January 2017

A Comparison Of Starting Techniques Out Of An Athletic Stance Position

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A COMPARISON OF STARTING TECHNIQUES OUT OF AN ATHLETIC STANCE POSITION

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Bachelor of Science, University of North Dakota, 2004

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota

May
2017

This thesis, submitted by Aaron Schwenzfeier in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Grant McGimpsey
Dean of the School of Graduate Studies

Date

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Title	A Comparison of Starting Techniques Out of an Athletic Stance Position
Department	Kinesiology
Degree	Master of Science

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Aaron Schwenzfeier
April 27, 2017

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ACKNOWLEDGMENTS

I wish to express my sincere appreciation to the members of my advisory Committee for their guidance and support during my time in the master's program at the University of North Dakota.

ABSTRACT

The purpose of this study was to compare the false step (FS) to the straight out step (SOS) out of a parallel athletic stance (PAS) in Division I college athletes. 30 Division I college athletes from football, baseball, softball, and volleyball performed three repetitions each of the FS and SOS. Each trial was timed at 5 and 10 yards using the TC Brower Timing System as well filmed from two vantage points for kinematic data collection using the Ariel Performance Analysis System (APAS). From this, the velocity of the center of mass (VCM), projection angle of the center of mass (PCM), and acceleration (A) was calculated. Results showed greater VCM and A for the FS compared to the SOS. The PCM was in the upwards direction for the FS, while the PCM for the SOS was downward. The results from this study suggest that the FS is superior in terms of increasing the velocity of the center of mass and acceleration, while projecting the center of mass in a direction that allows for better velocity and acceleration.

INTRODUCTION

The ability to accelerate is of major importance and a primary skill in many ground based sports (Lockie, 2011). The ability to accelerate as fast as possible is of paramount importance in many sports and the split-second differences between acceleration times can mean vast differences in competitive success (Duthie 2006). There has been much debate regarding the best technique for acceleration out of different stances, and much has centered around acceleration out of starting blocks for short sprints in track and field. Very little research has been done in the area of acceleration in team sports in which competitive play occurs in a chaotic environment (Cronin, 2005).

Biomechanics

Starting stance is critical for acceleration and in team sports a proper stance must be assumed to prepare and be able to adjust to the random movements that may and do occur in competitive play (Brown, 2014). Often times the best stance for being ready for movement in any possible direction is that of an athletic stance (Figure 1., Figure 2.), in which the feet are in parallel and the athlete is in a quarter to half squat position with the center of mass positioned over the mid foot (Brown, 2014).

Figure 1. Parallel Athletic Stance position sagittal plane.

Figure 2. Parallel Athletic Stance position frontal plane.

This proper athletic position allows the athlete the ability to see action, interpret what is happening, and react quickly to accelerate in the necessary direction. In order for an athlete to accelerate in any given direction, the athlete must reposition their center of mass from within their body (in the athletic stance position) to outside their body as quickly as possible in the direction of which one chooses to accelerate (Whiting, 2006). This acceleration out of an athletic stance can occur in a number of different sports such as a short stop having to accelerate forward on short ground ball, a basketball player on defense attempting to steal a ball, a tennis player reacting to a drop shot over the net, a back row volleyball player sprinting ahead to get to a ball, or a linebacker reading a run and coming up to make a tackle in football (Burkett 2010).

In the athletic stance, there is one of two ways to initiate forward movement: a rotation of the body around the ankle and foot to displace the center of mass forward or repositioning one foot behind the body; false-step (Cronin, 2007). The starting movement is an area of debate among coaches regarding acceleration, and many advocate against the utilization of the so-called "false step", in which the athlete repositions one foot backwards behind the body in order to apply force into the ground to accelerate forward. Many coaches believe this stepping backwards does not project the center of mass forward and slows acceleration of the center of mass over a given distance.

Intuitively, this "false" step might seem counterproductive, however if the time taken to adjust one foot backwards does not exceed the time taken to reposition one's center of mass forward then the false step may potentially enhance one's acceleration equally, or possibly more, effectively.

Subconscious Decision Making

The other question regarding the use of the false step is that of reaction time to a given stimulus. It has often been noted among coaches that they have spent a great amount of time teaching athletes to not false step, but once the athlete is placed in a chaotic environment, the athlete “reverts” back to using a false step technique to quickly accelerate forward out of an athletic position. This has led to the questioning of the conscious effort to control this possible impulse to not false step in a closed-skill environment, to a subconscious overriding in an open-skilled environment in which the athlete reacts in the fastest manner they subconsciously know how.

Research has shown that activity in the brains motor region can be detected 300 milliseconds prior to the person feeling he/she has decided to move. As Benjamin Libet pointed out in his experiments done in the 1980’s (Libet, 1985):

> *“The finding that the volitional process is initiated unconsciously leads to the question: Is there then any role for conscious will in the performance of a voluntary act?”*

This presses the question regarding subconscious decisions vs. conscious ones and research in the field of neuroscience is showing a delay in the time between the subconscious and conscious (Dennett, 1992). Does utilizing one accelerating technique favor certain neurological processes over the other, and if so which one?

Additionally, in the forward model of motor control, it’s stated that often the consciousness is alerted to movements/behaviors that are already being planned and performed, and isn’t necessarily ‘causing’ these behaviors/movements (Miall, 1996). Does this potentially affect the different methods if one requires more conscious control?

To date, there is no evidence that not taking a false step out of a parallel athletic stance is faster than utilizing the false step (Brown 2004; Cronin, 2007; Cusik 2014; Frost, 2008; Johnson 2010; Kraan, 2001). There is, however, many anecdotes to this phenomenon of stepping backwards upon the stimulus to accelerate forward accompanied with coaches attempting to correct this so-called error in starting technique. Personally, as an athlete, I've been instructed against the method of using the false step and more recently, engaged in a couple different discussions with coaches who are strong proponents for not false stepping. I've also heard and read discussions amongst coaches either for or against the technique of false-stepping. Coaches feel that any step backwards (false step) is wasted movement.

