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Active landing velocity: "pawing motion"

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Abstract
The significance of this study is to newly examine a factor of sprint performance. Previous studies have examined the limiting factor of vertical force of contact during a sprint. Studies have yet to look at the horizontal velocity of the foot with respect to the center of mass prior to contact in a sprint. This study will look at this horizontal velocity to examine if that is also a limiting factor during the sprint. Past studies have shown that vertical forces of sprinters are as big two to three times the body weight during a sprint then when trying to stand (Ficklin & Dapena, 2011) and that vertical force production (i.e. vertical impulse made in short times) limits the running speed of sprinters (Weyand; 2000, 2010)

The purpose of this study is to find out how fast sprinters can bring their feet backward as in active landing in order to determine what, if any, limits the motion may impose on sprint speed.

ACTIVE LANDING VELOCITY:

"PAWING MOTION"

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Research

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CHAPTER I

INTRODUCTION

Sprinting is used in many different sports. Yet, it may also be one of the hardest actions to master. The mechanics of running or sprinting are broken down into phases that are similar to the walking gait cycle, but with important differences. In running or sprinting there is a phase between toe off and contact phase, where the foot has no contact with the ground during the swing phase, also known as the "flight phase". When the foot makes contact with the ground, this is where jogging and sprinting differ. In sprinting, the athlete is makes contact on the ball or toes of their foot. In running, the athlete usually makes contact with the heel before transferring weight to the toes. In sprinting, the contact that is made with the ground during the stance phase has to be quick to have the muscle recoil for when it makes ground contact again (Novacheck, 1997). With faster athletes the contact time is shorter compared to slower individuals. According to Weyand et al.(2010), an athlete needs to be able to reposition their leg during swing phase to get ready for the contact time, but he showed in one of his studies that swing time doesn't change with speed. This helps us understand the importance of the rapid turnover needed during the flight phase. The quicker turnover in the flight phase increases the step frequency during the sprint (Kratky & Millier, 2013). During this contact phase of sprinting, little time is spent with surface contact; therefore one must be able to create a vertical impulse in a short time, which requires a big vertical force and power from the ground.

At initial foot contact, a braking impulse, which needs to be minimized, occurs. Sprinters use a motion called a "pawing" at the ground; this is where an athlete is getting their foot moving backwards relative to their center of mass prior to foot strike to try to minimizing the braking impulse. After an initial braking half of contact, the athlete gains propulsion by pushing downward and backward on the ground. Titls part of contact should be extended (Young, 2007). During contact, if one strikes too far ahead of themselves or strikes with their heel it will increase braking impulse, slowing down the sprinter.

Because the sprinter is a projectile during flight, ground contact is when velocity can be increased. The limits to this may be seen as vertical or horizontal. Vertical force made during contact must overcome sprinter body weight to propel the athlete upward again after contact. Horizontal forces initially slow the sprinter down during early contact, and then speeds them up in late contact. Previous studies have examined the \'ertical forces as a limiter of velocity of sprinting. These studies suggest that the ability to make vertical force on the ground is what limits running speed since making the time on the ground too long means the body center of mass translates forward more slowly during contact. To date, there are no studies examining any limitation that may be imposed by the ability to bring the foot backwards in "pawing" motion. Although it is known that the foot moves backward with respect to the body center of mass prior to foot strike, it is unknown just how fast a sprinter can do this.

This study will examine "pawing" velocity from a standing position in order to shed light on this motion as a limiting factor to the maximal velocity during a sprint. Understanding the relationship between this ability and running speed may illustrate new information about the limits of sprinting speed.

Significance and Purpose of the Study

The significance of this study is to newly examine a factor of sprint performance. Previous studies have examined the limiting·factor of vertical force of contact during a sprint. Studies have yet to look at the horizontal velocity of the foot with respect to the center of mass prior to contact in a sprint. This study will look at this horizontal velocity to examine if that is also a limiting factor during the sprint. Past studies have shown that vertical forces of sprinters are as big two to three times the body weight during a sprint then when trying while standing (Ficklin & Dapena, 2011) and that vertical force production (i.e. vertical impulse made in short times) limits the running speed of sprinters (\Veyand;2000,2010)

The purpose of this study is to find out how fast sprinters can bring their feet backward as in active landing in order to determine what, if any, limits the motion may impose on sprint speed.

Hypothesis

Ho: There is a limitation on how fast the foot is able to come back compared to maximal sprinting.

H1: There is not limitation on how fast the foot is able to come back between standing and maximal sprinting.

Delimitation:

In this study, the subjects range from professional athletes to recreational runners, having a wide range of age, skill level, and knowledge of sprinting. In addition, this study will only examine horizontal factors of sprinting.

Limitation:

By having different levels of knowledge of sprinting, there will be variability of motion. Not knowing how to properly execute the motions could magnify any limiting effects of the motion. Having different levels will also affect the subjects know what the cocked position is before bring the foot backward.

