The Crouch Start Modeling and Simulation Based on AnyBody Technology

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Abstract

Crouch start technique is the most important factor in Sprint starting. For achieving the best starting moves fitting biomechanical characteristics of the human body, it is necessary to take comparative analysis on crouch start in biomechanics in order to obtain the fastest initial velocity through quick and timely departure from the quiescent state. In this paper carries on the sport biomechanics analysis in view of crouch start, and applies new three-dimensional force transducer system in the posterior starting block's inclined plane. And the experiment to gain the maximum treading force with the starting block's position variation. Modeling and simulation with AnyBody Technology, analysis results showed that athletes obtain larger forward momentum, the soleus and the gastrocnemius of max muscle activity also increases accordingly. Therefore, adjust the starting position to consider posterior starting block's factors. Maximum force can adversely affect the running fastest speed. To start training, improve athletes run speed has certain reference value.

Keywords: *Crouch Start, Muscle Activity, AnyBody Technology, Inverse Dynamics*

1. Introduction

In any sprinting, the starting is the most important factor for predicting success. So, there is a need to have an efficient starting type in the sprinting events. In this paper we look at testing the crouch starts for the correct block starts' positions. Within various limitations, we try to implement three types of sprint starts program which addresses the biomechanical needs of the sprints.

Sprinters comfortable is the psychological feel-good about the starting block distance between the posterior and the front, while discomfort is the physiological disaccording between the soleus and the gastrocnemius.

Crouch start is starting from a position with both feet and both hands on the ground. There are three types of Crouch starts [1]:

- Bunch or Bullet start - The toes of the rear foot are approximately level with the heel of the front foot and both feet are placed well back from the starting line.
- Medium start - the knee of the rear leg is placed opposite a point in the front half of the front foot.
- Elongated start - the knee of the rear leg is level with or slightly behind the heel of the front foot.

Research by Henry (1952) and Sigerseth and Grinaker (1963) [2] support the medium start as being the one that offers the most advantage to the sprinter.

The aim of this study was to design a crouch starts experiment and use three-dimensional force transducer for measuring the normal vertical pressure and the shear forces in crouch starts. Simultaneous acquisition crouch starts the movement of athletes between the shoe and starting blocks the three-dimensional interaction force and there are inputs AnyBody system for analysis and correction techniques of athletes. Action to improve the training effectiveness and athletic performance is of great significance

2. Crouch starts experiment

A preliminary experiment of the sole force measurement carries on the sport biomechanics analysis in view of crouch start, and applies new three-dimensional force transducer system in the starting block's inclined plane. And the experiment to gain the maximum treading force with the starting block's position variation in three types (See Figure.1 Figure.2).

This three-dimensional transducer thick is 12 mm. High speed signal acquiring system is connecting with computer. Experimental results are display and record on the computer (See Figure.1).

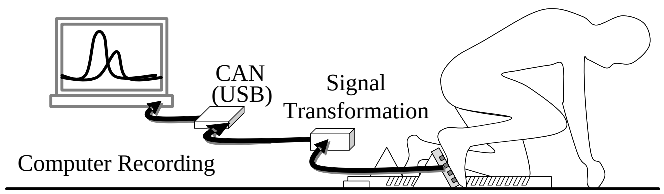

Figure 1. Experimental setup

Force of transducer of the starting was measured with a healthy sprinter (27-years-old male, height 180 cm and body mass 73 kg). Each type was measured five separately. The transducer coordinate starting block (See Figure.2).

Reference Figure.2 may promote the direction of three-dimensional force, F_Z and F_X composed together starting the power forward. And we observes sprinter starting the video recording and find the athletes body is swinging in the starting, this may explain F_Y produces reason.

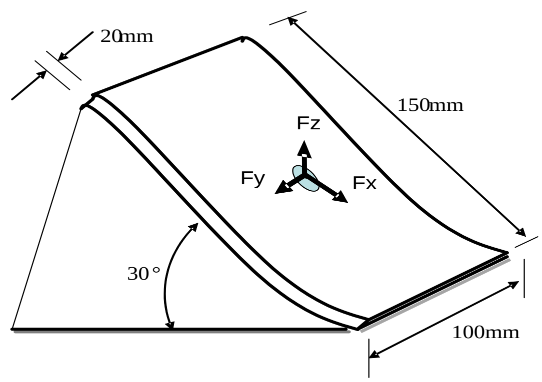

Figure 2. Transducer coordinate

The measurement result of the three-dimensional force of the direction of F_X, F_X, F_Z obtained by this experiment is shown in table.1. The three types in a result are displayed.