Dynamical Systems Theory

Another factor to be considered in this on-going debate of the best movement technique for acceleration out of an athletic stance is the time to 'learn' the skill of not stepping back upon the movement initiation. If the false step is a subconscious process and has the potential to decrease one's reaction and acceleration time, might it be a better decision to allow this process of the body's self-organization to take place, versus attempting to override this innate ability through hours of repeated practice in semi-controlled environments, whereas the skill tested in a very chaotic one? This process of self-organization that is inherent to many physical, chemical, biological, social and cognitive systems, falls under the category of chaos theory or dynamical systems theory (Kelso, 1995). In this specific case of acceleration technique, we take a look at the skill through the dynamic systems approach to motor learning (Davids, 2008). This dynamic systems approach asserts that movement patterns arise from the self-organization of the body through the influence of biomechanical and environmental factors, along with specific task constraints (Kelso, 1995; Kelso, 2000). Particular skills may emerge when an individual can control particular degrees of freedom within a movement task (Kelso, 2000). In terms of the "false step", individuals are allowed the degrees of freedom to perform an acceleration task while allowing the brain to self-organize the movement, leading to a possibly faster cognitive, decision, and reaction time because one is utilizing an inherent process of the human brain. A dynamic systems approach to movement potential gives strong favor to increased movement success in an athletic environment (Araujo, 2006), in this case of accelerating out of an athletic position; utilizing the inherent properties that are currently there (and faster) rather than attempting to 'override' this inherent nature.

Purpose

The purpose of this study was to determine if there were significant differences in sprint start kinematics between the false step and the straight out step from a parallel athletic stance. The goal of the research is to identify the optimal starting technique to help coaches of sport to improve the quality of their coaching instruction with regards to utilizing optimal starting technique out of an athletic stance.

Hypothesis

It is the author's hypothesis that utilization of the false step will result in a faster five and ten meter acceleration time than not taking a step back (straight out step) upon initiation of movement. It is also hypothesized that the false step will result in a forward repositioning of the center of mass. The author also hypothesizes that there will be greater velocity at first and second toe off with the false step as compared to the first and second toe off with the straight out step. Acceleration is also hypothesized to be greater at first and second toe off with the false step than the straight out step. Both velocity and acceleration of the false step are supported by the current literature to be greater than the straight out step with regards to starting technique out of a parallel stance (Cronin, 2007, Cusik, 2014, Frost, 2008, Kraan 2001, Johnson, 2010). While the kinematics of center of mass has not been examined with regards to the false step, it is hypothesized that there will be no significant difference between the false step and straight out step.

REVIEW OF LITERATURE

In 2001, Kraan et al (Kraan 2001), looked at force in the forward direction, begin time, and impulse time of three different starting stances: parallel with a step backwards (false step), parallel with no step backwards, and a position of one foot in front of the other (staggered). 95% of the non-instructed trials of the ten participants involved the false step. The false step was found to have significantly higher force in the forward direction, significantly faster begin time, and significantly lower impulse time than both other stances. The push-off force was highest in starting type (a) where the participants started in front of a force platform starting on their own initiative, which had the shortest time to build up the push-off force. The results indicate a positive contribution to the force and power from a step backwards, that resulted in significantly greater horizontal force and power production at push off via a contribution from the stretch-shortening cycle (SSC).

Cronin et al. (Cronin, 2007) found the parallel start (athletic position) with an initial forward step to be significantly (0.05) slower than the other 2 Stances (split stance and false step) for both the 5 (8.3%) and the 10-m (5.9%) distances. Along with these results, Frost et al (Frost, 2008) noted that despite similar performances to the first timing gate (0.80 and 0.81s for F and B, respectively), utilizing a step forward to initiate movement resulted in significantly slower sprint times to both 2.5 and 5 m (6.4% and 5.3%, respectively) than using the false step technique.

Johnson et al. (Johnson, 2010) compared four different starting stances; parallel, false step, staggered, and staggered false step. Interestingly, the staggered false step, utilizing a staggered stance of one foot forward and one behind while switching feet upon initiation of the started, produced the fastest sprint time over 15 feet. The false step was a close second in performance, followed by the staggered stance and the parallel stance turning out the slowest time.

Further, Cusik et al. (Cusik, 2014) compared a forward step, and rhythm step (false step) starting method with 16 collegiate level linebackers. The researchers used a block start as a standard and comparison mark for each individual's fastest possible acceleration to be compared to the intervention methods. Of the two methods, the rhythm step was found to be significantly faster than the forward step at both timing intervals of 0 - 2.5 meters and 0 - 5 meters, with no difference between 2.5 – 5 meters. The results suggested the rhythm step (false step) to be superior to the forward step for collegiate linebackers.

LDune et al. (2012) compared the forward step and the false step with ten Division I college soccer plays and found velocity and displacement to be faster with the forward step in the first two steps than the false step, but not for the third step. However, they found the false step to produce greater acceleration than the forward step. The results from this study concludes the forward step to be superior than the false step for getting from point A to point B.