CHAPTER II

LITERATURE REVIEW

With sprinting being one of the most common fundamental movements that crosses many different sports, it is important to know what the factors are that could be a possible limitation for maximal velocity. And, if there are limitations in sprinting, is it possible for someone to partially overcome these limitations to train and become a faster-athlete. Therefore, in sprinting, it comes down to how much force the athlete is able to create with the ground in a short time (Bezodis, Kerwin, & Salo, 2008). The ability to measure how fast one can recoil their muscles to be able to create the same or even more force upon the ground. The muscle recoil and the energy transfer of the leg muscles are one the most important mechanical power that is needed for an athlete to create the power and lift needed to push them forward (Weyand & Davis, 2005). Mechanical energy used to reposition limbs is based largely on the elastic recoil and energy transfers between each of the body segments (Weyand et al., 2000). The different components of the legs with muscle, ligaments, and tendons are all used as springs when sprinting. Elastic energy is created when muscles, tendons, and ligaments are stretched and recoiled during the movements. This elastic behavior of the leg during a sprint somewhat mimics a single linear spring (Farley & Gonzalez, 1995). The sprint-like behavior of the muscles, tendons, and ligaments is one of the most important factors for being able to create forces more quickly.

The ability to make vertical force has been previously proposed as a limiter of sprint speed. In a Weyand et al. (2000) study that examined how faster running speeds are achieved, they looked at the force that was created on the ground. They concluded that at faster running speeds that had a bigger vertical ground forces were more important than rapid leg turnover as was previously thought. In another Weyand study with Sandell, Prime, and Bundle, they examined the actions of the athletes doing different kind of single legs hops. They looked at the hopping forces that are created and then compared them to the forces that are made when an athlete is sprinting (Weyand, Sandell, Prime, & Bundle, 2010).

Leg stiffness is used in many studies as a parameter to characterize leg function. This is based on ground reaction force and a mass-sprint model (Blum, Lipfert, & Seyfarth, 2009). Greater stiffness from the muscle is needed to be able to create greater vertical accelerations, meaning that faster speeds come from greater stiffness of the leg. This greater stiffness is needed to push the athlete off the ground in shorter contact time (Chelly & Denis, 2001). The stiffness of the knee and ankle joint helps create the spring-like behavior.The stiffness at the knee affects the stiffness that happens at the ankle joint (Kuitunen, Komi, & Kyrolainen, 2002).

The changes in the stiffness of the legs changes by alternating the stiffness between the hip and knee of the leg that touches down (Hobara, Inoue, Muraoka, & Omuro, 2010). The stiffness remains consistent during top-speed running velocity. The stiffness from the joint from the hip, knee, and ankle have different effects on running speed. Stiffness of individual joints determines leg stiffness (Brughelli & Cronin, 2008). Concentration of the hamstrings helps increase the stiffiiess of the leg for faster speed as desired (Chumanov, Heiderscheit, & Thelen, 2007). A spring-mass model is used in most cases to represent running during support (Morin, Dalleau, Kyrolfilnen, Jeannin, & Belli, 2005).

Overspeed training is a common way that coaches create the small contact time with the ground that is desired. In overspeed training, supramaximal muscular movements are performed in maximal and supramaximal sprinting. Overspeed training and eccentric training have effects on the two components of muscular performance that lead to a positive effect on power output. This kind of training helps stimulate the eccentric loading on the lower body (Cook Beaven, & Kilduff, 2013). Overspeed training, like running with a body-weight supporting kite, can help the athletes learn to reduce the contact time with the ground. This kind of training is a very specific method of training. This type of training should be used with additional sprinting training (Kratky & Millier, 2013). Downhill running is another way of training overspeed running. In an Ebben, Davies, & Clewien (2008) study, they examined the effects of running velocity and acceleration at different degrees of hill slope. They determined that to get the most benefit out of downhill running, slopes need to be 5.8° to get the maximize effect of sprinting. Overspeed training is one way of being able to examine how the active landing motion influence sprinting velocity by helping reduce the ground contact time.

Another type of training that is important to look at is resisted sprinting training. Resisted sprint training is a common method used to help improve sprint strength (Alcaraz, Palao, Elvira, & Linthome, 2008). Resisted training will have effect on the ground contact time when used by athletes. In Clark et al. (2009) study they looked towing influence on the kinematics of supramaximal sprint. The results from the study showed with this training contact time decreased, with the increase in stride rate. In Bowtell, Tan, & Wilson (2009) study examined the feedback-controlled of a treadmill and the comparison with maximum speed during over-ground running. In the study they showed that subject ran faster on the treadmill than over-ground. One of the factorS that caused this was the lack of air resistance. The treadmill got the subjects up to their maximal speed faster because of the belt pulling the foot backwards to help with the recoil. Resisted sprinting training is important to stride frequency and rate.

