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Manipulation of attention focus in long jumpers to enhance performance and coaching instructions

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MANIPULATION OF ATTENTION FOCUS IN LONG JUMPERS TO ENHANCE PERFORMANCE AND COACHING INSTRUCTIONS

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CERTIFICATE OF APPROVAL

MASTER OF SCIENCE THESIS

This is to certify that the Thesis of

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ABSTRACT

The event of long jump is unique because it allows some athletes to exert an effort that can stand apart and not be influenced by competitors and teammates. Attention focus is an important aspect to the event of long jump as there are many stimuli to attend to in the environment, including the runway, take-off board, jumping mechanics, and the sand pit. The present study investigated how manipulating a distal external focus of attention would affect performance in college-level long jumpers (N = 10; M_{age} = 19.20 years old). Athletes completed 4 conditions consisting of 3 jumps each. The conditions were Control 1, Treatment 1 (consisted of attending to a low distal target (LDT)), Treatment 2 (involved attending to a high distal target (HDT)), and Control 2. Each athlete completed an attention focus questionnaire at the conclusion of each condition to assess attention focus during each jump. True jump distance, horizontal velocity at take-off, vertical velocity a take-off, take-off angle, and approach velocity were measured for each participant in each jump. Focusing on a HDT did not lead to significantly further jumps (M = 4.58 m) compared to focusing on a LDT (M = 4.58 m) or Control 1 (M = 4.64 m). Athletes jumped the farthest in Control 2 (M = 4.74 m), yet commonly reported looking up while jumping. Findings from the present study suggest that focusing on a high above-ground external target may aid in jump performance, but only if the target is self-selected by the athlete and not when instructed to attend to a specific external target. Further research on a larger sample of long jumpers is recommended.

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INTRODUCTION

The sport of track and field is unique because it allows some athletes to exert an effort that can stand apart and not be influenced by competitors and teammates. An athlete's opponent is often time, distance or height rather than another person, such as the long jump. In the long jump, the athlete runs her approach down the runway, takes off from a designated board, and completes a series of technical movements to jump as far as possible into a sand pit. The distance from the board to her mark in the sand is the result of the performance. Essentially, the athlete only competes directly against herself and the long jump pit, not other athletes.

Because a long jumper's performance cannot be manipulated by a competitor, exploring the psychological processes of such competitors allows for direct analysis into how those processes effect outcome. The mental process of attention has been shown to be particularly important as a performance factor for track and field athletes because there are many stimuli present throughout the entire performance. For instance, whether the long jumper should focus predominantly on internal cues or external cues is in question.

Experimental research on attention focus has been conducted by analyzing its effect on physical tasks such as balancing on a stabilometer (McNevin, Shea, & Wulf, 2003; Wulf, McNevi,n & Shea, 2001), serving a volleyball (Wulf, McConnel, Gärtner, & Schwarz, 2002), putting a golf ball (Shafizadeh, McMorris, & Sproule, 2011) and throwing a discus (Zarghami, Saemi, & Fathi, 2012). The most pertinent research in regards to attention focus and the event of long jump stems from vertical jump testing

(Wulf & Dufek, 2009; Wulf, Zachry, Granados, & Dufek, 2007) and standing long jump testing (Porter, Anton, Wikoff, & Ostrowski, 2012; Porter, Anton, & Wu, 2012; Porter, Ostrowski, Nolan, & Wu, 2010; Wu, Porter & Brown, 2012). The majority of research on attention focus and athletic movements has confirmed that focusing externally enhances performance while focusing internally does not. Furthermore, investigators have found that extending the distance of an external focus from the body amplifies performance enhancement (Porter, Anton, Wikoff, & Ostrowski, 2012).

Research on long jumping has also indicated that visually attending to the board early on in the approach leads to a smoother take-off (Bradshaw & Aisbett, 2006) while gaining maximal controllable speed during the approach leads to farther jumps as well (Bridgett & Linthorne, 2006; Linthorne, Guzman, & Bridgett, 2005; Muraki, Ae, Yokozawa, & Koyama, 2005). Additionally, Linthorne et al. (2005) found that the optimum take-off angle for a long jumper is between 21° and 25.2° which is primarily manipulated by take-off speed.

Although ample research exists on both attention focus and long jump as separate entities, none has been conducted on the effect of attention focus on long jump performance. While Porter, Ostrowski, et al. (2010) suggested that coaches alter techniques to instruct athletes to focus on a distal external target while long jumping, Porter, Wu, et al. (2010) found that 84.6% of athletes who competed in a USA track and field championship received instructions during practices that were internal focus based. Furthermore, Porter, Anton, and Wu (2012) found that when left to their own choices, athletes asked to perform the standing long jump did not focus externally. These findings confirm not only a gap between applying attention focus to an event such as long jump, but also a gap between scientifically based evidence and actual coaching instructions.

Statement of Purpose

The purpose of this study was to analyze the manipulation of distal external attention focus on long jumpers by way of a low distal target (LDT) versus a high distal target (HDT).

Hypothesis

The hypothesis of this study was that attending to a high distal target distal placed 5.22 m above the end of a sand pit would cause athletes to jump farther than when athletes were instructed to focus on a low distal target placed on the ground at the end of a sand pit or performed under normal focus conditions.

Scope of the Problem

The scope of the study involved assessing attention focus manipulation on long jumping. Based on previous research, only distal external foci were manipulated in this study. The effect of attention focus on long jumping performance was analyzed through collecting data on true jump distance, take-off angle, vertical velocity at take-off, horizontal velocity at take-off, and approach velocity. Participants in the study were collegiate long jumpers.

Delimitations

A significant delimitation of the study was that data would only be gathered from athletes who represent Division III of the National Collegiate Athletic Association (NCAA). High school athletes and athletes representing other NCAA divisions and other governing bodies were not represented in this study. Another delimitation was the manipulation of attention focus. Because research has indicated that only an external focus enhances performance, athletes did not jump under internal focus instructions in this study. To keep data collection manageable, participants were gathered from a local northeastern college. All participants took three jumps per condition during the project to simulate a meet situation. Finally, the experimental portion of the study only used two distal focus targets.

Limitations

The key limitation of this study was the participant pool. All participants were volunteers from a single northeastern college. Results based on these data cannot be generalized to athletes elsewhere. Another limitation to the study was the experimental set-up of the study. All participants completed three jumps in small groups for Control 1, Treatment 1 (LDT), Treatment 2 (HDT), and Control 2 in order to minimize the time frame of each session and minimize chance of injury. Finally, the researcher measured take-off velocities from the iliac crest and based the height of the HDT from the human average height of center or mass in order to simplify methodological procedures.

Assumptions of the Study

This investigation assumed that a minimum of one year of long jump experience qualified an individual to be considered skilled and thus able to participate in the study. Also, based on the research, it was assumed that an internal focus would not enhance performance more so than an external focus or no instructions on focus. Furthermore, the mean average height of center of mass for men and women in the United States was assumed to be an appropriate measurement to use in calculating the height of the HDT and that this height would be appropriate for all participants. Finally, it was assumed that the average of the optimal take-off angle range found by Linthorne et al. (2005) would be an appropriate angle to use in calculating the height of the HDT.

Operational Definitions

Approach velocity – Measurement of forward velocity taken from a 10 m length of the athlete's approach.

Attention focus – How well an athlete can concentrate on a task (Ives, 2013).

Center of mass – Highest point on the iliac crest from a sagittal view on the midline.

Distal external focus – Attending to a visual cue placed at a distance from the body.

External focus – Attending to stimuli outside of the body.

High distal target (HDT) – A 1 m orange cylinder placed horizontally and centered 5.22 m above the end of the sand pit.

Internal focus – Attending to stimuli or thoughts inside the body or mind.

True distance – The measurement taken from where the participant's foot leaves the ground at take-off to the closest imprint in the sand relative to the board.

Low distal target (LDT) – A 1 m orange cylinder placed horizontally and centered at the end of the sand pit at a distance of 10.96 m from the designated take-off board.

Take-off – The first moment of non-contact with the runway caused by long jump flight. Determined by the first video camera frame where the jumping leg does not touch the runway caused by long jump flight.

Take-off angle – The angle created by the velocity of the center of mass at take-off. Measured by the arctangent of vertical take-off velocity divided by the horizontal take-off velocity.

Take-off velocity – Velocity of the iliac crest at the instant of take-off.

Chapter 2

REVIEW OF LITERATURE

Introduction

The purpose of this study was to analyze the effect of manipulating focus of attention on long jumpers. Athletes from small a northeastern college served as participants and were analyzed on jump distance, approach and take-off velocities, and take-off angle. These factors were used to determine if manipulating focus of attention caused athletes to jump further. This literature review covers research on attention focus, long jump, and quiet eye to rationalize the use of targets and measurements for the current study.

Attention Focus

Experimental research on attention focus spans a variety of sports and physical movements. Substantial findings have been gained. Attention focus can be broken down into narrow-external, narrow-internal, broad-internal, and broad-external (Nideffer, 1976). Narrow-external indicates focusing on few environmental cues outside of the body while narrow-internal signifies focusing on few factors inside the body. Broad-internal identifies focusing on many factors inside the body including thoughts, while broad-external refers to focusing on many characteristics in the environment outside of the body (Nideffer, 1976).

Previous research has shown that external attention foci produce better performances than internal attention foci (McNevin et al., 2003; Wulf et al., 2001). One possible explanation for this phenomenon is described as the constrained action hypothesis. This hypothesis states that consciously controlling movements (internal focus) could constrain the automatic control of the motor system whereas focusing on the movement result (external focus) could allow for normal automatic control of the motor system (McNevin et al., 2003). Furthermore, others have speculated that increasing the distance of an external focus cue could further enhance performance and learning based on previous findings (Wulf & Prinz, 2001).

To test the constrained action hypothesis, McNevin et al. (2003) asked 40 college students to complete a stabilometer task. One set of markers was placed 26 cm outside of the feet (external-far) while other markers were placed between the feet near the midline of the platform (external-far). A different set of markers was placed directly in front of the feet (external-near). The internal focus condition asked participants to focus on their feet. It was hypothesized that participants focusing on the markers far outside of their feet and far inside of their feet would balance more efficiently because the distance of the markers were far from the body but at relatively the same distance of 26 cm. Participants focusing on the markers close to their feet would perform less accurately due to possible interference with the automatic control process while the internal focus group would have the least accurate performances. Participants were randomly assigned to one of four groups. The three external practice conditions instructed participants to focus on different markers while the internal practice condition asked participants to focus on their feet. Individuals in all groups were instructed to only look straight ahead but to mentally focus on their given cues. Every participant completed seven practice trials during 2 days and then a retention session on day 3 that involved no instruction. The authors found no significant differences in performance between the four groups during the practice trials; however, the external-far groups performed both similarly and more effectively in the retention session as compared to the external-near focus group and the internal focus group. The authors concluded that increasing the distance of attention from the body does enhance learning and thus supports the constrained action hypothesis.

Wulf et al. (2001) had previously tested the constrained action hypothesis by asking 28 participants to complete a stabilometer task that was accompanied by a reaction time task. Adding this cognitive task to the stabilometer experiment allowed for in depth testing of learning differences between external focus and internal focus conditions. Wulf et al. (2001) hypothesized that individuals in the external focus condition would show more accuracy in the balancing task and also reduced reaction time to environmental stimuli due to less attention placed on balancing than the internal focus group. Participants were randomly assigned to either the internal focus condition or the external focus condition. The internal condition instructed individuals to focus on their feet and keep them horizontal while the external condition instructed participants to focus on the markers placed on the platform 22 cm from their feet. Participants were not instructed to look at their feet or markers but rather to mentally attend to keeping them horizontal. Each person completed seven 90 s trials in both the practice and retention sessions, six of which involved a finger response to pseudo-random audio stimuli while balancing. One trial was only the stabilometer task to ensure that performance was not influenced by the reaction task. Participants also completed a baseline reaction task without the stabilometer before and after each practice and retention session to serve as a comparison for the combination task.