Biomechanical, Neurological, and Physiological Support for Hypothesis

Along with the current literature, there are three reasons for this hypothesis; biomechanical, neurological, and physiological. First, from a biomechanical perspective, re-positioning the feet to accommodate a staggered athletic stance optimizes the positioning of the body for applying maximal horizontal ground reaction forces (Harland, 1997; Mann, 1980; Salon, 2004). Second, looking at the task neurologically, if a staggered foot position affords the better performance over a parallel foot position, allowing the body to self-organize in this position without instruction and practice to override this tendency to quickly reposition the feet, also optimizes performance simply from the lag time between conscious versus unconscious decision making processes (Dennett, 1992; Libet, 1983; Libet, 1985). If the false step appears to occur when an individual is not given instruction, a possible conclusion is that part of the performance outcome when compared against not false stepping, resides in the faster response time of the subconscious brain than the conscious control. This tendency to re-adjust body position out of the parallel stance at the start also highlights the self-organizing properties of complex systems such as the human body (Kamm, 1990; Kelso, 2000; Miall 1996), which would be a quality that might not be ideal to sidestep in a place of a conscious decision of having the body perform a less that optimal technique. Finally, from a physiological viewpoint, the rapid step backwards adds an element of eccentric loading to the Achilles tendon and it's attachment to the the triceps surae complex which would elicit a stretch-reflex response, resulting in more powerful subsequent contractions for increased velocity in the initial steps of acceleration (Berardelli, 1982; Komi, 2000).

Research Questions

The research questions looking to be answered with this experiment were:

1. What are the kinematics of the individuals center of mass upon initial movement in the starting task of both the false step and non-false step technique?

2. Does the false step decrease an individual's acceleration time over ten meters versus a starting technique of not false stepping; initial movement of taking a step forward.

Significance

The primary impetus for this research was an ongoing argument of many sport coaches that an athlete should not take a false step out of a parallel athletic stance in order to accelerate forward. Many sport and performance coaches continue to argue that the false step is a wasted movement that degrades the potential for adequate or improved performance in forward acceleration – the argument is that the false step takes too much time and actually projects the athlete's center of mass backwards, or at the very least no change forward acceleration. The goal of the research, then, is to determine if in fact the false step out of a parallel athletic stance is slower than a straight out step and if the center of mass does go backwards or at the very least stays in the same position.

METHODS

The purpose of this study was to determine if one of the two possible first movement accelerations methods is faster than the other. Along with that, does one of the two starting methods work better in open skill environment in which reaction time is of great importance?

Experimental approach to the problem

The aim of the study is to determine the effectiveness of two different started techniques out of a parallel athletic stance (PAS). The independent variables for this study were the forward step out of the PAS and the false step out of the PAS. In the forward step, the individual's first movement out of the PAS is a step forward. In the false step, the individual's first movement is that of a step backwards. The reason these independent variables were chosen was because the false step versus the forward step has been a point of contention with many sport coaches of whom coach athletes in sports that utilize a starting position of the PAS. Many coaches argue that the forward step is a much more effective starting technique than the false step in accomplish a movement from point A to point B. Thus the dependent variables for this study are velocity of center of mass, acceleration of center of mass, projection angle of center of mass, and height of center of mass. Sport coaches who coach 'against' the false step believe that either the false step is slower in terms of acceleration and velocity, or does not project the center of mass in the forward direction, or both.

The experiment was set up to also require the participants to utilize their reaction abilities to simulate an athletic environment in which athletes who use the PAS most often must react to an outside stimulus (sound, visual cue), making the study closer replicate a game situation.

Without the reaction component, individuals in the study could potentially gain an advantage in mentally and physically begin preparing to start their forward movement by subtly shifting their center of mass forward while cognitively deciding when to begin their forward acceleration versus having to wait for an auditory cue and react to start their movement. In waiting for the auditory cue, the individuals must maintain their center of mass so as not to fall over, which is precisely what must occur in an athletic environment or the athlete could not complete the necessary tasks to achieve their goals of movement within their respective sports. Also, reacting to an outside stimulus (auditory cue) the individual cannot cognitively decide when to move, they must react which requires that they must use a decision making process that would be similar to that of a sport situation. Granted, most skills in a team sport setting use reaction to a visual stimulus, the reason for an auditory start signal over a visual start signal was because it was the simplest way for us to coordinate the reaction stimulus for the participants and to initiate start of the timing system (Brower Timing System) with the equipment we had available to collect data for this experiment.

The individuals asked to volunteer for the study were athletes from football, baseball, softball, and volleyball that use the PAS within their positions of their respective sports. The reason these athletes were recruited was because 1) these athletes would give the study relevance for coaches of who this question of starting techniques would apply, and 2) these particular athletes have had ample practice opportunities and skill in starting out of the PAS, helping control for a learning curve in the performance of the skill in the study. These athletes also use a reaction decision making to begin forward movement out of the PAS.

With the dependent variables, velocity was a measure we wanted to determine between the two starting techniques to determine if one starting technique had an advantage over the other in initiating change at the first instant of forward movement at first toe off and second toe off. From there we wanted to see velocity at 0 to 5 meters, 5 to 10 meters, and overall velocity from 0 to 10 meters. This distance was chosen as we felt it would give us enough indication of acceleration and velocity over a distance that might be required to be covered in those particular sports that initiate movement from a PAS and to give us helpful data to determine the effectiveness of the two different starting techniques.

Participants

The participants of this study consisted of 30 healthy, college aged (18-23 years) male and female athletes at a Division I institution. All participants were given a thorough explanation of the purpose and experimental design of the study before the experiment. Participants completed and signed an informed consent and HIPAA forms prior to the start of the experimental testing. Participants under the age of 18 were not included in this study. The University of North Dakota gained IRB approval of all procedures and forms prior to any data collection. Sport coaches' approval was obtained prior to the study, to conduct this study with the athletes on their respective teams. Permission from compliance officers at the University of North Dakota was also sought and granted prior to the beginning of the study.

Study Design

The study used a randomized experimental design and attempted to determine if there was a difference between two different starting techniques out of a parallel athletic stance. We included one trial prior to the randomized starting techniques to observe the self-selected technique the athlete performs without any instruction other than the starting position of the parallel athletic stance.

