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# Comparison of Select Kinematic Variables Between a Heel up Sprint Start vs a Heel Down Start

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# COMPARISON OF SELECT KINEMATIC VARIABLES BETWEEN A HEEL UP SPRINT START VS A HEEL DOWN SPRINT START

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Research Methods in Health, Physical Education, and Leisure Services

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# CHAPTER I

## INTRODUCTION

In today's society sports are more popular than ever. There are various professional leagues across the nation generating billions of dollars of revenue. The most common national sports in the United States are baseball, basketball, football and hockey; the utmost popular national sport in the U.S. based off of economic revenue is the National Football League (NFL) (Plunkett Research, 2010).

The NFL was started in 1920 where it was originally called the American Professional Football Association (National Football League, 2010). The NFL consists of thirty-two teams with fifty-six players per team (National Football League, 2010). Because of the relatively small roster sizes and the prevalence of collegiate programs, it's very difficult to secure a position on an NFL roster. The NFL evaluates their prospective players looking at various physical and mental tests. These tests are performed at the NFL combine and organized university "pro-days".

The NFL combine is held in Indianapolis each year (National Football League, 2010), bringing together the very best college football players in the nation. At the NFL combine, there are many tests performed to evaluate several physical and mental attributes of each invited player. The tests included at the combine are the following: 40-yard dash, bench press, vertical jump, broad jump, 20-yard shuttle, 3-cone drill, 60-yard shuttle, position-specific drills, interviews, physical measurements, injury evaluation, drug screen, the Cybex test, and the Wonderlic (National Football League, 2010).

Although all these tests have a purpose, arguably the most important evaluation is the 40-yard dash (Sierer et al., 2008).

The 40-yard dash is often the indicator for a decision by a team on the future of an athlete. No matter what position one may play, the outcome of an individual's 40-yard dash can determine if they will be drafted or not. It is generally accepted that the attributes that 40-yard dash performance can play a very large role in determining the potential success of an athlete on the playing field (Sierer et al.,2008).

The 40-yard dash is an evaluation of linear speed and acceleration (Gough, 2006) which makes it a valuable tool for the NFL. The importance of the 40-yard dash has motivated coaches and athletes to develop various strategies for improving performance. Upon observation of the 2010 combine, most athletes use a staggered three point stance with the rear heel elevated from the ground (Figure 1a). This positioning results in a dorsiflexion countermovement of the rear leg when the athlete initiates the sprint. To prevent this countermovement, thus potentially saving time, some of the athletes appeared to deliberately push the heel of the rear foot flat on the ground, resulting in a stretching of the Achilles tendon and greater amount of dorsiflexion in the ankle (Figure 1b). It is postulated that since rapid dorsiflexion occurs during the start of the sprint, positioning the foot in such a way may save time resulting in a quicker start.

## Statement of the Problem

The purpose of this study is to compare select kinematic and temporal variables involved in the heel-up (HU) sprint start vs. that of the heel down (HD) sprint start.

Hypotheses

1. Null hypothesis #1: There will be no difference in stride length between HU and HD.
2. Null hypothesis #2: There will be no difference in time through the first 5 yards and 10 yards between HU and HD.

## Significance of the Study

Completing this study will be very beneficial for athletes. Many sports require athletes to be evaluated on their linear speed and acceleration using the 40-yard dash. The testing of the 40-yard dash test is seen at all levels of competition. For high school athletes, it is often a predictor on whether or not a college team will recruit an athlete and offer them a scholarship (Gough, 2006). As the level of competition increases, so does the significance of the 40-yard dash (McGee and Burkett, 2003). In high school, one may not show the best results in the 40-yard dash and will still get an opportunity for collegiate football (Gough, 2006); but, when moving from the college level to professional sports, one's future is determined by a more minimal margin (McGee and Burkett, 2003). There is a significant difference in the 40-yard dash times in collegiate football players drafted by the NFL and those who were not (Sierer et al., 2008). The differences in times with college football players could literally cost hundreds of thousands of dollars.

A satisfactory or unsatisfactory 40-yard dash maybe determined by fractions of a second. With this in mind, it is very important for athletes to seek and apply the best

techniques required to run their best time in the 40-yard dash that they are capable of. Recently, many athletes have begun to use a new technique (HD) which essentially limits the countermovement that occurs when the classic HU technique is used. This study will determine which technique is more advantageous, and ultimately will help athletes to reach their maximal potential when being tested.