Results of the Wulf et al. (2001) study confirmed the hypothesis that constrained actions can be explained by attention processes. Although all participants had reduced reaction times to the stimuli between the practice and retention sessions, those in the external focus group displayed significantly quicker reaction times. The external focus group also balanced on the stabilometer more effectively than the internal focus group. Given these results, the authors concluded that an external focus allows for the motor system to function more efficiently which also creates learning benefits because attention can be paid to other tasks.

Wulf et al. (2002) expanded on these previous findings by manipulating attention focus during actual sport movements. The first experiment involved serving a volleyball toward a bulls-eye target that held different point values for accuracy. All participants received general instructions on how to serve the ball. Players were then broken down into novice and experienced groups and then into internal focus and external focus groups to create four groups. Both internal focus groups received serving instructions related to body movements whereas the external focus group received serving instructions pertaining to the effects of the proper movements. All participants completed two practice sessions that were separated by 1 week and involved 25 trials. A retention session followed 1 week after the second practice session and involved 15 trials with no instruction. Two raters assessed movement quality in all participants.

Results of the experiment revealed that regardless of experience level and practice versus retention sessions, the external focus groups completed more accurate shots than the internal focus groups. Both external groups also showed higher scores for movement quality than the internal groups during the practice sessions; however the novice internal focus group improved to that of the novice external group during the retention session.

Wulf et al. (2002) concluded that an external focus of attention allows for higher accuracy in volleyball serve shots than an internal focus regardless of experience level. Furthermore, an external focus proves to have a relatively permanent learning effect for athletes based on the improvement in performance between the second practice session and the retention session. Lastly, the results of this experiment showed that instructions do not have to pertain to the athlete's body movements in order for the correct technique to be exhibited.

Since the novice internal focus group improved in form during the retention session, the next logical progression was to manipulate feedback frequency along with type of feedback. Wulf et al. (2002) utilized a second experiment to test moderately experienced soccer players in a lofted pass task that operated similarly to the volleyball serve task. They hypothesized that the external focus groups would perform better than the internal groups, but that the internal group who received instruction 33% of the time would perform better than the group that received feedback 100% of the time. Wulf et al. (2002) also speculated that the external group who received 100% feedback would perform better if not at least as effectively as the external group who received 33% feedback. These investigators sought to identify if less internal focus instruction is better than more frequent instruction, and if more external focus instruction is better if not equal to less external focus instruction.

Results from the practice sessions indicated that the external focus groups generally completed more accurate shots than the internal groups regardless of feedback frequency. The retention session conveyed the same results for accuracy between groups compared to the practice sessions; however the internal focus group with 100% feedback performed less accurately than the 33% internal feedback group. Also, although the external focus group that received 100% feedback performed better than the external focus group that received 33% feedback, the results were not statistically significant.

Wulf et al. (2002) concluded from the second experiment that reduced internal focus feedback did allow for more accurate skill performance than constant internal feedback. Both constant external feedback and reduced external feedback allowed for a better learning experience than an internal focus of attention. In general discussion of both experiments, Wulf et al. (2002) recognized that, although it has been shown that instructions should refer to the performer’s movements as little as possible for increased performance, the results were the opposite of instructional practices in the real world.

More recent research has expanded the findings by Wulf et al. (2001, 2002) and modified the constrained action hypothesis. One such study was conducted by Shafizadeh et al. (2011), who related external focus of attention to the perception-action perspective. The perception-action perspective indicates that learning a skill occurs through the interaction between receiving cues that are relevant to the movement and performing the movement (Shafizadeh et al., 2011). These researchers applied this learning perspective to participants in a golf putting task in which the golfers experienced conditions that differed in external focus cues. One condition involved instructions to focus on length and direction of a swing marker placed behind the ball (club swing), another condition provided instructions to focus on a trajectory marker placed in front of the ball (target) while the third condition combined both club swing and target cues.

Shafizadeh et al. (2011) hypothesized that because the perception-action perspective indicates that learning occurs through perception and action, the target-club swing group would perform and learn more effectively than the other two groups. Thirty novice undergraduate golfers took a pretest and were divided into three equal groups. Each group was given a different external focus cue based on the three conditions. The putting target was 5 m away from the starting point and not visible to the golfers. Participants were given a score of his or her putt along with feedback. Performance was calculated by distance of golf ball to target after each shot.

Results from the acquisition phase of the experiment conveyed that target group performance was better than the club swing group. Analysis of the retention test found that the target-club group was better than both the target group and club swing group (Shafizadeh et al., 2011). The authors concluded that golf putting instructors should present external focus cues that emphasize both action planning and environmental perception.

A subsequent study that emphasized these findings was conducted by McKay and Wulf (2012) who experimented with external focus cues for dart throwing. These researchers sought to expand on previous literature by showing that a distal external focus would enhance performance more than a proximal external focus. McKay and Wulf (2012) indicated that the purpose of the study was to find the effectiveness of distal versus proximal focus, find novices’ sensitivity to the different foci, examine order effects of performing both the distal focus task and proximal focus task, and examine whether participants who preferred distal focus would perform better than those who liked proximal focus.

Thirty-six college students participated in the McKay and Wulf (2012) study. Participants tested which focus he or she favored with one throw. Half of the participants were allowed to perform his or her preference as the first condition of the experiment while the other half were not. The proximal condition instructed participants to focus on dart trajectory while the distal condition instructed participants to focus on the bulls-eye. Results showed that dart throwing was more accurate with distal external focus regardless of which method the participants preferred or the order in which they completed the conditions. The majority of participants preferred the distal external focus condition and also performed significantly more accurately than those who preferred the proximal external condition. McKay and Wulf (2012) concluded that although distal external focus allowed for more accurate performances in this experiment, novices might perform better on complex tasks when given proximal external focus instructions. Experts might perform better with distal focus because it allows for automaticity of movements that he or she has already learned while novices may have more success with proximal instructions as they are more closely related to the goal of the complex movement (Wulf & Prinz, 2001).

Although many researchers have found that an external focus of attention is more beneficial for performance than internal focus of attention, some remain skeptical. Ziv, Meckel, Lidor, and Rostein (2012) argued that research on attentional focus and endurance activities have been inconsistent. These authors were interested in establishing results for attentional focus on the physiological responses of running without the aid of cues related to that task (Ziv et al., 2012). Previous studies by Mohler, Thompson, Creem-Regehr, Pick, and Warren (2007) as well as Prokop, Schubert, and Berger (1997) had only manipulated the visual speed of movement as a means to analyze attention focus on human gait.

Ziv and colleagues (2012) hypothesized that there would be no differences in the physiological responses to running between an external condition that did not give information on running speed and an internal focus condition that called attention to legs and running motion. These authors tested 17 male adolescent Israeli basketball players. A shuttle test was completed to estimate VO_2 max. Each player was also measured for heart rate reserve (HRR), height, weight, body composition, rating of perceived exertion, and predicted maximal heart rate. Players were then tested at a velocity that matched 60% of HRR for 30 minutes on a treadmill. These 30 minutes were broken up into 10 minute consecutive sessions of warm-up, internal focus condition, and external focus condition. The warm-up did not include attentional focus instructions. The experimental conditions were counter balanced. The internal condition cued athletes to focus on movement of running and moving the legs while the external condition instructed athletes to focus on a video of a basketball game or the offensive and defensive teams in the basketball video. Cues for both conditions were given via a compact disc recording. The authors found no significant difference between measurements taken between the experimental conditions. The authors then compared variables in experimental conditions to the warm-up and found statistically significant differences. The authors concluded that an external focus of attention without pertinent visual feedback does not cause changes in physiological responses or improve running economy when compared to the internal condition.

Research that more closely aligns with the plan for the current project was conducted by Zarghami et al. (2012) on University of Ahvaz students. Twenty males, who had learned to throw the discus in a university class, participated in the study. Zarghami et al. (2012) hypothesized that participants would throw further when instructed to use external focus of attention than with internal focus of attention. This hypothesis was based on the constrained action hypothesis.

In the experimental portion of the research, participants took five warm-up throws, five throws in the external condition and five throws in the internal condition. The external condition prompted participants to use maximal strength to throw the discus as far as possible while focusing on the discus and its landing location while the internal condition instructed participants to use maximal strength to throw the discus as far as possible while focusing on the wrist and hand. The experiment was spread over 3 consecutive days where the order of conditions changed for each participant. Analysis of performance in each condition revealed that the mean throw for the external focus condition was significantly further than that of the internal condition. These results align with previous research on motor performance and attention focus such as Wulf et al. (2001, 2002).

Research on jump and reach height conducted by Wulf et al. (2007) may have important implications for attention focus in jumping events. These researchers sought to identify whether or not an external focus would enhance performance over an internal focus or no focus condition. Wulf et al. (2007) extended the study by seeking to explain any differences found in the first experiment by making procedural adjustments. They hypothesized that an external focus of attention would enhance coordination by reducing unnecessary energy use in the motor system.

The first experiment involved 10 physically active university students. Each participant completed five jumps in each of the three conditions. The external condition had participants focusing on reaching the highest vanes possible on the Vertec jump measurement instrument, while the internal condition required participants to concentrate on their fingertips. The control condition provided no instructions for focus (Wulf et al., 2007). Results of the experiment revealed that participants reached significantly higher vanes when externally focused than in the internal or control condition. The internal condition neither increased nor decreased performance as compared to the control condition.

The second experiment involved 12 new participants and rotated the order of each condition to account for potential practice effects or fatigue. Wulf et al. (2007) calculated center of mass height for each participant in each jump. The researchers wanted to differentiate that higher jumps were caused by force production rather than a product of joint stretching in the air. Results revealed that center of mass for each participant reached higher heights in the external focus condition as compared to both the internal and control condition. Wulf et al. (2007) concluded that participants either increased force production or optimized coordination in the external condition which led to higher jumps. The authors also implied that a high jumper might increase performance by focusing on the bar instead of body mechanics while a pole vaulter might jump higher by focusing on bending the pole over focusing on body mechanics. The findings by Wulf et al. (2007) provide rationale for long jumping that focusing on the end of the sand pit may increase jump distance.

A follow-up study to that of Wulf et al. (2007) sought to solidify the reasons as to why participants in the external focus group for vertical jumping performed better than the internal focus group by mirroring the study with the addition of analyzing impulse and sagittal-plane joint moments. Wulf and Dufek (2009) found that participants in the external focus group exhibited greater displacement of center of mass, greater impulse measurements and higher joint moments than the internal focus group. Wulf and Dufek (2009) concluded that the higher jumps in the external focus condition were caused by greater force production which was specifically defined as greater impulses and joint moments at the ankle, knee, and hip joints. The findings identified that focus instructions directly affect the mechanical characteristics that athletes exert and allow for performance that is superior to what is typically achievable (Wulf & Dufek, 2009). It is unknown how broadly applicable these findings may be.

Finally, research on focus of attention and standing long jump provides the most insight on how verbal instructions manipulate performance and also how these findings can impact track and field athletes and coaches. One study conducted by Porter, Ostrowski et al. (2010) sought to expand on findings that an external focus of attention leads to enhanced performance over an internal focus of attention by using a non-object manipulation activity. One hundred and twenty undergraduate students were randomly assigned to either the internal focus condition or the external focus condition. Each person took a total of five standing long jumps with either the instructions to rapidly extend the knees while jumping (internal) or to jump as far past the start line as possible (external). Results of the experiment revealed that participants in the external focus group jumped significantly further than participants in the internal condition. It was also indicated that jumping ability is significantly manipulated by verbal instruction. Porter, Ostrowski et al. (2010) suggested that a practical application of this study would be for coaches to alter instructions to direct attention to specific cues such as a target in order to create an external focus of attention for the athlete.