Instruments

Each participant in this study performed seven acceleration trials over ten meters. All participants underwent the standardized warm-up (see below) first. After the warm-up we then filmed (from the two vantage points) each participant perform one uninstructed trial and three of each instructed trials of the false step and non-false step techniques. The testing took place on an indoor artificial turf surface, with the Brower Timing System laser timing gates used at 5m and 10m to collect acceleration data. The Brower TC Timing System for its' wireless radio transmitted laser timing gates. The TC Brower Timing system allows for easy set-up, has a radio transmission signal strength of up to a thousand feet and accurate collection of time to a thousandth of a second (Brower Timing, 2017). The system also will allow for the use of an auditory start signal to help create for a reaction component to the experimental trials.

Starting was initiated with a starting gun substitute, clapping two 12 inch long two-by-four pieces of wood that provided enough of a sonic signal to initiate the Brower Timing System, as well as indicate to the subject to begin their acceleration.

Filming was taken from two vantage points for kinematic data collection using the Ariel Performance Analysis System (APAS). For each testing session, we first filmed a calibration element (a calibration cube) from both vantage points which was later used to calibrate each film set with the APAS system. From the film, kinematic data was collected utilizing the APAS. All experimental trials which we filmed were digitized into the APAS system. The digitized frames of all 210 trials were subjected to direct linear transformation along with calibration cube data in order to provide three dimensional kinematic data. The data was filtered at 7Hz utilizing a second order high low band Butterworth filter. Kinematic data were then extracted for Velocity at 5meters, 10 Meters and in between 5 and 10 meters. From this, velocity, acceleration, projection angle, and height of CM was extracted for each participant at toe-off of the first step. Next, velocity, acceleration, projection angle, and height of CM were extracted for each participant at toe-off of the second step.

Procedures

Each participant went through a standardized warm-up prior to the testing protocol. The warm-up procedure consisted of a series of dynamic movements targeted at the lower body to increase body temperature and neuromuscular activity. The movements chosen for the standardized warm-up were dynamic and ballistic in nature and were chosen because of the evidential support for these types of movements in a warm-up for sprint and power type activities (McMillian, 2006; Sim, 2009; Stewart, 2007). Each movement progressed in intensity, preparing the participants for performing maximal effort sprints in the experimental trials. We've purposely added three forward runs/sprints out of the parallel athletic stance in order to allow for specific practice to the experimental trials. The warm-up was as follows.

Knee to chest x 10e

Side Step with overhead arm swing 2 x 25 yards

Cross in front run 2 x 25 yards

Cross behind run 2 x 25 yards

Carioca 2 x 25 yards

Backwards run 2 x 25 yards

Staggered stance accelerations (rest 30 second between reps)

1 x 10 @ 65% Perceived effort

1 x 10 @ 75%

1 x 10 @ 85%

1 x 10 @ 95%

1 x 10 @ 100%

3 practice trials of the forward step for 5 meters

Following the warm-up, the participants rested for two minutes while we reviewed again the procedures for the tests. After this recovery period, the participants attempted one trial of a ten meter acceleration without receiving any prior instruction on starting technique, only that they must start in the athletic parallel stance. We wanted to see what the individuals chose for a starting method when not receiving any instruction. This was to give us an indication as to the self-organized behavior created within these particular task constraints.

After the first trial, the participants received three minutes of rest while they were instructed on the rest of the experimental procedures. The participants were instructed on taking the same PAS (parallel athletic stance) with randomized trials of three of each utilizing the false step (3 attempts) and the forward step (not taking a step back upon the start signal). Rest intervals were approximately between 1:30-2:00 minutes between trials. The techniques used was a starting position of a parallel athletic stance (PAS) (figure #) for which the participants started each trial to initiate first movement upon the starting sound. The first technique (a) was a forward step out of the PAS. The second technique (b) the participants will again utilize a parallel athletic stance (PAS) while this time upon the starting signal, taking a step back to initiate acceleration.

The start signal was initiated by the Brower TC Timing system's auditory sound notification simulating a starting gun. This allowed the participants acceleration trials to also involve a reaction component which we felt was imperative to make this study more applicable to team sport athletes who may or may not use the false step technique in forward acceleration in a chaotic environment, in which reacting is the impetus for any such movement out a of PAS.

Statistical Analysis

Data in this study provided detailed significant differences between variables for the false start when compared to the straight out start. We used paired t-tests to determine the significant differences between the dependent variables; center of mass height and projection, acceleration at first and second toe off, and velocity at first and second toe off for both conditions of the false step and the straight out step. We set the alpha for this assessment at .05. The following section presents the data and significant testing of those data for the Velocity of CM, Acceleration of the CM, the height of CM, and the projection angle of CM, for the false step and straight out steps we looked at in this study.

Interatrial variability

We acknowledge that there was the possibility of a learned effect during this experiment. It is possible that this learned effect comes from participants lacking coaching in the false step and/or straight out step. Because all participants utilized the false step for the uninstructed trail, it is possible that after more practice repetitions, the participants could possibly prefer or be as equally or more successful with the straight out step technique. To help account for this, all participants were given three practice trials with the straight out step. We purposely gave no practice trials with the false step to see if this technique would still be utilized on the first trial with no instruction for what technique to use. We acknowledge that the learning effect could have been possible from a personal preference between the false step and the straight out step techinques.

To help determine if there was a learning effect across the study, within the statistical analysis, we were able to conduct an analysis of interatrial variability with the repeated measures ANOVA used. From this analysis, if there was a learning effect, we would have expected to see a measurable degree of variability between trials, which we did not. We found no significant difference between any of the trials across all categories of variables within this study.

RESULTS

The key variables we looked at was velocity at first and second toe off of both the false step and straight out step conditions. We also collected time velocities at for both zero to five meters and five to ten meters. Along with velocity, we looked at acceleration for both conditions at first and second toe off. Additionally, we collected data regarding the kinematics of the center of mass for the false step and the straight out step.

Velocity of the Center of Mass

A key variable we looked at was velocity out of the parallel athletic stance. For the false step, the instantaneous velocity of the center of mass at first toe off was 2.4 meters per second. The velocity at first toe off for the false step was 1.3 meters per second faster than first toe off for the straight-out step which was 1.1 meters per second.

