out playing on a field, I know what everyone is doing.	☐	☐	☐	☐	☐
28. I am good at rapidly scanning crowds and picking out a particular person or face.	☐	☐	☐	☐	☐
29. I have difficulty shifting back and forth from one conversation to another.	☐	☐	☐	☐	☐
30. I get confused trying to watch activities such as a football game or circus where a number of things are happening at the same time.	☐	☐	☐	☐	☐
31. I have so many things on my mind that I become confused and forgetful.	☐	☐	☐	☐	☐
32. I can't resist temptation when it's right in front of me.	☐	☐	☐	☐	☐
33. I can plan several moves ahead in games like bridge and chess.	☐	☐	☐	☐	☐
34. In school I was not a "thinker".	☐	☐	☐	☐	☐
35. In a roomful of people I can keep track of several conversations at the same time.	☐	☐	☐	☐	☐
36. I have difficulty telling how others feel by watching them and listening to them talk.	☐	☐	☐	☐	☐
37. People have to repeat things to me because I become distracted by irrelevant sights or sounds around me.	☐	☐	☐	☐	☐
38. I make mistakes because I try to do too many things at once.	☐	☐	☐	☐	☐
39. I am good a t analyzing situations and predicting in advance what others will do.	☐	☐	☐	☐	☐
40. On essay tests my answers are (were) too broad, bringing in irrelevant information.	☐	☐	☐	☐	☐
41. People fool me because I don't bother to analyze the things they say; I take them at face value.	☐	☐	☐	☐	☐
42. I would much rather be doing something than just sitting around thinking.	☐	☐	☐	☐	☐
43. I am constantly analyzing people and situations.	☐	☐	☐	☐	☐
44. I get confused at busy intersections.	☐	☐	☐	☐	☐
45. I am good at glancing at a large area and quickly picking out several objects, such as those hidden figures drawings in children's magazines.	☐	☐	☐	☐	☐
46. Even when I am involved in a game or sport my mind is going a mile a minute.	☐	☐	☐	☐	☐

TAIS (page 3)

	Never	Rarely	Sometimes	Frequently	All the Time
47. I can figure out how to respond to others just by looking at them.	☐	☐	☐	☐	☐
48. It is easy for me to bring together ideas from a number of different areas.	☐	☐	☐	☐	☐
49. Sometimes lights and sounds come at me so rapidly they make me lightheaded or dizzy.	☐	☐	☐	☐	☐
50. People have to repeat things because I get distracted by my own irrelevant thoughts.	☐	☐	☐	☐	☐
51. People pull the wool over my eyes because I fail to see when they are obviously kidding by looking at the way they are smiling or listening to their joking tone.	☐	☐	☐	☐	☐
52. It is easy for me to keep sights and sounds from interfering with my thoughts.	☐	☐	☐	☐	☐
53. It is easy for me to focus on a number of things at the same time.	☐	☐	☐	☐	☐
54. In games I make mistakes because I am watching what one person does and forget about the others.	☐	☐	☐	☐	☐
55. I have a tendency to get involved in a conversation and forget important things like a pot on the stove, or like leaving the motor running on the car.	☐	☐	☐	☐	☐
56. It is easy for me to keep thoughts from interfering with something I am watching or listening to.	☐	☐	☐	☐	☐

Scores:

BET: ____________________

OET: ____________________

BIT: ____________________

OIT: ____________________

APPENDIX B

Order of condition testing by subject ID number

Subject ID Number	Trial 1	Trial 2
101	MO	NM
102	NM	MO
103	NM	MO
105	NM	MO
106	NM	MO
107	MO	NM
108	MO	NM
109	MO	NM
110	NM	MO
111	NM	MO
112	MO	NM
113	NM	MO
114	MO	NM
115	MO	NM
116	MO	NM
117	NM	MO
118	NM	MO
119	NM	MO
120	MO	NM
121	NM	MO
122	NM	MO
123	NM	MO
124	MO	NM
125	MO	NM
126	NM	MO
127	MO	NM
128	NM	MO
129	MO	NM
130	MO	NM
131	NM	MO
132	MO	NM
133	MO	NM
134	MO	NM
135	NM	MO
136	MO	NM
137	NM	MO
138	MO	NM
139	NM	MO
140	MO	NM
141	MO	NM

APPENDIX C

Pre-exercise Testing Health & Exercise Status Questionnaire (PAR-Q)

RECRUITMENT NO.______________

PRE-EXERCISE TESTING HEALTH & EXERCISE STATUS QUESTIONNAIRE

OKLAHOMA STATE UNIVERSITY
DEPARTMENT OF HEALTH AND HUMAN PERFORMANCE

Name ____ Date_____________

Cell/Work Phone ______________________

E-mail address _____________________

Person to contact in case of emergency ____

Emergency Contact Phone _____________________

Gender ________ Age ______(yrs) Height ______(ft)______(in) Weight______(lbs)

Females Only: Are you currently taking any birth control pill or related medication?