These findings were also confirmed by Wu et al. (2012) who conducted a similar study. Undergraduate males and females performed a standing long jump task in which each participant completed both the internal and external focus conditions along with a baseline condition. Whereas the internal focus instructions remained the same as in Porter, Ostrowski et al. (2010), the external focus condition instructed participants to jump as close as possible to a target cone that was placed 4.57 m from the start line. Wu et al. (2012) did not find significant differences between peak forces at jump take-off between conditions, however the authors suggested that other variables such as projection angle could have caused the differences in performance between conditions.

Porter, Anton, and Wu et al. (2012) built upon the conclusions of both Porter, Ostrowski et al. (2010) and Wu et al. (2012) by manipulating the distance of the external focus cue during the standing long jump task. Undergraduate male participants completed the three conditions of control, external near, and external far. The external near condition instructed participants to jump as far past the start line as possible while the external far condition instructed participants to jump as close as possible to a cone that was placed 3 m in front of the start line. Results revealed that participants jumped significantly farther in the external far condition as compared to both the control and external near conditions. Porter, Anton and Wu et al. (2012) also discussed that the results from the control condition of this study indicate that when left to their own choices, athletes did not choose to utilize an external focus of attention.

Lastly, a culminating study of the previously mentioned standing long jump experiments was conducted by Porter, Anton, Wikoff, et al. (2012). Division I male athletes completed the four conditions of control, internal, external near, and external far.

The researchers placed the cone 3 m from the start line for the external far condition and again asked participants to rapidly extend the knees while jumping for the internal condition. Results confirmed that the external far condition allowed athletes to produce the farthest jumps; the authors discussed these findings in the context of track and field through previous research. A study conducted by Porter, Wu, and Partridge (2010) indicated that 84.6% of the athletes surveyed during a USA Outdoor Track and Field National Championship reported that their coaches instruct an internal focus of attention during practices. Furthermore, 69% of those same athletes used an internal focus of attention while competing. Those findings indicate an important gap between experimental research and real world application to sport.

Experimental research on attention focus has consistently shown that an external focus of attention allows for better performance. These findings correspond to the perception-action perspective and the constrained action hypothesis; they also indicate that the cues must be relevant to the task in order to enhance performance.

Delving into research has shed light on the possibility that the results for the current project might yield better performances when participants receive external cue instructions as compared to receiving internal cue instructions. The next step to be considered is to determine placement of a distal external cue for the long jumper. The study conducted by Wulf et al. (2007) used the external cue of reaching higher vanes on the Vertec jump instrument that could actually be reached by the participants, but only done so with increased force exertion or coordination. Research on standing long jump has utilized target cones placed 3 m and 4.57 m from the start line to enhance performance. Since the long jump cannot include an external cue that can be touched other than the sand, an appropriate visual and mental cue might be the end of the sand pit or a fixed point at the end of the sand pit above the ground. Those cues would be physically unattainable but could provide a safe and difficult target to propel toward. Furthermore, focus cues provided at the end of the sand pit are easily replicable points that coaches can implement in a training environment. The findings by Porter, Wu, et al. (2010) on the internal nature of instructions given by elite coaches also indicated that the current experiment may be validated by the fact that long jumping would be the manipulated task which would encourage coaches to change their instructions to an external focus because they may have real-world findings for their sport.

Long Jump

The primary purpose of this project was to examine the effect of distal external attention focus on long jumpers. As such, it was critical to understand the mechanisms in place during long jump in order to know where appropriate attentional cues may be placed. Many researchers have chosen to analyze the long jump with biomechanical methods. Bradshaw and Aisbett (2006) were interested in relating horizontal velocity before take-off to distance of the jump. Because previous investigators had not studied the effect of visual regulation on distance of jump, these authors sought not only to investigate visual regulation but also stride patterns, visual control strategies during the approach, and foot placement off the board. Finally, Bradshaw, and Aisbett (2006) examined stride adjustments before take-off in approaches where the athlete ran through the board as compared to the actual long jump approach.

Six athletes, 3 males and 3 females, participated in the study. All were Australian state standard long jumpers and 2 of the women were national level heptathletes. The experimental portion of the study involved three run-throughs, six long jumps and another six run-throughs by each jumper. A digital video camera operating at 50 Hz was used to obtain data. It was placed 6 m above the ground and 10 m from the runway and manually panned from the side to capture the entire approach for each trial. Two marker strips were placed along each side of the runway to enable calculation of distance between toe and take-off board (Bradshaw & Aisbett, 2006). Visual control was determined by the point at which stride pattern changed the most during the entire approach after which point the stride pattern normalized as the athlete neared the take-off board. Visual control indicates the onset of visual regulation of stride length so as to meet the target, in this case the board, accurately and with a smooth stride (Bradshaw & Sparrow, 2001).

Results indicated that there was a 0.1 s increase in the duration of the approach when the athlete visually regulated stride pattern so as to hit the board with accurate foot placement. This increase was associated with a 209 mm longer jump. Also, if visual control began 100 mm earlier in the approach, the jump was predicted to be 22 mm longer. During the acceleration of the run-up, stride length and speed were significantly longer and faster during the run-through than during the jump approach. Visual control onset started 1.01 s sooner during the approach than the run-through which was 3.59 strides farther from the take-off board. Visual regulation that started sooner in the approach led to fewer adjustments in each stride as compared to visually regulating in the last stride which caused major adjustments.

Bradshaw and Aisbett (2006) concluded that starting visual regulation earlier in the approach would be associated with a significantly longer jump. These authors suggested that coaches use this information to find supplementary exercises other than the run-through to help athletes start visual regulation sooner in the approach. The results of this research indicate that a narrow, distal external focus on the board during most of the approach may lead to a longer jump.

Jaitner, Mendoza, and Schöllhorn (2001) also analyzed long jump approach and take-off by breaking down final strides and body movements. These researchers used 57 trial jumps from 18 participants to gather time continuous data on the movement patterns of each flight and support phase for the final three strides. Support phase was identified as starting with the first ground contact of the foot at touchdown and ending with the last contact at take-off for the next stride. Flight phase signified the last contact at take-off to ground contact at landing for the next stride.

Results showed that there were noticeable structural differences in the second to last stride and support phase due to changes in swing leg and support leg. The movements of the swing leg and trunk position were primarily responsible for differences in movement patterns of the third to last stride and last stride. Jaitner et al. (2001) concluded that the swing leg and trunk play an important role in take-off preparation and flight phase of the last stride. Results of this study can be related to the current project because it has been shown that upright trunk position is responsible for appropriate take-off position. Considering Bradshaw and Aisbett's (2006) findings as well, an external focus cue must not be too low or too high because it could negatively alter trunk position at take-off. Thus, visual regulation of the board may not be the most beneficial cue.

Research by Muraki et al. (2005) went deeper into the biomechanics of the take-off phase by analyzing the functions of the take-off leg as a support mechanism. The goal of the study was to make suggestions for improving take-off technique. Eleven male long jumpers participated in this study and were videotaped so that the researchers could determine horizontal and vertical velocities as well as center of mass characteristics. A force platform captured support leg forces. More specifically, Muraki et al. (2005) analyzed radial displacement (e.g., change in distance between center of mass and rotation axis of the support leg at touchdown), change of radial length of center of mass relative to the board at touchdown, spring force of the support leg (e.g., convert downward motion of center of mass to an upward motion at take-off), and damper force of the support leg (e.g., the body absorbs some of the spring force in order to complete the take-off movement). Variables were calculated based on models and equations that used ground reaction force.

Results of this study showed that horizontal velocity of center of mass decreased while vertical velocity increased during take-off. Radial velocity of the center of mass increased during take-off as it passed over the support leg. Spring force occurred for up to 75% of the take-off phase while the damper force only appeared on impact of the support leg to the board.

Muraki et al. (2005) concluded that touch-down of the last step consisted of an immediate and large impact force as well as negative radial displacement and velocity. These patterns indicated that large spring and damper forces occurred during impact. These patterns also showed that the take-off leg is a support mechanism for long jump that is characterized by large and fast radial displacement and large impact forces shortly after touch-down. The authors concluded that the jumper should enhance stiffness of take-off leg to resist impact force and support the body. The jumper should also extend the knee joint more at touchdown and exert a large spring force to resist impact and prevent excessive knee flexion (Muraki et al., 2005). The authors concluded that jumpers need increased stiffness in the take-off leg which is attributable to spring force at touch-down and that an external cue that could help athletes stiffen the take-off leg in the current project may propel the athlete further into the pit.

Bridgett and Linthorne (2006) also studied take-off factors along with approach speed. Previous research by Alexander (1990) and Seyfarth, Blickhan, and Van Leeuwen (2000) had predicted that both a fast run-up and knee angle of the support leg at take-off between 60° and 65° would result in the best model for a jump. To test these hypotheses, Bridgett and Linthorne (2006) used one male long jumper with a personal best performance of 8.30 m. The experiment involved trial jumps with his normal approach and interventions reducing various strides from the approach to reduce speed at take-off.

Results showed that the athlete jumped further as run-up speed increased. These findings coincide with previous research. Increased speed during the run-up led to increased speed at take-off and a greater magnitude of horizontal speed during the jumping action. For this athlete, take-off angle decreased steadily with increasing run-up speed. Leg angle to horizontal decreased in range with maximal run-up speed. This athlete straightened the knee joint at touchdown with increasing run-up speed. A stiffer leg during take-off allowed for the center of mass to pivot over the take-off foot which caused increased vertical speed and a longer jump. This finding coincides with that of Muraki et al. (2005) and identifies the importance of maximal speed during the approach to optimize biomechanical positioning.

Bridgett and Linthorne (2006) concluded that performance in long jump is mostly determined by the athlete's run-up speed. This study showed that knee angle at touchdown increases with increasing run-up speed. The long jumper should approach the board with the most speed that he or she is able to maintain. The plant of the take-off leg should be at 61° to horizontal with minimum knee flexion to achieve the greatest jump distance (Bridgett & Linthorne, 2006). The results of this study support the importance of instructing athletes in the current project to use a maximal effort down the runway and while jumping in order to achieve the farthest jumps. Although take-off angle may lessen with increased take-off velocity, overall jump distance will be best when maximal velocity is attained by take-off.

Research by Linthorne et al. (2005) sought to find the optimum take-off angle for a long jumper by assessing a free-flight equation, long jump related variables, and video of 3 male long jumpers. Previous research by Hay, Miller, and Cantera (1986) indicated that flight distance accounts for 90% of official distance while the take-off and landing only account for 5% each of the official distance. Linthorne et al., (2005) assumed that previous research also indicated that the take-off angle that maximizes the flight distance should be the same that maximizes official distance.

The optimum take-off angle was calculated by combining an equation for the flight distance of a body in free flight with the jumper’s specific combination of take-off speed, take-off angle, and relative take-off height. Optimum take-off angle was observed for each jumper by using competition performances and training sessions with no intervention. Two interventions took place where the jumper was instructed to jump at low, high or very high angles using whatever approach length and speed he felt appropriate for the task. Low angle jumps were achieved by long and fast strides and higher angles were achieved by shorter and slower run-ups. Ariel Performance Analysis System video images were used to capture take-off angles.

Linthorne et al. (2005) began analysis of the optimal take-off angle for long jumpers with 45°, the angle that produces the furthest distance for a projectile released at ground level with constant speed. Results of the experiment revealed that for long jumping, the speed an athlete can produce reduces the angle to between 22° and 27°. Take-off height decreases with an increasing take-off angle due to knee flexion, reducing the angle of center or mass at take-off to 21.3° or 25.5°. At take-off, the jumper's center of mass is in front of the take-off line which decreases optimum take-off angle to 21.1° or 25.3°. Landing distance decreases with increasing take-off angle which again reduces optimum take-off to 21° or 25.2°. All modifications to optimum take-off angle for athletes were based on approach speed.