At second toe off, the velocity for the false step was 3.6 meters per second. The velocity of the center of mass for the straight-out step at second toe off was 2.8 meters per second, for a difference of a .8 meters per second between the false step and straight out step techniques.

For the timed velocities using the Brower Timing System, the velocity between zero and five meters was an average of 3.2 meters per second for the false step condition and 2.8 meters per second for the straight out condition. From five to ten meters, the velocities between the two techniques evened out with no significant difference at 6.5 meters per second each. Overall, the difference between the false step and straight out techniques over the entire distance of zero to ten meters was an average of .4 meters per second faster for the false step condition. From zero to ten meters the timed velocity was a mean of 4.3 meters per second for the false step. For the straight out step, the velocity from zero to ten meters was 3.9 meters per second.

Acceleration

Acceleration data was collected after first toe off and second toe off. There were significant differences found for initial acceleration of the center of mass at first toe off. For the false step condition, the mean acceleration was 9.7 m/s/s, while the straight-out start was 6.1 m/s/s. There were no significant differences for the CM acceleration after the second toe off, however. For the second toe off, acceleration was 9.0 m/s/s for the FS and 9.3 m/s/s for the SO technique.

Height of Center of Mass

There were significant differences between the FS and SO conditions for the height of the center of mass for both the first and second toe off. At first toe off, the mean center of mass height was significantly lower with FS condition than the SO. For the FS, the mean center of mass height at first toe off was 72.9 cm. The mean height of the center of mass for the SO at first toe off was 80.5 cm, for a difference of 7.6 cm between the FS and SO. However, at second toe off the mean center of mass height was significantly higher for the FS than the SO. The mean height of the center of mass was 79 cm for the FS at second toe off, while the mean height of the center of mass for the SO was at 76.9 cm, for an average difference of 2.1 cm between the two conditions.

Projection Angle of Center of Mass

The projection angle for the center of mass was also looked at. Our data showed that the mean projection angle for the center of mass at the toe off for the false step was directed upward about 1.6 degrees to the transverse plane in the direction of movement. The mean projection angle for the straight-out step at first toe off showed a downward motion of 18.3 degrees to the transverse plane in the direction of movement, being significantly different than the false step. In the second toe off, the straight-out condition continued downward at .6 degrees, while the false step continued upward at 3.2 degrees, again showing a significant difference.

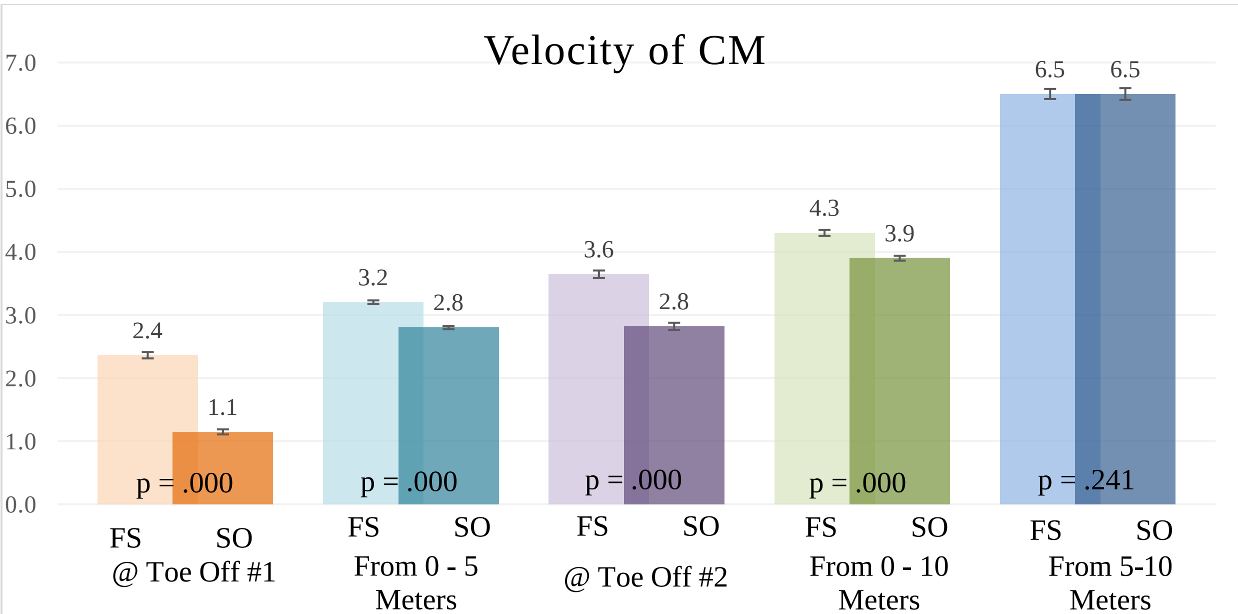

Figure 3. Velocity of center of mass for both the false step (FS) and straight out step (SO) at first and second toe off, and for both the FS and SOS from zero to five meters and zero to ten meters.

Table 1. Acceleration, height, projection angle, and velocity of the center of mass for the false step and straight out step.