# CHAPTER II

# METHODOLOGY

## Research Participants

Seventeen subjects were recruited for this study. Sixteen of the subjects were Division-I football players. One of the subjects was an NFL player. The subjects' age was 21.29 ± 1.67 years. The subjects' stature and mass were 187.66 ± 6.53 cm and 102.43 ± 17.24 kg respectively. Subjects were informed of the risks associated with the study. All methods used in this study were approved by the Internal Review Board at the University of Northern Iowa.

## Instrumentation

A Brower Electronic Timing System was used to collect the times at 5 and 10 yards (Brower Timing Systems, Draper, UT). A digital HD video camera recorder with a sampling at a rate of 30 Hz was used for a video analysis of each trial (Sony, New York, NY). Dartfish Connect 5.5 computer program was used to calculate the kinematic and temporal variables during the sprint start (Dartfish, Alpharetta, GA). The Dartfish software allows for the deinterlacing of the frames captured by the camera resulting in the ability to acquire 60 frames per second.

## Procedures for Collecting Data

Data was collected over a two day period. On the first day, demographic data was collected. On both days prior to sprinting, a dynamic warm-up was performed which

lasted approximately 15 minutes and involved 10 drills that were specific to sprinting. Furthermore, prior to data collection, each subject performed three sprint starts in order to familiarize them with the particular technique utilized that day. Each subject performed three sprint starts of either HU (a) or HD (b) on each of the two days. The order in which the treatments occurred was randomly assigned to prevent an order effect.

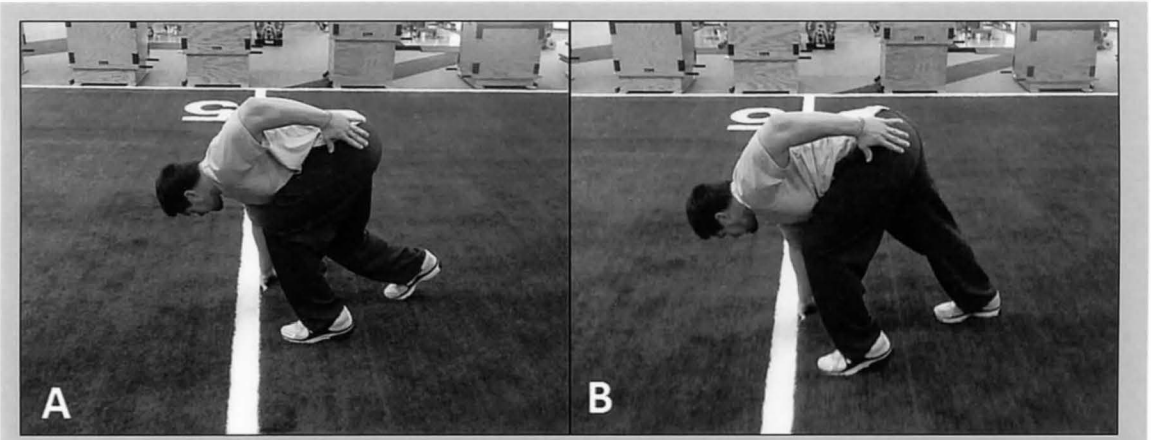


**Figure 1.** A) Heel up sprint start B) Heel down sprint start

Two Brower Timing System gate sets were placed at the 5 and 10 yard marks. The video camera was placed 5 yards perpendicular to the start line. The average time to sprint through 5 yards (5Y) and 10 yards (10Y) was recorded to the nearest $100^{th}$ of a second. Additionally the average length of the first two strides (SL1 and SL2) was recorded to the nearest $100^{th}$ of a meter. All testing was performed indoors on a flat surface where no environmental factors could affect performance (Epley, 1982).

Data Analysis

Descriptive statistics (mean ± SD) were calculated for all performance variables. A multivariate t-test was used to determine if there was a treatment effect for any of the

dependent variables. In the case of a rejected null hypothesis, separate independent t-tests would be used to determine which variables were affected by the treatment. Alpha was set at $p<0.05$ for all statistical tests.

# CHAPTER III

# RESULTS, DISCUSSION AND CONCLUSIONS

## Results

Descriptive statistics of all dependent variables can be found in Table 3.1. The multivariate t-test indicated that there was no significant treatment effect for any of the dependent variables ($F=0.619, 4, 29, p=0.65$). No posthoc analysis was needed.

| | HD | | HU | |
|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD |
| 5Y (s) | 1.18 | 0.11 | 1.14 | 0.07 |
| 10Y (s) | 1.88 | .13 | 1.83 | 0.09 |
| SL1 (m) | 0.82 | 0.06 | 0.84 | 0.05 |
| SL2 (m) | 0.87 | 0.07 | 0.89 | 0.67 |

Table 3.1 Descriptive statistics of all dependent variables.