Linthorne et al. (2005) concluded that if a jumper is to obtain a distance within 5 cm of maximum achievable distance, the take-off angle must be within 1° of optimum take-off angle while also maintaining velocity. Also, it is more important to obtain a high speed at take-off because variations in speed cause more loss in distance than take-off angle. The authors recognized that the method of determining the optimum take-off angle is not likely to become a common practice used by coaches or biomechanists (Linthorne et al., 2005).

Linthorne et al. (2005) has important because the significance of speed gained during the approach is prevalent. In order for jumpers to perform at a maximal effort, he or she must reach take-off with the most speed possible. An appropriate instruction along with focusing on a distal external target could also be to reach it with maximal effort. Furthermore, because take-off angle is affected by take-off height, center of mass position at take-off and landing distance, visual external focus on a fixed point during the approach and flight may allow the jumper to appropriately alter mechanics so as to exhibit a more optimal take-off angle and thus overall jump.

Finally, angular momentum at take-off and center or mass position at landing was studied by Bouchouras, Moscha, Papaiakovou, Nikodelis, and Kollias (2009). The purpose of the research was to compare the hang style jump to the 2 ½ hitch kick style jump on flight distance. Bouchouras et al. (2009) hypothesized that the hitch kick would create greater angular momentum at take-off and thus would allow for better landing efficiency. This better landing would be achieved by the heels landing closer to the theoretical point of landing of the center of mass and with the pelvis closer to the heels which would inhibit a backward fall.

Twelve male long jumpers who had jumped beyond 6 m were chosen for this study. Six athletes used the hang style and 6 used the hitch kick. Three cameras were used to record take-off and landing. Results indicated that the horizontal and vertical velocities of the center of mass at take-off did not differ between jumping styles. When breaking down the horizontal and vertical velocities of extremities during take-off, however, the hitch kick had significantly higher horizontal velocity in the back arm and higher vertical velocity in the front arm and front thigh. Higher angular velocities at take-off for the hitch kick were also observed in the back arm, front shin, and front foot (Bouchouras et al., 2009). Both groups of athletes landed behind the theoretical point where center of mass should optimally land, though the hitch kick group showed greater angular momentum. During the landing phase, the hitch kick group landed with the pelvis in front of the heels. Hang style group participants landed with the pelvis slightly behind the heels which shortened the final distance of the jump. In conclusion, the hitch kick group had higher velocities in the arms and front leg at take-off which led to greater angular momentum. The hitch kick group also had greater landing efficiency.

The biomechanical breakdown of long jump conducted by researchers provides significant information on what athletes should accomplish in order to complete the best jump possible. Bouchouras et al. (2009) showed evidence that the hitch kick is the best jumping style to use while Bridgett and Linthorne (2006), Linthorne et al. (2005), and Muraki et al. (2005) showed the importance of speed during the approach to the overall jump. Results found by Linthorne et al. (2005) may also indicate the importance of an external focus point during the approach to achieving optimal take-off angle and thus furthest possible jump. Results by Bridgett and Linthorne (2006) as well as Muraki et al. (2005) also indicated that a stiff take-off leg is critical to an optimal jump distance. Straightened leg angle has been shown to be manipulated by maximal effort through the entire approach. Jaitner et al. (2001) proved the importance of trunk and swing leg position in the final strides of the approach while Bradshaw and Aisbett (2006) conveyed the importance of early visual regulation in the approach to minimize major stride adjustments near take-off. Overall, it appears that an appropriately placed external focus target paired with external instructions may allow athletes to position themselves for an optimal jump distance.

Quiet Eye

Results on visual regulation in long jump found by Bradshaw and Aisbett (2006) bring forth the need to analyze eye movements more closely. Some researchers interested in sport and attention have investigated a measure of visual regulation now called the quiet eye (Vickers, 1996). Quiet eye is defined as the length of time spent fixating on a final target point before executing the technical movements to complete a task (Vine & Wilson, 2010). Vickers (1996) has suggested that a longer duration of quiet eye allows for organization of the neural structures necessary for the task and helps minimize distractions.

Research in this area has been solely concerned with aiming tasks such as basketball, billiards, golf putting, virtual archery, and air pistol shooting. Studies by Vine and Wilson (2010), Harle and Vickers (2001), Williams, Singer, and Frehlich (2002), Lee, Kim, and Park (2009), and Behan and Wilson (2008) have revealed that longer quiet eye durations led to more accurate performances. Inaccurate performances were characterized by shorter quiet eye durations. Furthermore, Williams et al. (2002) and Behan and Wilson (2008) indicated that quiet eye should be incorporated into pre-performance routines.

Quiet eye research is important to attention focus and long jumping because it may be beneficial to use in conjunction with research by Shafizadeh et al. (2011) which suggests that incorporating action planning and environmental perception allows for enhanced performance on a task.

Summary

The event of long jump in track and field is different and important to study because the athlete's performance cannot be manipulated by a competitor. Exploring the attentional focus of long jumpers allows for direct analysis into how those processes effect outcome. Attention focus has been shown to be particularly important to consider as a performance factor for such athletes because there are many stimuli present throughout the entire performance. Whether the long jumper should focus predominantly on internal cues or external cues is in question.

Studies on attention focus have shown that external focus allows for better performances when compared to an internal focus. Furthermore, research by McKay and Wulf (2012) has shown that a distal external focus yields better performance results for those who are experienced in the task. A distal external focus allows for automaticity of movements. Research conducted by Wulf et al. (2007) conveyed that an external focus allowed for biomechanical coordination or increased force exertion which increased performance on the task. Further analysis by Wulf and Dufek (2009) revealed that this increased force exertion caused increased impulse and joint moments. This research, along with findings on standing long jump, has shed light on the fact that a distal external focus such as the end of the sand pit may help athletes jump farther.

Biomechanical breakdowns of long jump performances have yielded the importance of maximum speed, a stiff take-off leg and proper trunk and swing leg position to reaching the optimal distance. Most importantly, Linthorne et al. (2005) discovered an optimum take-off angle range between 21° and 25.2° that is primarily affected by approach speed. Furthermore, Bradshaw and Aisbett (2006) indicated that attending to an environmental object during the approach allowed for a smoother approach and better jump.

Consequently, instructing participants to focus on a low distal target in one condition versus a high distal target in a different condition, may create differences in horizontal velocity at take-off, vertical velocity at take-off, take-off angle, approach velocity, and overall jump distance. Results of this project should be applicable for track and field athletes and coaches because it would be the first to manipulate attention during the event of long jump.

Chapter 3

METHODS

The purpose of this project was to analyze the effect of a high distal target (HDT) and low distal target (LDT) focus of attention on long jump performance. Long jump performance was assessed through take-off angle, horizontal velocity at take-off, vertical velocity at take-off, approach velocity, and true distance. This author hypothesized that a HDT would lead to faster velocities, steeper take-off angles and, ultimately, farther jumps as compared to a LDT or no intervention. This chapter describes the methodology of the project by defining participants, procedures, measurements, and statistical analysis.

Participants

Participants were experienced in long jump performance and were 18 years of age or older. Experience was defined as at least one year of participation in the event at the college or high school level. Although males and females were recruited from two Northeastern colleges, only females from one college consented to participate. Long jumpers were contacted by word-of-mouth and e-mails sent to the head coach of each college.

Athletes were also selected based on current school clearance to compete in athletics. Athletes were not selected if deemed inexperienced, injured or otherwise unable to participate as indicated by an athletic trainer or coach.

Procedures

Overview

Athletes read and completed a consent form approved by the Ithaca College Human Subjects Review Board (Appendix A). After providing informed consent and explanation of the procedures, all athletes completed a demographic questionnaire (Appendix B). Athletes also signed up to be in groups of 6 that would complete a 4 day testing schedule. This schedule involved four conditions: Control 1, Treatment 1 (LDT), Treatment 2 (HDT), and Control 2 that were separated by a minimum of 48 hours. All conditions took place indoors in the Athletics and Events Center at Ithaca College.

Demographics and Pretest Performance Data

Participants answered a demographic questionnaire for height, weight, age, gender, race/ethnicity, years of experience, year in school, name of school, and clearance to participate. Height and weight were those recorded from the most recent doctor's appointment or athletic training clearance physical evaluation.

Pretest performance data were gathered online through the Track & Field Results Reporting System (TFRRS; http://www.tfrrs.org/). Athletes' best jump of their career was recorded for comparison to performance in the current project.

Control 1

On day 1 of testing, each group was informed that the purpose of the session was to take three maximal effort jumps with a full approach. Each group of 6 was instructed to warm-up by jogging four laps followed by eight dynamic exercises. This warm-up was consistent with their actual performance warm-up routine. Athletes were also instructed to complete two run-throughs, two pop-ups, and one practice jump. A reflective marker was then placed on the right iliac crest so that velocity and take-off angle data could be measured. A Smartspeed™ timing system (Fusion Sport, Australia) was set up along the runway to measure approach velocity. The first gate was placed 12 m from the board and the second was placed 2 m from the board to capture 10 m of approach not affected by take-off preparation.

Next, groups were informed that they were to jump in the order announced by the researchers. The researchers called the athlete who was up, on deck, and on hold to simulate a meet situation. Athletes were instructed to jump as far as possible and also told that the camera would capture take-off regardless of take-off placement relative to the board. Athletes were allowed to step over the board for this experiment and were not told the distance of any jump. Each jump was measured and the pit was raked after each jump. Once the three jumps were complete, an attention focus questionnaire was provided to be filled out on site (Appendix C). This questionnaire asked athletes to record thoughts and focus points during jump 1, jump 2, and jump 3. Participants were then instructed that the session was finished and that a four lap cool down may begin.

Treatments 1 and 2

Treatment conditions were balanced over subject groups and across days. Treatment 1 operated similarly to Control 1 except participants attended to the LDT placed 10.96 m from the take-off board at the end of the sand pit. This LDT was a 1 m orange cylinder. Participants were instructed to visually and mentally focus attention on the target just before beginning the approach and to use a maximal effort to reach the target. Once three jumps were completed, athletes were instructed to once again complete the attention-focus questionnaire. Then they were informed that the session was complete and they may complete a four lap cool down.

LDT placement was based on findings by Wulf et al. (2007). In that study, participants either focused on their finger tips or the vanes of a Vertec jump instrument while performing a jump-and-reach task. The vanes served as the external focus condition and were also tangible objects for the participants. Because it was neither realistic nor safe to have a long jumper touch a cue during performance, it was hypothesized that placing a cue out of range but seemingly attainable could positively affect take-off angle resulting in a further jump.

Treatment 2 required that participants attended to the same 1 m orange cylinder that was instead placed 5.22 m above the end of the sand pit at 10.96 m from the take-off board. The target was fixed at this height using long poles. Each participant was instructed to visually and mentally focus attention on the HDT just before beginning the approach and to use a maximal effort to reach the target. Once three jumps were completed, athletes were instructed to once again complete the attention-focus questionnaire. Then they were informed that the session was complete and they may complete a four lap cool down.

The HDT was placed as such based on findings by Linthorne et al. (2005) concerning optimal take-off angle. Because it was found that the best angle for the center of mass at take-off ranges between 21° and 25.2°, it was hypothesized that placing an attentional cue at a height to allow for that angle range to be created by the center of mass would result in a further jump. The HDT height was based on the average of the range of degrees, 23.1°, and also the average height of center of mass for men and woman, 0.55 cm. Attending to an object placed up high could cause a more upright trunk at take-off which could also lead to faster horizontal and vertical velocities caused by appropriate knee extension and stiffness. Figure 1 depicts the set-up for the HDT and LDT.