Variable	FS Mean	SO Start	Sig
Acceleration of CM at Toe off #1	9.7 m/s/s	6.1 m/s/s	0.000
Acceleration of CM at Toe off #2	9.0 m/s/s	9.3 m/s/s	0.660
Height of CM at Toe off #1	72.9 cm	80.5 cm	0.000
Height of CM at Toe off #2	79 cm	76.9 cm	0.000
CM Projection Angle at Toe off #1	1.6°	-18.3°	0.000
CM Projection Angle at Toe off #2	3.2°	-0.6°	0.000
CM Velocity at Toe off #1	2.4 m/s	1.1 m/s	0.000
CM Velocity From 0-5 M	3.2 m/s	2.8 m/s	0.000
CM Velocity at Toe off #2	3.6 m/s	2.8 m/s	0.000
CM Velocity From 0-10M	4.3 m/s	3.9 m/s	0.000
CM Velocity From 5-10 M	6.5 m/s	6.5 m/s	0.241

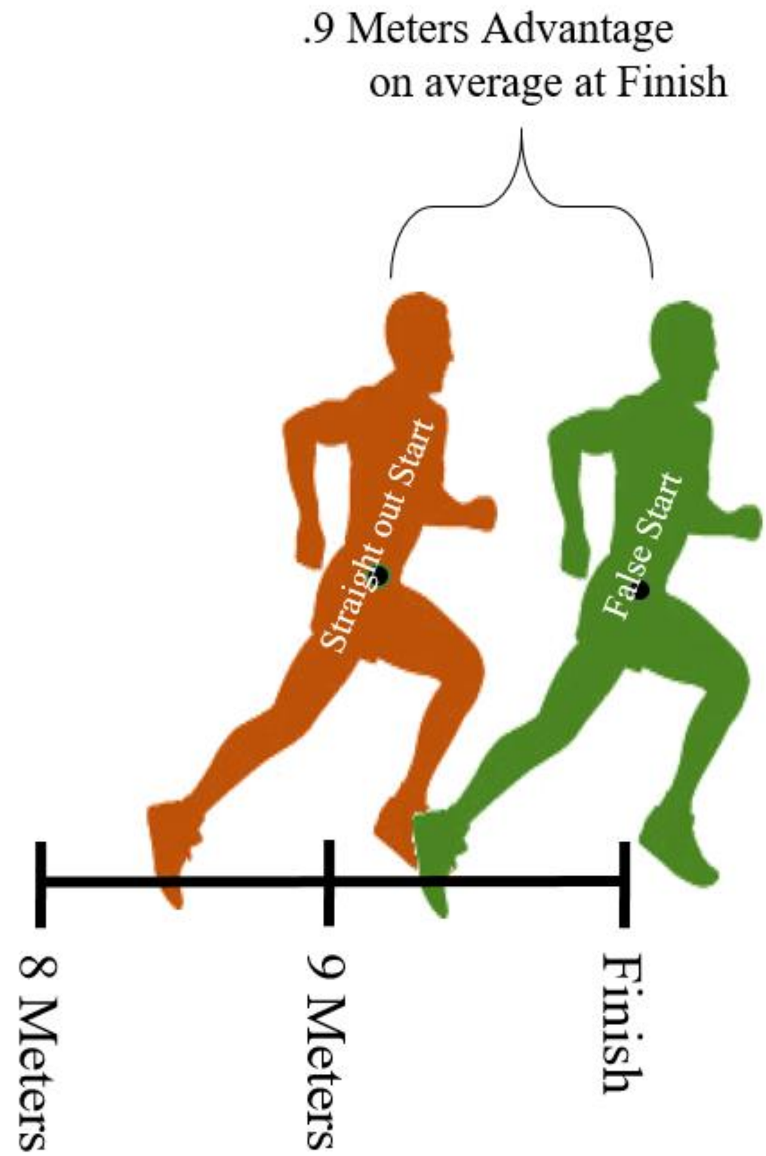

Figure 4. Distance advantage of the false step vs. the straight out step at ten meters.

DISCUSSION

In many team sports, acceleration and velocity are critical factors in performance success. Also in team sports, the parallel athletic stance is a key position used in order to be ready to move in all possible directions. Being able to accelerate straight forward as fast as possible out of a parallel athletic stance (PAS) is one of the possible directions and often a determinant of successful completion of a task within the competitive environment. This study indicates that forward acceleration and velocity out of a PAS are maximized when utilizing the false step.

The motivation for this present study has been the debate among sport coaches of whether the false step is an effective vs ineffective technique to use for accelerating forward out of a PAS. Sport coaches might assume that an athlete taking a step backwards loses forward motion and therefore delays effectiveness in getting from one point to another, however, our data indicate otherwise. All 30 participants in this study had more success with the false step than the straight-out technique for all trials, supporting previous work (Cronin, 2007, Cusik, 2014, Frost, 2008, Kraan 2001, Johnson, 2010) showing the false step to be superior to the straight-out technique. The one study that did not show the false step to be superior than the straight-out step by LeDune et al. (LeDune, J. A. 2012), argued that the work of Cronin et al. (Cronin, 2007) and Johnson et al (Johnson, 2010) did begin timing until the participants went through the first timing gates after initial movement had already started, therefore taking into consideration the time of the first movement. This study, however, controlled for that by starting the timing system and the participants with an audio signal, therefore collecting time data for all movement and the results showing still the false step to be superior in velocity and acceleration than the straight-out step.

Acceleration and Velocity of the False Step

Based on the results found in this study, it was determined that the significant difference between the false step and the straight out step lies in the acceleration and velocity in the first five meters. After the first five meters, five meters to 10 meters there was no significant different in velocity nor acceleration. This is consistent with the current literature (Cronin, 2007, Cusik, 2014, Frost, 2008, Kraan 2001, Johnson, 2010). The higher velocity and acceleration findings in this study and others, added to findings by Kraan et al. (Kraan 2001) that initial force applied being higher continues to lend support that the false step is much more effective than the forward step in three important variables with regards to movement out of the parallel athletic stance. Thus athletes in sports that often start their forward accelerations out of the PAS (defensive stance in volleyball, linebacker and running back positions in American football, infielders in baseball and softball), should be allowed to employ the false step for these movements if they want to get from a point a to point be as fast as possible.