## Discussion

Early in sports, a successful athlete was often gauged on their determination, work ethic and team leadership skills. As sports have evolved, in particular the sport of football, the importance of physical attributes such as strength, size and speed has gained ground. Although all of the characteristics listed are important, a case can be made for running speed as being the most important in the sport of football. An individual's speed

can be evaluated in various ways, but the most popular test is the 40-yard dash (Gough, 2006).

In order to perform well in the 40-yard dash, many factors must be considered. A quick reaction to a the starting signal (if used), high rates of force development in the lower limbs during the first few strides, high initial degrees of acceleration and the ability to sustain near maximal velocity throughout the race are all keys to performance. The ability to evaluate both acceleration and speed has made coaches at all levels aware of the significance of the test (Gough, 2006).

For one to have a successful 40-yard dash one must be able to have a quick reaction off of the line, be able to generate maximal force, accelerate quickly over a short distance, be able to reach maximal velocity quickly and be able to maintain that maximal velocity; these characteristics for success in the 40-yard dash are also keys to success in many sports as well. The noticeable traits involved in the 40-yard dash have made coaches at all levels aware of the significance of the test (Gough, 2006).

To this day the most common starting style for running the 40-yard dash is one that requires a countermovement (HU). Briefly, this starting style requires the sprinter to have their weight forward on the balls of the feet and no heels touching the ground (Johnson et al., 2010). The countermovement can be seen by watching the heel of the back foot of the sprinter when they begin the sprint. Recently, a new technique has been observed at the combine where the real heel is pushed down (HD). It is assumed that this technique was developed to prevent the "false movement" that occurs as a result of the countermovement in the HU starting style.

The results of this study indicated that there was no significant difference in any of the temporal or kinematic variables between the two techniques. There may be several explanations for why the HD condition did not improve starting performance in the subjects. First, by pushing the heel down with the new technique, the degree of countermovement that occurs in the rear limb was minimized which should have theoretically allowed the athlete to "start faster" by saving this time. However, upon qualitative analysis of the video, it appears that it is the upper body action which is the rate limiting step of the start. In other words, the subjects did not initiate their first step until their arms were in the appropriate position, regardless of the size of the countermovement that occurred in the rear leg.

Interestingly, although there was no significant treatment effect, there was a trend towards a superior performance with the HU technique. In fact, 14 of the 17 subjects had a faster performance in the HU trial than the HD trial. Small sample sizes and a small effect size prevented the differences from being statistically significant, however it should be noted that from a practical standpoint, the observed differences of 0.04 and 0.05 seconds through 5Y and 10Y respectively with the HU technique is a relatively big improvement in performance.

Other studies have showed similar results. What starts as an honest attempt to improve performance ends up hindering the stretch-shortening cycle (SSC). The SSC is defined as a stretch (eccentric contraction) of the muscle followed by an instantaneous shortening (concentric contraction) of that same muscle (Hennessy and Kilty, 2001). The stretching of the muscle causes the tendon to lengthen and act as a spring. After the

stretching of the tendon the muscle starts to concentrically contract; the tendon then recoils quickly resulting in a higher force production (Turner and Jeffreys, 2010). This phenomenon has been observed and reported many times (Frost et al., 2008).

The increase in force resulting from the SSC was noticed in a study by Hennessy and Kilty in 2001. This study's purpose was to examine the relationship between commonly used SSC actions and sprint performances over different distances in well-trained female athletes. The authors hypothesized that a bounce drop jump (BDJ) would positively correlate with shorter sprint performances. The theory was that during shorter sprinting distances there are shorter foot support phases and that the BDJ is a SSC action that requires minimal ground contact time (GCT) with a maximal jump for height. The results proved their hypothesis to be correct; the BDJ had the most significant relationship to that of shorter sprinting distances. This study's results are beneficial with explaining the relationship between various SSC actions and sprint performances in athletes (Hennessy and Kilty, 2001).