When examining a sprint, one needs to look at the stride frequency and rate. In Hanon & Gajer study (2009), they examined the velocity and stride parameters ofworld-class athletes and less experienced ones. World class sprinters use an aggressive pace strategy, which causes greater fatigue than in less experienced runner. With more strides taken and the greater distance covered in each, the quicker a world-class sprinter can get up to speed faster. It also shows the greater recoil of the muscle to bring the foot back faster. The rate and frequency that an athlete takes each stride shows how the stiffness is important to be able to create the force on the ground. To date, however, there is a dearth of information about the effects of leg-sprint stiffness overspeed training, resisted training, and stride frequency on the ability to bring the fort rearward with respect to the body center of mass prior to foot strike. To begin examination of these questions it must first be understood what the capabilities of the sprints are in the "pawing" motion.

CHAPTER III

METHODOLOGY

Subiects

In this study, 13 male subjects with varied age and skill level of sprinting participated. The data was collected via video analysis of the subjects standing and executing three trials. The video cameras that were used were CASIO EF-XI.

Procedure

In each trial, the foot is brought up into a cocked position matched to their previously analyzed running fonn. Each leg was recorded in three trials. Previously analyzed video data were used to find each athlete's maximal sprint speed and the distance the foot travels forward of the body center of mass in order to set a forward boundary for the cocked position . This portion was marked with a hanging pipe. Subjects then extended a cocked leg forward to their limit and brought the foot backward as fast as this was done three times for each leg.

Analysis

Video data were converted and moved to MaxTraq . Digitized from the frame the toe of the "pawing" foot was at the farthest point forward, with the onset of "pawing", up to foot strike, or when the toe passed the other, support toe. Custom matlab software was created to compute the velocity in meters per second based on a 5-m calibration distance.

After the data were collected from the matlab software the velocities of the right and left foot were compared from the real running speed and the real "pawing" speed, which were attained from the previous video data.

CHAPTER IV

RESULTS

The results from a paired t-test showed that when standing and executing the swing test, the subjects are able to bring their foot back in the "pawing" motion an average of 3.26 +/- 1.97 *mis* faster than when actual running (8.64 +/- 2.12 *mis* vs. 5.38 +/- 1.45 mis). However, they cannot significantly bring their foot backward in the "pawing" motion faster than their actual running velocity (8.64 +/- 2.12 *mis* vs. 8.23 +/- 1.00 mis, p= .1547).

Subjects	avgSwingLt (mis)	avgSwingRt (mis)	avgSwingBoth	comVel (mis)	runSwing (mis)
1	8.30	11.28	9.79	7.84	2.89
2	8.22	9.33	8.78	8.70	5.43
3	9.28	10.26	9.77	8.23	4.18
4	6.68	7.11	6.90	8.44	5.57
5	9.40	9.53	9.47	8.41	6.47
6	5.89	6.54	6.22	6.64	4.77
7	4.87	5.61	5.24	6.36	4.57
8	9.37	8.84	9.11	8.16	5.58
9	9.13	9.63	9.38	8.67	5.01
10	5.40	6.28	5.84	7.02	5.28
11	8.91	9.26	9.09	8.65	4.26
12	10.66	8.58	9.62	9.28	7.47
13	12.87	13.41	13.14	9.58	8.46
AVG	8.4 ± 2.2	8.9 ± 2.2	8.6 ± 2.1*	8.2 ± 1.0	5.4 ± 1.5

*Greater pawing speed than in actual sprinting ($p < 0.001$)

CHAPTERV

DISCUSSION

Discussion

The results from this study suggest that the subjects are able to bring their foot back equal to their running speed, but not faster. Therefore, it cannot be ruled out as limiting running speed. It is probable that the limits to running speeds are more complicated than just being "horizontal" or "vertical". Even though subjects are able to bring the foot back as fast as their running speed, this does not happen in sprinting until the foot is finally making contact on the ground. This means that there will always be a braking impulse at the foot strike.

This is probably due to the weight bearing conditioning of an actual spnnt, as well as there being a bigger forward swinging velocity of the foot prior to the "pawing" motion when compared to the motion of this specialized, designed task. Taken together these facts lend some credibility to the thought that backward velocity of foot is a limiter of the running speed. However, the question is more complicated than simply examining "vertical" or "horizontal" limits to sprint speed, and future research is needed to fully understand the question.

Since athletes are able to sprint at speeds faster than their "maximal" speed in overspeed training, there may be an important effect of the braking impulse also helping create backward foot velocity with respect to the body center of mass. To explore this, the active landing velocity of the foot prior to foot strike should be measured in overspeed training conditions.

Finally, it is evident that active landing, or "pawing", plays a role in reducing braking impulse. However, once on the ground, friction brings the foot backward with respect to the center of mass anyway, and so the importance of minimizing the braking impulse is hard to weigh against the importance of making vertical impulse in minimal time via large and rapid vertical force production.

Conclusion

Jn conclusion, this study helped showed that an athlete or anyone is able to bring their foot backwards in a "pawing" motion as fast as they are able to during an actual maximal sprint. This data is showing that the "pawing" motion cannot be ruled out as a limitation to maximal sprint speed. Future studies need to be done to look at how the "pawing" motion is effected during overspeed training or during a towing action, since during these actions the athletes are running faster than their "maximal" speed.

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