Even after the differences in instantaneous velocity and acceleration are eliminated after five meters, our results show the false step has already afforded a .9 meter advantage over any additional meters sprinted (Figure 1). Considering this in the context of a sport, an athlete would be nearly one meter away from catching or reaching a ball or an opponent, or avoiding another player in American football, all of which is obviously a significant disadvantage. Thus the false step is a technical advantage in sprinting straight forward out of a PAS.

Importance of the Parallel Athletic Stance Position

In Johnson et al. (Johnson, 2010), they found that the staggered stance actually produced the fastest time with the false step out of a PAS to be second in performance. However, we'd like to note that although the staggered stance afforded better performance, it is not practical for the particular question we are asking, which is what is the most effective technique for accelerating forward out of a parallel athletic stance? The reasoning is that although the staggered stance may be faster when accelerating forward, if a particular athlete had to accelerate laterally or move backwards, the staggered stance would make for a difficult position to start moving from. Thus the PAS is employed in many sport positions where the movements to follow are unknown and highly variable and the athlete must react to an outside stimulus such as the trajectory of the ball or another opponent. For example, a linebacker in American football might have to move laterally or retreat backwards if the offensive team is passing the ball, or quickly accelerate forward during a run play. A shortstop in baseball might have to accelerate forward on a short grounder or bunt, or they may have to retreat backwards or laterally if the ball is hit another direction. The same scenario plays out for a defender in volleyball where they do not necessarily know their next movement until the offensive team has made play on the ball… thus certain positions in sports must be prepared to most effectively move in all positions and why we used the parallel athletic stance (vs. the staggered stance) for our starting position and recruited athletes that use this position in their respective sport for this study.

Projection of the Center of Mass

An additional argument among coaches arguing against the false step is not only that it is slower in accelerating forward, but that the center of mass also goes backwards. Which is an interesting argument, considering that even if the center of mass did go backwards for a brief moment, the fact that the athlete consistently gets to 'point B' faster using the false step than the straight out step, it should be a moot point. The only way this argument could be valid would be in a situation where an athlete had to engage with another athlete to physically push them backwards, in which case one would want an absolute forward motion of the center of mass such as that of an offense or defensive lineman. However, these particular athletes and their respective positions already account for this demand by assuming a three point stance; with one point being a hand on the ground to create a position of a forward center of mass to maximum forward acceleration and velocity. However, these positions do not employ the PAS, because the positional demands do not require the ability to move in multiple directions. Interestingly enough though, our research indicates that in fact the center of mass does move forward using the false step.

The False Step – An "Attractor State"

Additionally, when each participant self-selected their starting technique on the first trial without any prior instruction, all individuals used the false step. This supports the idea that the false step is an emergent pattern of the dynamic system that the human body is, lending credibility to the effectiveness of allowing the body to self-organize into the most advantageous position for forward acceleration, or an "attractor state". As stated by Glazer et al (Glazer, 2003),

> *"Dynamical systems theorists claim that the number of biomechanical degrees of freedom of the motor system is dramatically reduced through the development of coordinative structures or temporary assemblages of muscle complexes (Turvey, 1990). The reduced dimensionality/complexity of the motor system encourages the development of functionally preferred coordination or "attractor" states to support goal-directed actions. Within each attractor region (the "neighborhood" of an attractor) system*

dynamics are highly ordered and stable, leading to consistent movement patterns for specific tasks."

From the perspective of the current study this "attractor" state appears to be the staggered stance in which the athlete quickly positions themselves in during the first movement of the false step technique. The staggered stance appears to be the preferred position to allow the body to most effectively accelerate the center of mass in a linear direction. The staggered stance was shown to be the fastest starting stance by Johnson et al (Johnson, 2010) when compared against the false step and straight out start techniques, which would help explain the "attractor" state it is when an athlete quickly repositions themselves into this stance in the false step technique out of a PAS.

Only one previous study (Kraan 2001) looked at the participants' self-selection technique for starting technique out of the parallel athletic stance, which is why we wanted to see what the subjects did without any prior instruction; to see if there was a preferred technique by the subjects. Also, because five of the six studies this thesis reviewed (Cronin, 2007, Cusik, 2014, Frost, 2008, Kraan 2001, Johnson, 2010, LeDune, J. A. 2012) showed the false step to be a faster technique, we purposely did not give the participants practice with this technique in which to see if the false step would still be used by some participants in the uninstructed trial. All the participants only practiced the straight out step in the warm-up prior to the test trials. All participants in our study performed the false step during the uninstructed trial, which again provides evidence for an emergent "attractor" state.

Appearing as an emergent pattern of a dynamical system (Glazer, 2003; Holt, 2010; Mack, 2000), it appears the false step is a subconscious decision in reaction to an environmental and specific task demand, making it both faster from a neurological perspective (Libet, 1985) and a biomechanical one. This understanding may allow for coaches to not waste valuable time attempting to coach the false step 'out' of the athlete and coach other more pertinent skills in one's particular sport. Further, the false step seaming to being an emergent pattern of the body's self-organizing qualities, combined with the decision to using the false step out of parallel athletic stance appearing to be subconscious and that the false step is biomechanically superior to the straight-out step, one would not have to 'coach' an athlete at all on this skill.

Limitations

The most obvious limitations within this study are that of the study not occurring in a competitive environment within the individual's particular sport. However, within team sports it is nearly impossible to set up a standardized test to evaluate specific movement skills because of the infinite number of possible scenarios of which movement skills can and must occur. Another limitation of this particular study is that certain individuals within the study have had more or less practice of not executing the false step depending on the coaching philosophy and techniques the participants of this study have been exposed to. Given the time to practice not false stepping might have an impact on an individual's ability to perform the straight forward step out of the parallel athletic stance.