Most sports require an athlete to initiate movement out of a parallel athletic stance (Frost et al., 2008). The initiation of movement can be done in one of two ways by positioning the body's center of mass (COM) anterior to the base of support. The first way is by rotating the body at the ankle joint, transferring the COM forward. The second way is to displace the support area behind the COM; in other words place one foot backwards. Taking a backwards step has been considered to be inferior and a wasted motion; but authors reviewed that ninety-five percent of individuals instinctively take a counter step when initiating a sprint. Authors examined the differences between the two

different sprint starts out of a parallel stance and one that required a staggered stance. The results showed that the staggered stance was significantly faster, but when examining the two parallel starts there were no significant difference between them. Knowing that individuals naturally take a counter step and that there is no significant difference in time over short distances when eliminating that counter step, the study concludes that when athletes initiate movement out of an athletic stance they should do whatever feels natural for them (Frost et al., 2008).

Stride lengths were also measured to help determine if the HD technique would change the ability to displace the center of mass during the start. Upon analysis there were no significant differences in SL1 or SL2 between the two trials but the trend was similar. Twelve of the 17 subjects had larger stride lengths with the HU technique.

The results of this study are interesting in that a difference one way or another was expected. Perhaps the HD technique was less effective because the subjects were unfamiliar with putting their heel in this position. Allowing more time to familiarize themselves with the technique may have improved their performance with this technique. On the other hand, the importance of the SSC cannot be denied. Even during the HD trial, the naturally occurring countermovement was observed, although it was less pronounced. The HD effect was effective at eliminating the heel countermovement but subjects overcame this by creating a countermovement at the hip.

In conclusion, there was no significant technique effect on any of the kinematic or temporal variables in this study. Athletes should feel free to experiment and use different techniques based on their personal preference. Although there was no

significant effect in this study, the results of this study indicate that more research in this area is needed to determine the technique that optimizes the utilization of the SSC in the shortest amount of time.

# REFERENCES

Brughelli, M. , Cronin, J. , & Chaouachi, A. (2011). Effects of running velocity on running kinetics and kinematics. *Journal of Strength and Conditioning Research, 25*(4), 933.

Elliot, B.C., & Blanksby, B.A. (1979). The synchronization of muscle activity and body segment movements during a running cycle. *Medicine & Science in Sports and Exercise, 11*(4),

Epley, B. (1982). The nebraska timer: a simple, accurate way to measure the 40 yard dash. *Strength and Conditioning Journal, 4*(5), 14-15.

Frost, D.M., Cronin, J.B., & Levin, G. (2008). Stepping backward can improve sprint performance over short distances. *Journal of Strength and Conditioning Research, 22*(3), 918-922.

Fry, A.C., Housh, T.J., Hughes, R.A., & Eyford, T. (1988). Stature and flexibility variables as discriminators of foot contact during the squat exercise. *Jounral of Strength and Conditioning Research, 2*(2), 24-26

Gough, M. (2006). The forty-yard dash for the high school athlete. *National Strength and Conditioning Association, 28*(2), 24-25.

Hennessy, L., & Kilty, J. (2001). Relationship of the stretch-shortening cycle to sprint performance in trained female athletes. *Journal of Strength and Conditioning Research, 15*(3), 326-331.

Johnson, T., Brown, L.E., Coburn, J.W., Judelson, D.A., Khamoui, A.V., Uribe, B.P., & Tran, T. (2010). Effect of starting stance on sprint time in naia volleyball players. *Journal of Strength and Conditioning Research, 24*, 1.

McGee, K.J., & Burkett, L.N. (2003). The national football league combine: a reliable predictor of draft status?. *Journal of Strength and Conditioning Research, 17*(1), 06-11.

National Football League. (2010). *Scouting combine*. Retrieved from http://www.nfl.com/combine

NFL Scouting Combine. (2010). *Nfl scouting combine history*. Retrieved from http://www.nflcombine.net/history

Plunkett Research. (2010). *Sports industry overview*. Retrieved from http://www.plunkettresearch.com/Industries/Sports/SportsStatistics/tabid/273/Default.aspx

Sierer, S.P., Battaglini, C.L., Mihalik, J.P., Shields, E.W., & Tomasini, N.T. (2008). The national football league combine: performance differences between drafted and nondrafted players entering the 2004 and 2005 drafts. *Journal of Strength and Conditioning Research*, *22*(1), 06-12

Slawinski, J. , Bonnefoy, A. , Leveque, J. , Ontanon, G. , Riquet, A. , et al. (2010). Kinematic and kinetic comparisons of elite and well-trained sprinters during sprint start. *Journal of Strength and Conditioning Research*, *24*(4), 896.

Turner, A.N., & Jeffreys, I. (2010). The stretch-shortening cycle: proposed mechanisms and methods for enhancement. *Strength and Conditioning Journal*, *32*(4), 87-99.