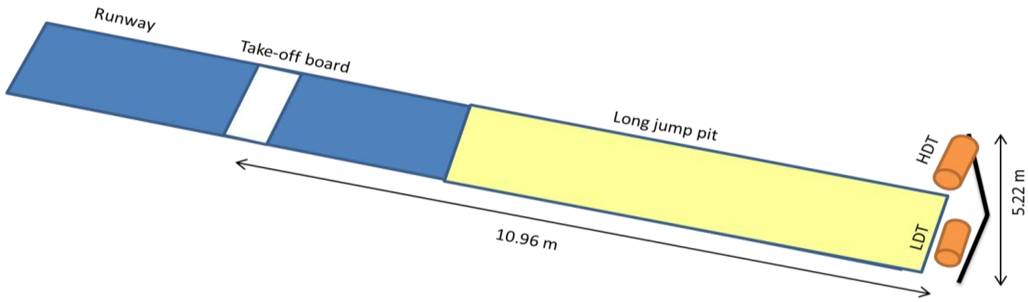

Figure 1. HDT and LDT set-up.

Control 2

Control 2 operated identically to Control 1. Participants were instructed to use a maximal effort to jump as far as possible. No targets were present. Athletes again completed the attention focus questionnaire. Once all four sessions were completed participants were informed that the study was complete and that they may refer to the informed consent document for contact information of the researcher should they have any questions.

Measurements: Questionnaire Data

Participants were asked to complete an attention-focus questionnaire at the completion of each day of the project (Appendix C). Athletes were asked to answer what they thought about and focused on during jump 1, jump 2, and jump 3. The data were qualitatively analyzed to serve as a possible explanation for performance differences between conditions, as well as to check adherence to the instructions to focus on the HDT or LDT.

Measurements: Jump Performance Data

Jump performance data were collected from jump distance from the board, timing gates, and video analysis of each jump. The distance of each jump from the board was measured with a standard measuring tape and poker used for NCAA regulation meets. Researchers recorded each jump distance and gathered approach velocity from the Smartspeed™ timing system.

Each jump in each condition was captured with a Fujinon digital camera operating at 200 frames per second with a 3.8 - 13 lens. It was placed to obtain a sagittal view 6 m away from the board and 1 m high. The video camera was operated from a laptop and video was collected live with Stream View LR 1.4.1 software. A 1 m steel tape used for calibration was marked on the runway next to the board in view of the video camera. The video camera was set to record 1.5 s prior to stopping to capture take-off.

After completion of all days of data collection, video clips of each jump were uploaded into the MaxTRAQ (Innovision Systems, Inc., MI) software program for analysis. Horizontal velocity at take-off, vertical velocity at take-off, take-off angle, and true distance were measured for each jump. The steel tape was used as a scale factor.

True distance was calculated by using the horizontal calipers in MaxTRAQ. One caliper was placed at the toe of the athlete's foot at take-off and the other was placed at the end of the board. True distance measurements were gathered by adding or subtracting the distance between the athlete's foot and the board at take-off to the jump distance recorded during the conditions.

Horizontal velocity at take-off and vertical velocity at take-off were calculated using the central difference method. The marker on the iliac crest was tracked through five frames before and after take-off. Take-off was defined as the first frame in which the foot left the runway due to jumping. The X and Y coordinates of these 11 frames were then exported into an Excel document. X coordinates defined horizontal motion while Y coordinates defined vertical motion. Velocity was then calculated for each coordinate using the following equation, $v(\text{frame}) = [v(\text{frame} + 1) - v(\text{frame} - 1)] / t$, where t is the time between the two frames (0.01 sec). Figure 2 depicts the calibration of the aforementioned measurements.

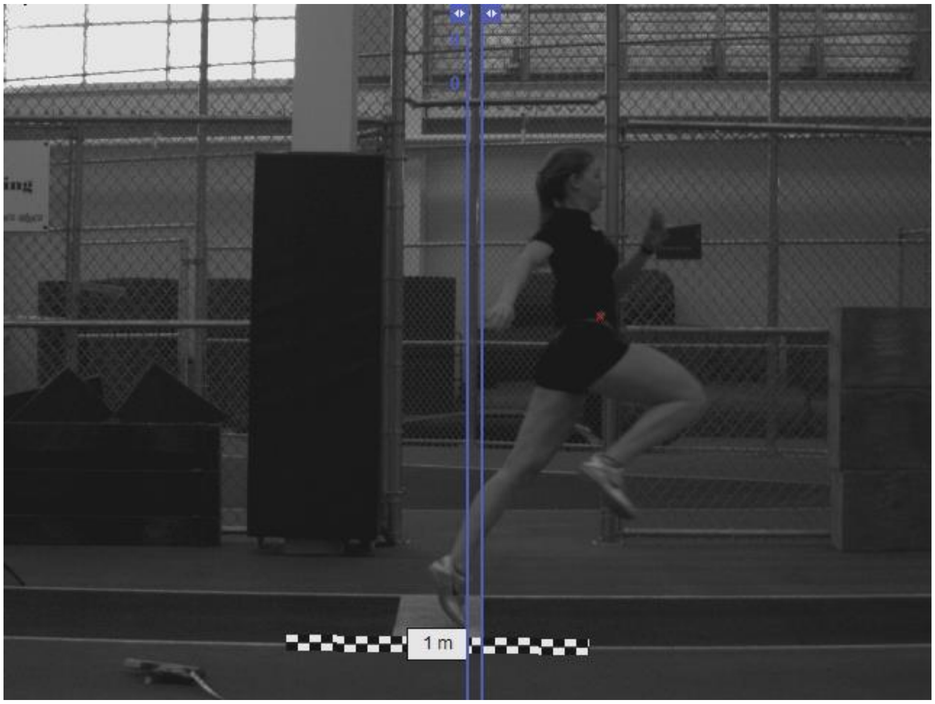

Figure 2. Measurement calibration for jump distance and velocity.

The sixth frame in the sequence was marked as the frame of take-off for each participant. Take-off angle was calculated by taking the arctangent of the vertical velocity divided by the horizontal velocity. Specifically, take-off angle was calculated using the following formula: $\theta = \tan^{-1} (v_y / v_x)$, where θ = take-off angle, v_y = vertical velocity at take-off, and v_x = horizontal velocity at take-off. Figure 3 depicts all variables measured in the project.

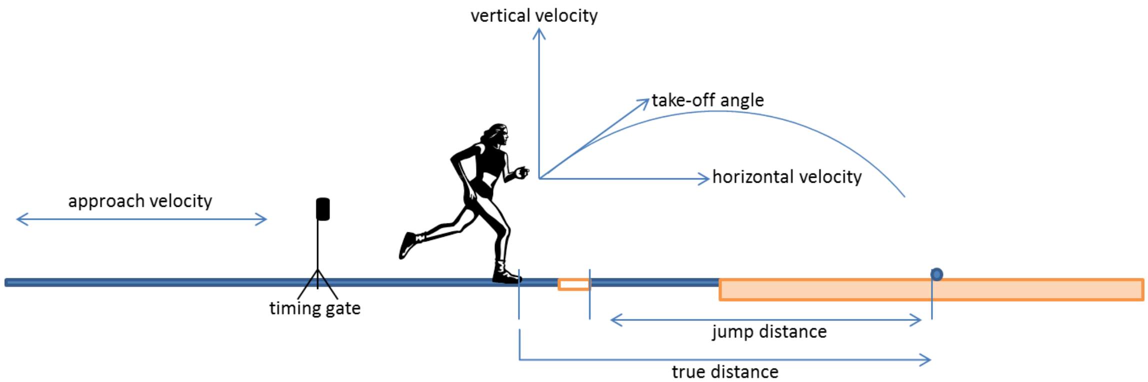

Figure 3. Project independent variables.

Statistical Analysis

A 4 x 3 condition by trial repeated measures ANOVA was completed for all jump performance data: vertical velocity at take-off, horizontal velocity at take-off, take-off angle, approach velocity, and true distance. The four conditions were Control 1, Treatment 1 (LDT), Treatment 2 (HDT), and Control 2. The three trials were jump 1, jump 2, and jump 3.

The single farthest jump for participants regardless of condition was compared to best results found on TFRRS with descriptive statistics. The difference between the jumps from each condition served as a reference point for the effectiveness of the conditions for each athlete. The alpha level was set a $p \leq 0.05$ for all statistical analyses. Data were further analyzed using each participant's best jump under each condition with a one-way repeated measures ANOVA. The best jump in each condition was determined by jump distance. Finally, a frequency measurement was conducted to show how many athletes improved in long jump performance by each measurement variable. Only conditions that showed a significant main effect were analyzed.

Chapter 4

RESULTS

The purpose of this project was to analyze the effect of focusing on a HDT and LDT on long jump performance. Attention focus was assessed through questionnaires. Long jump performance was assessed through take-off angle, horizontal velocity at take-off, vertical velocity at take-off, approach velocity, and true distance. It was hypothesized that a HDT would lead to faster velocities, steeper take-off angles and, ultimately, further jumps as compared to a LDT or no intervention. This chapter reports the results of the project.

Important considerations of the project should be noted as a preface to the report of results. First, athletes did not jump further than their best performances recorded on TFFRS. This outcome was likely due to the timing of the project. Participants completed the conditions at the beginning on the indoor track and field season when they were not in peak physical shape. This could have had an influence on jump performance data. Also, athletes completed the conditions in groups with their own teammates. This factor may have influenced sense of competition and thus long jump performance.

Demographics and Pretest Performance Data

Twelve female jumpers from Ithaca College volunteered to participate in the study. All participants met the requirements of having at least 1 year of experience in the long jump as well as medical clearance to participate in sport. Before sessions began however, 2 athletes became injured and dropped out of the study. Demographic data gathered from these athletes were not entered or analyzed for this project. As a result, 10 athletes completed the study; 6 in testing group 1 and four in testing group 2.

Athletes were between the ages of 18 and 21 (*M* = 19.20 years, *SD* = 0.92) and had between 1 to 3 years of experience long jumping (*M* = 1.70 years, *SD* = 0.68). These women had an average height of 165.0 cm (*SD* = 7.1) and average mass of 58.1 kg (*SD* = 3.4). The majority of athletes described themselves as Caucasian (*N* = 8) while one indicated both Caucasian and African American, and one did not answer. Half of the participants identified as sophomore (*N* = 5) while four identified as freshman and one as junior. Best jump distances of these athletes ranged between 4.19 m and 5.42 m (*M* = 4.80 m, *SD* = 0.42).

Jump Performance Analysis

The Smartspeed™ timing system did not record approach velocity for 3 of the participants in Group 2 during Control 2. Take-off velocities were missed for 7 participants during various trials of the project. Twenty-three true distance marks, 24 vertical velocities at take-off, 24 horizontal velocities at take-off, and 24 take-off angles were missing from a total of 600 possible measurements. These issues accounted for 16% of data loss. Every participant had all measurements recorded for at least one jump in all conditions. Statistical analysis was adjusted by gathering an overall average value for jumps by condition and measurement variable as well as the average of the top values available for each participant by condition and variable. One-way repeated measures ANOVAs were used to analyze each measurement variable by these new values.

True Distance Variables

The single maximum jump distance of the project, single minimum jump distance of the project, and average of all jumps are compared to values for best competition performances from TFFRS in Table 1. Table 2 depicts the descriptive statistics of the true distance variables while Table 3 shows the repeated measures ANOVA results. The maximum true distance variable showed a significant main effect across conditions. Post-hoc contrasts identified that Control 2 jumps were significantly longer (mean improvement of 16 cm) than HDT jumps. The proportion of variability attributable to jump distance for the maximum true distance variable is considered large (effect size; $\eta_p^2 = 0.26$). The mean for Control 1 was 6 cm farther than HDT and the mean for LDT matched the HDT but with more variability.