Yes _____ No ______

Females Only: Are you currently in the menstrual cycle?

Yes _____ No ______

A. JOINT-MUSCLE STATUS (✐Check areas where you currently have problems)

Joint Areas
( ) Upper Spine & Neck
( ) Lower Spine
( ) Hips
( ) Knees
( ) Ankles
( ) Feet
( ) Other_____________________

Muscle Areas
( ) Upper Back & Neck
( ) Abdominal Regions
( ) Lower Back
( ) Buttocks
( ) Thighs
( ) Lower Leg
( ) Feet
( ) Other____________________

B. HEALTH STATUS (✐Check if you currently have any of the following conditions)

( ) High Blood Pressure
( ) Heart Disease or Dysfunction
( ) Peripheral Circulatory Disorder
( ) Lung Disease or Dysfunction
( ) Arthritis or Gout
( ) Edema
( ) Epilepsy
( ) Multiply Sclerosis
( ) High Blood Cholesterol or Triglyceride Levels

( ) Acute Infection
( ) Diabetes or Blood Sugar Level Abnormality
( ) Anemia
( ) Hernias
( ) Thyroid Dysfunction
( ) Pancreas Dysfunction
( ) Liver Dysfunction
( ) Kidney Dysfunction
( ) Phenylketonuria (PKU)
( ) Loss of Consciousnes

( ) Allergic reactions to rubbing alcohol

C. PHYSICAL EXAMINATION HISTORY

Approximate date of your last physical examination______________________________

Physical problems noted at that time____

Has a physician ever made any recommendations relative to limiting your level of physical exertion? _________YES __________NO

If YES, what limitations were recommended?___________________________________
____

D. CURRENT MEDICATION USAGE (List the drug name and the condition being managed)

MEDICATION	CONDITION
_________________________	__________________________________
_________________________	__________________________________
_________________________	__________________________________

E. PHYSICAL PERCEPTIONS (Indicate any unusual sensations or perceptions. ✐Check if you have recently experienced any of the following during or soon after *physical activity* (PA); or during *sedentary periods* (SED))

PA	SED		PA	SED	
( )	( )	Chest Pain	( )	( )	Nausea
( )	( )	Heart Palpitations	( )	( )	Light Headedness
( )	( )	Unusually Rapid Breathing	( )	( )	Loss of Consciousness
( )	( )	Overheating	( )	( )	Loss of Balance
( )	( )	Muscle Cramping	( )	( )	Loss of Coordination
( )	( )	Muscle Pain	( )	( )	Extreme Weakness
( )	( )	Joint Pain	( )	( )	Numbness
( )	( )	Other________________________	( )	( )	Mental Confusion

F. FAMILY HISTORY (✐Check if any of your blood relatives . . . parents, brothers, sisters, aunts, uncles, and/or grandparents . . . have or had any of the following)

( ) Heart Disease
( ) Heart Attacks or Strokes (prior to age 50)
( ) Elevated Blood Cholesterol or Triglyceride Levels
( ) High Blood Pressure
( ) Diabetes
( ) Sudden Death (other than accidental)

G. EXERCISE STATUS

Do you regularly engage in aerobic forms of exercise (i.e., jogging, cycling, walking, etc.)? YES NO

How long have you engaged in this form of exercise? ______ years ______ months

How many hours per week do you spend for this type of exercise? _______ hours

Do you regularly lift weights? YES NO

How long have you engaged in this form of exercise? ______ years ______ months

How many hours per week do you spend for this type of exercise? _______ hours

Do you regularly play recreational sports (i.e., basketball, racquetball, volleyball, etc.)? YES NO

How long have you engaged in this form of exercise? ______ years ______ months

How many hours per week do you spend for this type of exercise? _______ hours

Are you able to run two miles consistently without having to walk? YES NO

What is the fastest time you can run a mile currently? ___________

How many hours per week do you spend for this type of exercise? _______ hours

APPENDIX D

Informed Consent Form

CONSENT FORM

Project Title: Pace and Progress Monitoring and Their Effects on Run Performance

Investigators: Todd Christensen, Graduate Student, Oklahoma State University
Doug Smith, Ph.D., Oklahoma State University
Health and Human Performance
School of Applied Health and Educational Psychology
Oklahoma State University

Purpose: As technological advancements continue to saturate the sports and fitness industries, corresponding research is necessary to determine the benefit or detriment of individual devices. Therefore, the purpose of this study is to determine if the use of a run tracking device is beneficial or detrimental to achieving maximum run performance.