Practical Applications

Data in this study support the hypothesis that the false start provides higher acceleration, and velocities than the straight out sprint start. These data have fairly wide ranging implications in that coaches should stop wasting valuable practice time in an effort to coach out the false start, unless the objective is not to get from point A to point B in the shortest amount of time possible. Additionally, the fact that the false step appears to be an emergent pattern in a dynamic system that requires little to no conscious effort, it allows an athlete to utilize more conscious processing and decision making to other more pertinent matters in a competitive environment. On average, athletes that utilize a false start will be ahead by .9 meters at a 10-meter distance. This cannot be overstated, the false start is an advantageous behavior that provides higher initial acceleration, higher initial velocity, better CM height at the initiation of forward motion, and a better projection angle. These four findings indicate that the false start is by far an advantageous technique out of a parallel athletic stance. The current study also suggests that the false step technique might be left alone to be utilized with no coaching at all, as it appears to be an emergent pattern out of the body's self-organizing capabilities.

Conclusion

In the majority of team sports, accelerating from one point to another as fast as possible is a critical to successful performance. In many team sports, athletes utilize a parallel athletic stance to be prepared to react and move in a number of different possible directions. Accelerating forward out of the PAS has been a point of contention among sport and performance coaches, with many arguing that the false step is a technique error and athletes should be coached to not false step and coached to straight out step on first movement. Our research concludes otherwise - when looking at the most effective starting technique used out of a PAS, our research indicates that the false step is more effective in forward acceleration and increased velocity. Our research also concludes, that when given a choice of how to accelerate forward out of a PAS, all our participants utilized the false step - which had faster times over five and ten meters than all of their straight out step trials. Based on this study, the false step is a more effective technique than the straight out step when accelerating forward out of an athletic stance, and coaches should not waste practice time coaching athletes to straight out step, nor use how to use the false step, as it appears to be an innate technique that taps into the natural self-organizing qualities of the human body.

APPENDICES

APPENDIX A

INFORMED CONSENT

A COMPARISON OF STARTING TECHNIQUES OUT OF AN ATHLETIC STANCE POSITION

Aaron Schwenzfeier
(701) 213-1923
Kinesiology

You are invited to participate in a research study at the University of North Dakota. This study is being conducted by Aaron Schwenzfeier from the University of North Dakota. As a student athlete, you are being asked to participate in this study.

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only participants who choose to take part. Please take your time in making your decision to participate. If you have questions at any time, please ask.

The purpose of this research study is to examine the difference in starting kinetics and kinematics of a linear sprint out of a parallel athletic stance. This study will help determine the most effective method in acceleration performance out of the athletic stance and will help coaches of sports that use the parallel athletic stance with choosing an appropriate method to teach their athletes.

Participation in this study will require you to perform the standardized warm-up followed by five accelerations of ten meters each. The acceleration trials will involve two different starting techniques of which you will be instructed upon. In addition to the test, measurements of leg length and body weight will be collected.

You will not have any costs for being in this research study. The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by Government agencies, and the University of North Dakota Institutional Review Board.

Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of the utilization of pseudonyms in all publication. All data will be kept in a locked cabinet. This cabinet will have only one key that is held by one researcher. All computer analysis of data will be kept on one computer, which is password protected. It should be noted, however, that there are some rare circumstances in which we may be required show your information to other people.

If we write a report or article about this study, we will describe the study results in a summarized manner so that you cannot be identified. Both the test data and the injury reports will be kept for five years and then destroyed.

Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota.

The researcher conducting this study is Aaron Schwenzfeier of the University of North Dakota. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Aaron Schwenzfeier at (701) 213-1923.

If you have questions regarding your rights as a research subject, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Name of Student Athlete ___________________

I have read and understand the above consent form and I voluntarily agree to participate in this study.

Student Athlete signature_______________________ Date___________________

APPENDIX B

Health Insurance Portability and Accountability Act

HIPAA[1] AUTHORIZATION TO USE AND DISCLOSE INDIVIDUAL HEALTH INFORMATION FOR RESEARCH PURPOSES

1. **Purpose.** As a research participant, I authorize Aaron Schwenzfeier and his thesis advisor, Dr. Rhoades, to use and disclose my individual health information for the purpose of conducting the research project entitled A Comparison of Starting Techniques out of an Athletic Stance.
2. **Individual Health Information to be Used or Disclosed.** My individual health information that may be used or disclosed to conduct this research includes: my age, sport participation, height, weight, and five and ten meter acceleration performance.
3. **Parties Who May Disclose My Individual Health Information.** The researcher and the researcher's advisor may obtain my individual health information form medical files contained in the UND Athletic Training Room, Grand Forks Family Medical Residency, other previous clinics/hospitals where I have had treatment at the discretion of myself, and from hospitals, clinics, health care providers and health plans that provide my health care during the study.
4. **Parties Who May Receive or Use My Individual Health Information.** The individual health information disclosed by parties listed in item 3 and information disclosed by me during the course of the research may be received and used by Benjamin Johnson and the researcher's advisor.
5. **Right to Refuse to Sign this Authorization.** I do not have to sign this Authorization. If I decided not to sign the Authorization, I may not be allowed to participate in this study. However, my decision not to sign this authorization will not affect any other treatment, payment, or enrollment in health plans or eligibility for benefits.
6. **Right to Revoke.** I can change my mind and withdraw this authorization at any time by sending a written notice to Aaron Schwenzfeier at aaron.schwenzfeier@athletics.und.edu to inform the researcher of my decision. If I withdraw this authorization, the researcher may only use and disclose the protected health information already collected for this research study. No further health information about me will be collected by or disclosed to the researcher for this study.
7. **Potential for Re-disclosure.** My individual health information disclosed under this authorization will not be subject to re-disclosure outside of the research study.

This authorization does not have an expiration date.

I am the research participant or personal representative authorized to act on behalf of the participant.

I have read this information, and I will receive a copy of this authorization form after it is signed.

_______________________________________ _________________________________

Signature of research participant or research participant's personal representative

Date

____

Printed name of research participant or research participant's personal representative

____

Description of personal representative's authority to act on behalf of the research participant

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