Table 1

Overall True Distances and Best Performances

	N	Max	Min	M	SD
Overall True Distance (m)	10	5.14	3.70	4.57	0.29
Best Performance Distance (m)	10	5.42	4.19	4.80	0.42

Table 2

Descriptive Statistics of True Distance Variables

	Control 1 M ± SD	Treatment 1 (LDT) M ± SD	Treatment 2 (HDT) M ± SD	Control 2 M ± SD	Main Effect *p*-value
Maximum True Distance (m)	4.64 ± 0.20	4.58 ± 0.30	4.58 ± 0.27	4.74 ± 0.30	0.04*
Average True Distance (m)	4.61± 0.21	4.51± 0.30	4.50 ± 0.28	4.64 ± 0.27	0.07

N = 10

* $p \leq 0.05$

Table 3

Repeated Measures ANOVA of True Distance Variables

Source	SS	df	MS	F	*p*	Effect Size
Maximum True Distance (m)						
Condition	0.17	3.00	0.06	3.10	0.04*	0.26
Error	0.49	27.00	0.02			
Average True Distance (m)						
Condition	0.14	3.00	0.05	2.62	0.07	0.23
Error	0.49	27.00	0.02			

N = 10

* p ≤ 0.05

The average true distance variable approached a significant main effect. The proportion of variability attributable to jump distance for the average true distance variable is also considered large (effect size; $\eta_p^2 = 0.23$).

Velocity Variables

Approach velocities were obtained from the Smartspeed™ timing system. The repeated measures ANOVA did not reveal a main effect. Table 4 displays descriptive statistics for the approach velocity variables while Table 5 shows the repeated measure ANOVA results for the approach velocity variables.

No main effects were observed for horizontal velocity at take-off or vertical velocity at take-off variables. Average horizontal velocity values failed Mauchly's test of sphericity thus Greenhouse-Geisser adjustment values were used. Table 6 displays the descriptive statistics for horizontal and vertical velocity variables while Table 7 portrays the repeated measure ANOVA values for the horizontal and vertical velocity variables.

Table 4

Descriptive Statistics for Approach Velocity Variables

	Control 1 M ± SD	Treatment 1 (LDT) M ± SD	Treatment 2 (HDT) M ± SD	Control 2 M ± SD	Main Effect *p*-value
Maximum Approach Velocity (m/s)	7.41 ± 0.25	7.28 ± 0.34	7.35 ± 0.23	7.47 ± 0.34	0.23
Average Approach Velocity (m/s)	7.31 ± 0.28	7.21 ± 0.34	7.25 ± 0.23	7.33 ± 0.29	0.46

N = 10

* p ≤ 0.05

Table 5

Repeated Measures ANOVA for Approach Velocity Variables

Source	SS	df	MS	F	*p*	Effect Size
Maximum Approach Velocity (m/s)						
Condition	0.19	3.00	0.06	1.51	0.23	0.14
Error	1.10	27.00	0.04			
Average Approach Velocity (m/s)						
Condition	0.09	3.00	0.03	0.89	0.46	0.09
Error	0.91	27.00	0.03			

N = 10

* p ≤ 0.05

Table 6

Descriptive Statistics for Horizontal and Vertical Velocity Variables

	Control 1 M ± SD	Treatment 1 (LDT) M ± SD	Treatment 2 (HDT) M ± SD	Control 2 M ± SD	Main Effect *p*-value
Maximum Horizontal Velocity (m/s)	7.26 ± 0.42	7.21 ± 0.69	6.89 ± 0.85	7.23 ± 0.75	0.20
Average Horizontal Velocity (m/s)	6.76 ± 0.46	6.83 ± 0.76	6.48 ± 0.56	6.89 ± 0.65	0.18†
Maximum Vertical Velocity (m/s)	2.58 ± 0.67	2.35 ± 0.60	2.08 ± 0.73	2.26 ± 0.47	0.18
Average Vertical Velocity (m/s)	2.17 ± 0.50	2.10 ± 0.61	1.84 ± 0.65	1.98 ± 0.52	0.48

N = 10

† Greenhouse-Geisser adjusted *p*-value

* p ≤ 0.05

Table 7

Repeated Measures ANOVA for Horizontal and Vertical Velocity Variables

Source	SS	df	MS	F	*p*	Effect Size
Maximum Horizontal Velocity (m/s)						
Condition	0.94	3.00	0.31	1.66	0.20	0.16
Error	5.08	27.00	0.19			
Average Horizontal Velocity (m/s)						
Condition	1.00†	1.79†	0.56†	1.92†	0.18†	0.18†
Error	4.68†	16.08†	0.29†			
Maximum Vertical Velocity (m/s)						
Condition	1.30	3.00	0.43	1.75	0.18	0.16
Error	6.67	27.00	0.25			
Average Vertical Velocity (m/s)						
Condition	0.60	3.00	0.20	0.84	0.48	0.09
Error	6.44	27.00	0.24			

N = 10

† Greenhouse-Geisser adjusted values

* p ≤ 0.05

Take-Off Angle Variables

Repeated measures ANOVA showed that there were no main effects between conditions for any take-off angle variables. Mauchly's test of sphericity was violated for the average take-off angle variable, thus the Greenhouse-Geisser adjusted *p*-values were used. Table 8 displays the descriptive statistics for the take-off angle variables while Table 9 reports the repeated measures ANOVA for the take-off angle variables.

Table 8

Descriptive Statistics for Take-Off Angle Variables

	Control 1 M ± SD	Treatment 1 (LDT) M ± SD	Treatment 2 (HDT) M ± SD	Control 2 M ± SD	Main Effect *p*-value
Maximum Take-Off Angle (degrees)	21.28 ± 7.04	19.20 ± 4.45	18.35 ± 6.23	18.38 ± 4.32	0.43
Average Take-Off Angle (degrees)	17.81 ± 4.32	17.08 ± 4.26	15.93 ± 5.75	16.10 ± 4.54	0.56†

N = 10
† Greenhouse-Geisser adjusted *p*-value
* $p \leq 0.05$

Table 9

Repeated Measures ANOVA for Take-Off Angle Variables

Source	SS	df	MS	F	p	Effect Size
Maximum Take-Off Angle (degrees)						
Condition	56.63	3.00	18.88	0.94	0.43	0.10
Error	540.90	27.00	20.03			
Average Take-Off Angle (degrees)						
Condition	23.19†	1.62†	14.32†	0.53†	0.56†	0.06†
Error	394.79†	14.57†	27.09†			

N = 10
† Greenhouse-Geisser adjusted *p*-value
* $p \leq 0.05$

Frequency of Performance Improvement

Table 10 depicts the frequency of how many long jumps (across subjects and trials) were improved in each measurement variable between Treatment 2 (HDT) and Control 2. Improvement was determined using a minimum improvement criteria for each measurement variable. This criteria was determined roughly from the standard deviations observed from each measurement variable in all conditions of the experiment. A positive difference from Treatment 2 (HDT) to Control 2 that was equal to or greater than the minimum criteria must have been present in order for the performance to be considered an improvement. Only positive improvements from Treatment 2 (HDT) to Control 2 were considered.

Table 10

Frequency of Performance Improvement from Treatment 2 (HDT) to Control 2 by Measurement Variable

	Minimum Improvement Between HDT and Control 2	Frequency of Improvement
Maximum True Distance (m)	0.1 m	5
Average True Distance (m)	0.1 m	5
Maximum Approach Velocity (m/s)	0.2 m/s	4
Average Approach Velocity (m/s)	0.2 m/s	3
Maximum Vertical Velocity (m/s)	0.4 m/s	2
Average Vertical Velocity (m/s)	0.4 m/s	3
Maximum Horizontal Velocity (m/s)	0.3 m/s	5
Average Horizontal Velocity (m/s)	0.3 m/s	4
Maximum Take-off Angle	3°	3
Average Take-off Angle	3°	2

N = 10

Questionnaire Analysis

Qualitative data were gathered for this project by way of attention-focus questionnaire presented to each participant after the completion of each condition. Athletes were asked to report what they focused on during each jump and what they thought about during each jump. Analysis by conditions revealed five categories of responses; narrow-internal focus of attention, broad-internal focus of attention, narrow-external focus of attention, looking down, and looking up.

A narrow-internal focus of attention was characterized by phrases such as “thought about knee drive and arm extension” and “foot under me, chest up,” while a broad-internal focus of attention identified responses such as “I thought about jumping far.” A narrow-external response was characterized by expressions such as “trying to reach the orange target.” Participant’s responses were categorized as looking down for statements such as “I looked at the sand” and “I looked at the orange tube at the end of the pit,” while responses were categorized as looking up for statements such as “I looked up at the target at the beginning” and “I looked up toward the stairs.”

The participants responded that they looked up during the jumps in Control 1 more than looking down. Narrow-internal focus of attention was almost equivalent to broad-internal focus of attention for Control 1. Looking down and a narrow-internal focus of attention were the most frequent responses for the LDT while looking up and narrow-external focus of attention were the most frequent answers for the HDT. Control 2 was characterized by a high frequency of looking up responses and a near equivalent distribution between a narrow-internal focus of attention and a broad-internal focus of attention. Table 11 displays the frequency table of self-reported responses to the direction of attention focus. Data are the number of times the subjects reported focusing attention in a particular direction. Some responses referenced more than one direction of attention.

Table 11

Frequency of Self-reported Direction of Attention Focus

	Control 1	Treatment 1 (LDT)	Treatment 2 (HDT)	Control 2
Narrow-Internal Focus of Attention	16	14	8	13
Broad-Internal Focus of Attention	14	13	9	16
Narrow-External Focus of Attention	1	7	15	0
Looking Down	12	28	7	9
Looking Up	21	6	27	23

N=10

Summary

The purpose of this project was to analyze the effect of focusing on a HDT and LDT on long jump performance. Attention focus was assessed through questionnaires. Long jump performance was assessed through take-off angle, horizontal velocity at take-off, vertical velocity at take-off, approach velocity, and true distance.

Qualitative analysis of responses to the attention focus questionnaire indicated that participants looked up more frequently than down in Control 2 and were nearly equivalent in narrow or broad-internal focus of attention in that condition. Athletes also looked up more frequently than down in Control 1 and were nearly equivalent in responses categorized as narrow-internal and broad-internal focus of attention.

A narrow-internal focus of attention was almost exclusively reported in the treatment conditions. Jump performance analysis showed that for the 10 participants who completed the project, there was a significant difference in maximum jump distance between HDT and Control 2. Five participants exhibited a significant improvement in maximum true distance and average true distance from HDT to Control 2. Results were not significant between conditions for any other variables.

Chapter 5

DISCUSSION

The purpose of this project was to analyze the effect of a HDT and LDT focus of attention on long jump performance. Attention focus was assessed through a questionnaire. Long jump performance was assessed through take-off angle, horizontal velocity at take-off, vertical velocity at take-off, approach velocity, and true distance. It was hypothesized that a HDT would lead to faster velocities, steeper take-off angles and, ultimately, farther jumps as compared to a LDT or no intervention. Results of the project did not support the hypothesis. Athletes did not jump further in the HDT treatment probably due to the effect of methodological procedures on long jump technique. The attention-focus questionnaire shed more light on why the hypothesis was rejected.

Treatments 1 and 2

The current project utilized the LDT and HDT to manipulate attention focus for long jumpers. The placement of these targets was based on previous research such as Wulf et al. (2001) who manipulated attention while participants balanced on a stabilometer. The major finding of that study was that the constrained-action hypothesis was validated. Participants who focused externally while on the stabilometer were able to react to audio stimuli quicker and balance more efficiently than those who focused internally. The motor system was less inhibited in the external-focus condition.

The current project utilized the constrained-action hypothesis to rationalize the use of distal external targets. It was speculated that attention to the LDT and HDT while on the runway and while jumping would place less constraint on the motor system and allow athletes to jump further. Better jumps would be produced from faster approach velocities and optimal take-off angles. Faster approach velocities were the determining factor for further jumps in studies by Bridgett and Linthorne (2006), Linthorne et al. (2005), and Muraki et al. (2005). The optimal take-off angle range for the current project was based from findings by Linthorne et al. (2005).