Procedures:

- As a participant you will visit the lab on 2 occasions, for a total of 1 hour over the course of 2 weeks.
- You will wear athletic shorts, shirt, and shoes each time you come to the lab.
- During the first visit to the lab you will complete this form and one other brief form that will give us an idea of your current health and physical activity status.
- Following a light 5-minute warm-up on a treadmill you will practice using the speed controls on the treadmill.
- You will complete a running protocol in which you will run 1 mile as fast as you can.
- During the test, you will have complete control of the speed controls of the treadmill.

Lab Location: 192 Colvin Recreation Center, Stillwater, OK

Exclusion Criteria: you will be unable to participate if you:

- Have a specific health condition that would not allow you to complete the testing.
- Have a recommendation or order from your physician to not participate in general fitness testing.
- Are not able to complete a 2-mile run without walking.

Risk of Participation: Risks associated with the study are minimal and with no greater phycisal demands than those experienced during a typical exercise routine. These may include minor muscular fatigue and a potential risk for muscle soreness lasting approximately 24-72 hours following the testing. Medical records will be used during screening process. In case of injury or illness resulting from this study, emergency medical treatment will be available (CPR certified investigator and 911). No funds have been set aside by Oklahoma State University to compensate you in the even of illness or injury.

Potential Benefits: These findings may help researchers and clinicians better understand the effects of pace and progress monitoring on run performance.

Compensation: No compensation is given for participating in this study.

Confidentiality:!Confidentiality!will!be!maintained!by!coding!all!information!with!individual! identification!numbers.!The!master!list!will!be!kept!in!a!locked!file!cabinet!in!the!advisor's! (Doug!Smith)!office.!Only!qualified!research!personnel!and!the!Oklahoma!State!University! Institutional!Review!Board!(IRB)!will!have!access!to!the!database!containing!study! information.!All!study!data!entered!into!statistical!analyses!and!publication!reports!will! contain!no!identification!to!participants.!Only!mean!(average)!values!will!be!reported.!No! individual!or!group!other!than!the!research!team!will!be!given!information,!unless! specifically!requested!by!the!IRB.!All!primary!data!sources!will!be!kept!in!the!locked!file! cabinet!located!in!the!advisors!office.!It!is!possible!that!the!consent!process!and!data! collection!will!be!observed!by!research!oversight!staff!responsible!for!safeguarding!the!right! and!wellMbeing!of!people!who!participate!in!research.!!

!

Contacts:!This!study!has!been!reviewed!and!approved!by!the!Oklahoma!State!University! IRB.!If!you!have!questions!about!the!research!project!you!may!contact!Doug!Smith,!Ph.D!at! doug.smith@okstate.edu.!For!questions!about!your!rights!as!a!research!volunteer,!you!may! contact!Dr.!Hugh!Crethar,!IRB!Chair,!223!Scott!Hall,!Stillwater,!OK!74078,!405M744M3377,!or! irb@okstate.edu.!

!

Signatures:'

!

I!have!read!and!fully!understand!the!consent!form.!I!sign!it!freely!and!voluntarily.!A!copy!of! this!form!has!been!given!to!me.!

!

!

!

_______________________________________!! ! !!!__________________________!

Signature!of!Participant! ! ! ! Date!

!

I!certify!that!I!have!personally!explained!this!document!before!requesting!that!the! participant!sign!it.!!

!

!

!

_______________________________________!! ! !!!__________________________!

Signature!of!Primary!Investigator!!!! ! !!!!!!!!!!!!Date!

!

APPENDIX E

Oklahoma State University Institutional Review Board

Date: Wednesday, October 19, 2016

IRB Application No ED16149

Proposal Title: Effects of pace monitoring on running speed

Reviewed and Processed as: Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 10/18/2017

Principal Investigator(s):

Todd Christensen
Stillwater, OK 74078

Douglas Smith
180 CRC
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1.Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2.Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3.Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4.Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

VITA

Todd Paul Christensen

Candidate for the Degree of

Master of Science

Thesis: ATTENTIONAL STYLE, PACE MONITORING, AND THEIR EFFECTS ON RATE OF PERCEIVED EXERTION AND RUN PERFORMANCE

Major Field: Health and Human Performance

Biographical:

Education:

Completed the requirements for the Master of Science in Health and Human Performance at Oklahoma State University, Stillwater, Oklahoma in May 2017.

Completed the requirements for the Bachelor of Science in Community Recreation at Southwest Baptist University, Bolivar, MO 2005.

Experience:

Graduate teaching assistant at Oklahoma State University.

Personal trainer

Group Exercise instructor

Professional Memberships:

American College of Sports Medicine

National Strength and Conditioning Association