The constrained-action hypothesis was not specifically tested in the current project, but there was, nonetheless, equivocal circumstantial evidence to either support it or refute it. Athletes actually jumped shorter maximum true distances during the LDT (*M* = 4.58 m) and HDT (*M* = 4.58 m) compared to the control conditions. These shorter distances were also accompanied by the slowest horizontal velocities at take-off, vertical velocities at take-off, and shallowest take-off angles. The biomechanical demands of long jump require full attention to the motor system, instructing participants to focus elsewhere took away from the automaticity of long jumping. This strategy may have led to all measurement variables being less optimal (albeit non-significantly in some cases) in the conditions with directed instructions to focus externally. Conversely, when left to their own choice of a focus of attention, the athletes' tended to adopt a distal external focus and jump farther. Thus, it is not possible to pinpoint how or if a specific external focus constrained the motor system.

The LDT and HDT placement were rationalized from research conducted by Wulf et al. (2007) who used a vertical jump and reach task. This task required participants to jump and reach the highest vanes possible on a Vertec instrument. The external focus condition instructed participants to touch the highest vanes possible. This condition inspired the LDT placement for the current project. The LDT was placed 10.96 m from the take-off board at the end of the sand pit in order to simulate the attainable target used by Wulf et al. (2007) while also remaining safe for long jumpers and realistic to a competition environment.

The HDT was placed 10.96 m beyond the take-off board and 5.22 m above the ground based on the analysis of the Wulf et al. (2007) study by Wulf and Dufek (2009). Wulf and Dufek (2009) found that higher vertical jumps in the external focus condition were caused by greater force production as a result of greater impulses and joint moments. It was rationalized that the placement of the HDT would be out of reach, yet if athletes did attempt to reach it, they would successfully alter approach velocities and take-off angles causing further jumps. Trying to reach the HDT would create the same benefits as reaching for higher vanes as seen in Wulf et al. (2007). The HDT was specifically placed 5.22 m above the sand pit to help athletes attain a 23.1° take-off angle for center of mass. 23.1° is the average of the optimal range determined by Linthorne et al. (2005).

Despite the rationale for having precisely placed external targets, the jump performances were not enhanced and the study hypotheses were rejected. One reason for this lack of effect may have been because the LDT and HDT were novel. The targets were an addition to the long jump environment making it difficult for athletes to focus on and try to reach them. This situation differs from Wulf et al. (2007) who used a distal target that was also the measurement apparatus.

Athletes in the current project had not previously been instructed to look at this type of LDT or HDT while jumping. Coaches oftentimes ask athletes to pick a high object to look at while jumping during practices and competitions, but these targets are self-selected, natural parts of the environment. Many times these objects were a distant window or a tree line. Jumpers' poor performance in the LDT treatment was perhaps because the placement of the target was novel and counterintuitive to coaching instructions. Athletes jumped poorly and had slow take-off velocities in the HDT treatment perhaps because the placement was higher and closer than typical practice and competition experiences. Participants may have felt that they could not actually try to reach the target. Doing so seemingly caused a negative alteration in jumping mechanics and attention. Focusing on specific targets while jumping did not enhance performance because the task might have been too novel for athletes to comprehend and utilize. This strategy differs from the vertical leap task in which the target had a direct relation to the task.

Specific external focus instructions for long jumpers was assessed and adapted for the current project based on research of standing long jump. Porter, Ostrowski, et al. (2010) found that college students jumped farther when given the external instruction to jump as far past the starting line as possible compared to the internal instruction to rapidly extend the knees while jumping. These researchers concluded that not only did instruction manipulate jumping performance, but they also suggested that a practical application of this study would be for coaches to alter instructions to direct attention to specific cues such as a target in order to create an external focus of attention for the athlete.

The current project directly used the conclusion drawn by Porter, Ostrowski, et al. (2010). During the LDT and HDT treatments, long jumpers were instructed to visually and mentally focus on the target while on the runway but before beginning the approach and to use a maximal effort to reach the target. These external focus instructions were postulated to effectively manipulate attention to cause farther true distances.

The instructional application suggested by Porter, Ostrowski, et al. (2010) did not lead to longer jumps in the present study. Participants for Porter, Ostrowski, et al. (2010) may have jumped farther in the external condition because those instructions were paired with a less physically and cognitively demanding skill. The present study paired distal external focus instructions with a complex and multi-faceted event. External focus instructions were novel and too difficult to comprehend and include to the demands of long jumping

Wu et al. (2012) also conducted a standing long jump study. Athletes jumped farther when instructed to jump as close to a target cone as possible as compared to being instructed to rapidly extend the knees while jumping. Although there were no significant differences in force production between the two conditions, Wu et al. (2012) concluded that projection angle caused the further standing long jumps in the external condition. The current research was based on the same rationale that the HDT would cause athletes to produce take-off angles within the range described by Linthorne et al. (2005) as compared to the LDT or no instruction to focus on and reach a target.

Results of the current project do not support Wu et al. (2012). Long jumpers did not jump further when instructed to try to reach the target cone. The maximum take-off angle range and average take-off angle range in the HDT treatment were the lowest of the project (M = 18.35°; M = 15.93°). Standing long jumpers in the Wu et al. (2012) study may have been able to jump farther in the external condition because those simple instructions were paired with a simple task. In the current study, novel instructions were paired with a complex task that led to poorer performance compared to control.

Control 1 and 2

The control conditions were meant to serve as baselines for the treatment conditions. No distal targets were provided. No attention focus instructions were given, athletes were only asked to use a maximal effort to jump as far as possible. It was hypothesized that athletes would not jump as far in these conditions as compared to the treatment conditions or at least the HDT.

Contradictory to the project hypothesis, athletes performed best during the control conditions. Even if some of these differences were not statistically significant, they matter in terms of performance in competition and are worth noting. Control 1 produced the second farthest maximum true distances of the project (M = 4.64 m) along with the highest maximum horizontal velocity at take-off, maximum vertical velocity at take-off, average vertical velocity at take-off, maximum take-off angle that feel into the optimal range (M = 21.28°), and steepest average take-off angle.

These results are partially supported by Bridgett and Linthorne (2006) who found that for their subject, increased speed during the approach led to decreased take-off angle. Athletes who jumped for the current study achieved the steepest take-off angles in Control 1 but not their fastest approach velocities. Bridgett and Linthorne (2006) also found that increased run-up speed led to increased take-off speed and greater horizontal speed while jumping. The current project produced contradictory results. Athletes had their highest maximum horizontal velocities at take-off during Control 1 but their fastest maximum approach velocities during Control 2. However, the athletes in the current project were not at the elite status of the subject used by Bridgett and Linthorne (2006).

Results of Control 2 did align with a conclusion drawn by Bridgett and Linthorne (2006). A main finding was that longer jumps were mostly determined by approach speed. Control 2 of the present study produced significantly farther maximum true distances than HDT that were also accompanied by the fastest maximum approach velocities. Frequency of improvement from HDT to Control 2 confirmed that half of the participants increased jump distance in Control 2 and four had faster maximum approach velocities. These results support notion that a significant variable for longer jumps is approach velocity.

Control 1 and Control 2 may have produced better long jump performances for the same methodological reasons Treatment 1 (LDT) and Treatment 2 (HDT) were unsuccessful. Although the constrained-action hypothesis was validated by Wulf et al. (2001) and McNevin et al. (2003), the external targets used in the treatment conditions for long jumpers interfered with the functionality of the motor system. Athletes in the current project had faster approaches, faster take-off velocities, steeper take-off angles, and further true distances when they were not instructed to focus on a distal external target. Because athletes were not asked to place their attention away from long jumping, they could attend to the task without restraining the motor system.

The control conditions did not involve novel targets. The treatment conditions instructed athletes to focus on targets that were new to the environment. The control conditions had no targets which let athletes look at objects that were familiar to the long jumping facility and perhaps in better alignment with their natural line of sight. Similarly to Wulf et al. (2007) who used an external focus cue that was the Vertec vane and consequently the purpose of the task, athletes in this study chose to focus on cues they were comfortable and familiar with during the control conditions.

Finally, the instructions provided during the control conditions were simple and typical for the athletes. Participants were not asked to do anything novel which allowed them to focus on jumping far. Farther jumps occurred with simple instructions. Porter, Ostrowski et al. (2010) and Wu et al. (2012) used simple instructions for the task of standing long jump, the current project was only successful when minimal instructions were implemented for the complex task of long jumping.

Attention Focus Questionnaire

The attention focus-questionnaire used in the current project was based on previous attention focus literature. Attention focus can be broken down into narrow-external, narrow-internal, broad-internal, and broad-external. Narrow-external indicates focusing on few environmental cues outside of the body while narrow-internal signifies focusing on few factors inside the body. Broad-internal identifies focusing on many factors inside the body while broad-external refers to focusing on many characteristics in the environment outside of the body (Nideffer, 1976).

A broad spectrum of studies has been conducted on the effects of attention focus and physical tasks, providing strong support that a narrow-external focus of attention is the most beneficial for enhancing motor skill performance. Confirming where attention is actually placed during these motor skill tasks has largely been checked by questionnaire after the performance. In a like manner, the current study manipulated attention focus on long jumpers and checked the precise direction of the attention focus by questionnaire after a series of three jumps.

Results of the attention focus questionnaire shed important light on what athletes focused on while jumping. Although a narrow-external focus of attention has been shown to improve performance for numerous physical tasks, the present study showed that reports of narrow-external focus almost exclusively occurred during the least successful conditions of LDT (N = 7) and HDT (N = 15). The more successful control conditions were accompanied by the most numerous reports of broad-internal focus of attention (Control 1, N = 14; Control 2, N = 16) and a high number of reports of narrow-internal focus of attention (Control 1, N = 16; Control 2 = 13). These results are similar to Porter, Anton, and Wu (2012) who found that during their standing long jump experiment, athletes did not focus externally without being instructed to do so.

Current results also relate to the notion that novel target placement and instructions may inhibit the motor system while simple instructions allowed athletes to focus on their body movements while long jumping. Attention focus questionnaire results show that a narrow-external focus of attention did not occur with further jumps. An internal focus of attention may be necessary for long jumpers due to physical and cognitive demands of a complex skill requiring multiple phases (approach run, take-off, in-air actions, landing) and consequently, multiple changes of attention focus. Also, the experience level of as little as 1 year of jumping for the current participants may have had an effect on their ability to visually and mentally attend elsewhere.

The attention focus questionnaire also provided critical information on precisely where athletes looked while jumping. As expected, the majority of athletes looked down for LDT (N = 28) and looked up for HDT (N = 27), confirming the effects of the instructions for these conditions. Of interest, participants also looked up more frequently than down during Control 1 (N = 21) and Control 2 (N = 23). These results coincide with the notion that the lack of external focus instructions and targets in the control conditions allowed athletes to focus on familiar cues. More specifically, these familiar cues that participants looked at were permanent environmental objects such as the top of the stairs, the exit sign, balcony, bleachers, doors, or windows.

The fact that athletes chose to look up on their own may indicate that external focus instructions and targets does not help athletes improve performance over a short time period. Allowing athletes to focus internally and then look up on their own occurred alongside faster velocities, steeper take-off angles, and further jumps. Using a HDT in practice sessions may produce different results if used over a longer time span and may be used in practice to encourage athletes to look up while jumping. Coaches might use instructions to encourage athletes to search for their own optimal attentional targets.

Summary

The purpose of this project was to analyze the effect of a HDT and LDT focus of attention on long jump performance. It was hypothesized that a HDT would lead to faster velocities, steeper take-off angles and, ultimately, farther jumps as compared to a LDT or no intervention. Results of the project did not support the hypothesis; however attention focus questionnaire results showed that farther jumps were accompanied by looking up.

Many studies have been done on the effects attention focus has on physical tasks. This research spans from manipulating attention while balancing on a stabilometer (Wulf et al. 2001) to vertical leap (Wulf & Dufek, 2009; Wulf et al., 2007) and standing long jump (Porter, Anton, Wikoff, et al., 2012; Porter, Anton & Wu, 2012; Porter, Ostrowski, et al., 2010; Wu et al., 2012).

These studies helped shape the procedures and hypothesis for the current project by overwhelmingly finding that a distal external focus of attention led to enhanced performance on the given task. Results of the present study did not support the outcome of previous research. The event of long jump is complex which may have caused the novel external focus instructions, targets, and target placements to have negative performance effects. Having no target and simple instructions during the control conditions placed less constraint on attention and actions leading to significantly farther true distances compared to treatment conditions. More specifically, the significantly farther jumps observed in Control 2 were accompanied by reports of looking up. Although a HDT and external focus instructions may not lead to farther jumps, looking up and farther jumps occurred together when specific instructions and targets were not present.

Finally, it should be noted that although most measurement variables were not significant, the fact that there were any differences in values between conditions is worthy for the event of long jump. The only measured variable during competition is jump distance. Millimeters can make the difference between how athletes are ranked at the conclusion of the event. This minimal difference could mean gold versus silver in championship meets. The current study did find some differences in jump distance as an effect of condition which bodes significance in the track and field community for athletes and coaches.

Chapter 6

SUMMARY, CONCLUSIONS, RECCOMENDATIONS

Summary

The purpose of the present study aimed to analyze the manipulation of distal external attention focus on long jumpers by way of HDT and LDT use during treatment conditions. Another purpose of this study was to bridge the gap between attention focus research and long jump research by determining the effect of distal external focus on long jump performance.

Ample research on attention focus has shown that a narrow-external focus enhances performance of physical tasks. Attention focus has been manipulated during a wide range of activities from balancing on a stabilometer (McNevin et al., 2003; Wulf et al., 2001), to vertical jump and reach (Wulf and Dufek, 2009; Wulf et al., 2007), to standing long jump (Porter, Anton, Wikoff, et al. 2012; Porter, Anton & Wu, 2012; Porter, Ostrowski, et al., 2010; Wu et al., 2012).

Research on long jumping has confirmed that approach speed is a determining factor to optimal jump distance (Bridgett & Linthorne, 2006; Linthorne et al., 2005; Muraki et al., 2005). The optimal take-off angle has also been determined to fall between 21° and 25.2° (Linthorne et al., 2005). Although there is a lack of research on manipulation of attention focus on long jumping, literature from both areas were combined in the present study to rationalize an experimental methodology. Athletes completed 4 conditions: Control 1, Treatment 1 (LDT), Treatment 2 (HDT), and Control 2. Three jumps were taken for each condition. Jumps were measured by approach velocity, vertical velocity at take-off, horizontal velocity at take-off, take-off angle, and true distance. Participants completed an attention focus questionnaire at the completion of each condition. It was hypothesized that a HDT would lead to faster velocities, steeper take-off angles and, ultimately, farther jumps as compared to a LDT or no intervention.

Results of the project did not support the hypothesis. Athletes did not jump further in the HDT treatment. Specifically, participants observed their slowest approach velocities, take-off velocities, shallowest take-off angles, and shortest true distance during LDT and HDT. Maximum true distance was significantly farther in Control 2 as compared to HDT. Five athletes significantly improved in true distance from HDT to Control 2. No other measurement variables were significant.

Conclusions

The attention focus instructions of the current project did not allow athletes to long jump farther in the HDT treatment. More specifically, the constrained action hypothesis that has been shown through stabilometer tasks by Wulf et al. (2001) and McNevin et al. (2003) did not appear to be associated with external focus and long jumping. The event of long jump appears too complex and multifaceted for performance benefits to be attained when attention is fixated to a distal external target, at least with this group of jumpers and without extensive practice time.

Project procedures were also rationalized from Wulf et al. (2007), Wulf and Dufek (2009), and Linthorne et al. (2005) for LDT placement at 10.96 m beyond the take-off board and HDT placement 10.96 m beyond the board and 5.22 m above the sand pit. Target placements were novel additions to the environment that may have been too difficult for athletes to use as a benefit to long jumping. The HDT was higher than athletes had been used to looking at in previous practice and competition situations while the LDT placement was counterintuitive to previous instructions by coaches under normal circumstances. Athletes jumped significantly farther in Control 2 and showed better measurement variables in Control 1, perhaps because they chose to focus internally and where also free to switch attention to look up at familiar objects in the facility that were more aligned with the natural line of sight.

Treatment condition instructions were based on conclusions drawn by Porter, Ostrowski et al. (2010) and Wu et al. (2012) who identified that focusing on a distal target could enhance standing long jump performance. Instructions to focus on the LDT and HDT in the current project were likely too novel for athletes to incorporate into the focus necessary to complete the task of long jumping. Reports of narrow-external focus of attention almost exclusively occurred in the LDT and HDT treatments while participants reported high frequencies of narrow and broad internal focus of attention during Control 1 and Control 2. These results point to the notion that long jump may be too complex for athletes to benefit from focusing externally with no previous training.

Finally, it should be noted that athletes consistently jumped shorter distances compared to their best competition performances. This finding was a result of the timing of the study occurring during the beginning of the indoor track and field season although most personal best performances occurred toward the end of the indoor or outdoor season. Also, athletes completed each condition in groups with their own teammates, this factor may have led to alterations in competitiveness.

Recommendations

Findings from the current project have led to potentially important recommendations for coaches and athletes. Although the HDT did not cause athletes to jump further than the LDT or control conditions, the attention focus questionnaire validated the significance of looking up to achieving longer jumps. It should be noted that a HDT may not produce enhanced performance. A greater emphasis should be made on attaining maximal approach speed.

Projects stemming from this study should consider procedural conditions such as: a) a larger and more representative sample size; b) a HDT that better coincides with where athletes might naturally look while long jumping; c) a lower HDT in a more familiar location to enhance performance; and d) a training period involving more sessions with external targets. These procedural changes could allow for researchers to study a learning effect among athletes. More sessions could also reduce the novelty of a LDT and HDT.

Finally, any future research on attention focus on long jumping is recommended so as to expand the literature in this area. Other studies could help bridge the gap between attention focus and long jump research and also confirm or contradict results from the current project. Future studies could also provide more evidence-based information for appropriate focus cues and instructions that coaches and athletes can use in the real world.

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APPENDIX A

Informed Consent Form

Attention Focus and Long Jumping

Purpose of the Study
You are being asked to participate in a research study investigating the effects of attention focus on long jumping. The purpose is to see if focusing on a low target or a high target while jumping enhances jump distance.

Benefits of the Study
The benefits of this study center on one issue, does focusing on a high distal target or low distal target improve performance in the long jump? Answering this question may result in better training programs for athletes, better understanding of appropriate instructions provided by coaches to athletes, and evidence of the effect of attention focus on the event of long jump.

There are no direct or immediate benefits to you while participating in this study. It may, however, give you insight into how attentional cues affect long jump performance.

Exclusion Criteria
To participate you must have no obvious physical or mental impairments that would prevent you from doing the long jump. You must also have been cleared to participate in sport by a college athletic director and have participated in the event for at least one year.

What You Will Be Asked To Do
You will first be given a questionnaire to fill out about demographics. It should take about 5 minutes to complete. Then you will sign up to be in a long jump group that will contain no more than 6 participants.

On day 1 of testing we will go over the general procedure of the session. The researcher for this session will ask you and your group members to complete a general warm-up of jogging four laps and completing 8 dynamic exercises and then a long jump warm up consisting of 2 run-throughs, 2 pop-ups and 1 practice jump. After warm-up the researcher will help you place a white circular marker on your hipbone and announce the jumping order for the session. You will be instructed to take 3 maximal effort long jumps in the manner that you normally compete. All jumps will be recorded by a video camera operated from a laptop by the researcher. You are allowed to foul in this study. Every jump you complete will be measured and an assistant will rake the pit thereafter. You will not be told the distance of your jumps. Once you and your group have completed 3 jumps you will then complete a brief attentional focus questionnaire. This should take about 2 minutes to complete. Once the questionnaire is complete and returned to the researcher you will be instructed to follow your team cool down. The session will then be complete.

On day 2, after at least 48 hours, you will perform similarly to Day 1. You will again follow the general warm-up. Once that is complete, depending on your group, you will either be asked to focus on a low target or a high target. You will then be asked to complete 2 run-throughs, 2 pop-ups and 1 practice jump while focusing on the target. The researcher will then help you attach the marker to your iliac crest. Then the researcher will announce the jumping order. Before each jump, the researcher will instruct you to attend to the target and try to reach it. All jumps will be videotaped, measured and raked from the pit. Once the group has completed 3 jumps you will again complete the brief attentional focus questionnaire, return it to the researcher and complete your regular team cool down. The session will then be complete.

On day 3, which will take place at least 48 hours after Day 2, you will perform similarly to Day 2. The only difference is that you will be instructed to reach the target that you were not asked to reach on Day 2. If you were instructed to reach the low target on Day 2, you will be instructed to reach the high target on Day 3 and vice versa.

On day 4, which will take place at least 48 hours after Day 3, you will perform exactly as you did on Day 1. Once Day 4 is complete, you will be finished with the study.

Risks

The physical risks of this study are minimal. Though the physical effort is maximal during jumps, the health risks are small. Because you are an athlete, these sessions are no more rigorous than your normal practices or competitions. As with any physical effort, however, there are risks of muscle strains, joint injury, and cardiovascular failure. The primary researcher is certified to perform CPR and first aid and will use prudence and communication with the subject to determine if outside care is necessary. A cell phone will be on hand at all times to contact Campus Safety if the need arises. An emergency plan will be practiced with the research assistant. If you choose to remove yourself from the study all information and data that has been gathered from you will not be used within the study.

Compensation for Injury

If you suffer an injury that requires any treatment or hospitalization as a direct result of this study, the cost for such care will be charged to you. If you have insurance, you may bill your insurance company. You will be responsible to pay all costs not covered by your insurance. Ithaca College will not pay for any care, lost wages, or provide other financial compensation.

If You Would like More Information about the Study

Please contact the primary investigator, Jacquelyn Mendes, to receive more information at any time about this study or to get an abstract of the results. She can be reached at (207) 205-0210 or jmendes1@ithaca.edu.

Withdrawal from the Study

Participation is completely voluntary and you may stop participation or withdraw from the study at any point in time without any questions being asked. Refusal to participate or a decision to discontinue participation during the study will not result in penalty or loss of benefits to which you are otherwise entitled. You are free to refuse to answer any questions you feel uncomfortable answering. If you wish to withdraw please inform the experimenters.

Confidentiality of the Data

All data acquired during the study will be kept confidential. All hard data will be kept in a locked cabinet or office file when not in use. Computer data will only refer to a participants' numerical codes. Only the investigators will have access to the data. Data may be used educational or scholarly publications and presentations, but you will be not be identified by name or any other identifying comments. If we use images that may identify you, we will get your permission.

Participant's Statement

I have read the above and I understand its contents. I have had an opportunity to ask questions and those questions were answered to my satisfaction. My signature below indicates my consent to participate in the study described to me. I acknowledge that I am 18 years of age or older. I have received a copy of this consent form for my own records.

____

Print Name (Participant)

____ _________________

Signature (Participant) Date

Image Release Consent

I give my consent to be videotaped and photographed and to allow that tape or image to be used in a scientific or educational presentation or publication as long as the image remains anonymous.

____ _________________

Signature (Participant) Date

APPENDIX B

Demographic Questionnaire

Attention Focus and Long Jumping

Please complete the following information:

Age: ________

Gender: M F

Race (choose all that apply): Caucasian African American Asian Hispanic
Other: __________

College: Ithaca College Cornell University

Year: Freshman Sophomore Junior Senior 5th year Graduate Student

Height: _____ft _____inches (as last recorded by your doctor or athletic trainer)

Weight: ______lbs (as last recorded by your doctor or athletic trainer)

Have you participated in the long jump for at least one year? Yes No

Have you been cleared for sports by your college athletic trainer? Yes No

APPENDIX C

Attention Focus Questionnaire

Attention Focus and Long Jump

What did you look at during jump 1? What did you think about during jump 1?

What did you look at during jump 2? What did you think about during jump 2?

What did you look at during jump 3? What did you think about during jump 3?