Table 1. The posterior starting block's the biggest three-dimensional force value in 3 places (F/N)

Starting mode	x/N	y/N	z/N
Bunch or Bullet start	85.8	46.8	136.2
Medium start	62.4	41.3	220.4
Elongated start	174.8	82.7	209.2

3. Modeling and Simulation

3.1. Inverse Dynamics

AnyBody mimics the workings of the central nervous system by computing backwards from the movement and load specified by the user to the necessary muscle forces in a process known as inverse dynamics[4]. This technique is known as inverse dynamics analytical. Human's inverse dynamics analytical process as shown in Figure.3

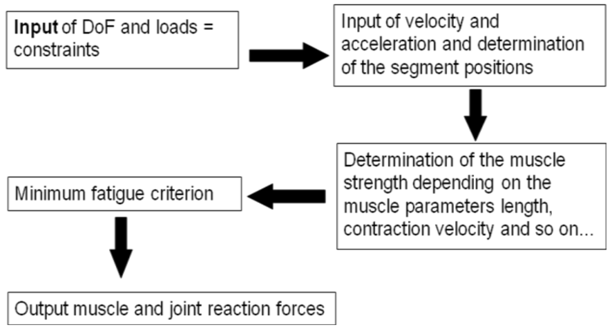

Figure 3. Inverse dynamics

AnyBody's full human musculoskeletal model estimates physical values on human kinematics with over 300 bones and muscles. AnyBody solves inverse dynamics problem of human musculoskeletal model. As figure.4 we input the bones.

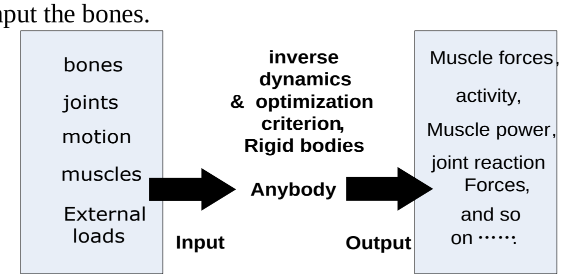

Figure 4. AnyBody technology analysis process

3.2. Sprint Best Preliminary Position

The sport biomechanics analysis in view of crouch start was carried on by AnyBody Technology. The best sprinter of all joint angles summarized as shown in Figure 5. However, these perspectives can be difficult to ensure every sprinter is the most suitable, but this should be a good ready position structure icon and coaches give their sprinter a basic reference.

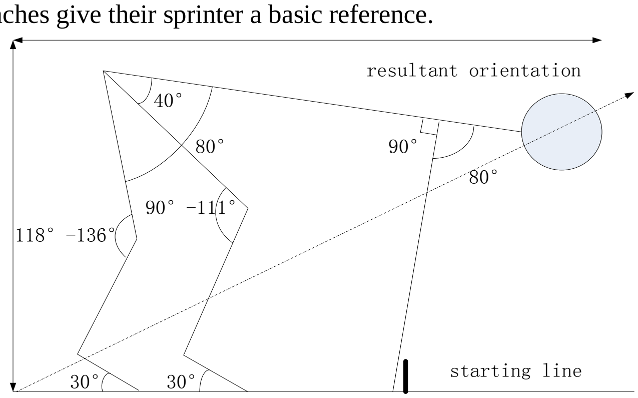

Figure 5. Sprint best preliminary position angles [3]

In practice, according to the sprinter's character and strength characteristics, feel, comfortable and technical characteristics, to make the corresponding adjustment. In this paper, the joint angles reference figure.5, then modeling and simulation utilize AnyBody Modeling System. The AnyBody Modeling System is the preferred musculoskeletal modeling and simulation tool utilized by the most renowned research institutions in the world. The AnyBody Modeling System enables researchers and students to build and analyze musculoskeletal models, or to freely draw upon existing model resources. AnyBody

Technology is suited for students of biomechanics, sports sciences, biomedicine and health technology, and kinesiology.

3.3. Important Position Parameter Setting

The numerical model of each important position parameter setting as follows:

- Pelvis setting

PelvisPosX= 0.5m;
PelvisPosY=0.68 m; // Pelvis height from the ground
PelvisPosZ=0;
PelvisRotX=0;
PelvisRotY=0;
PelvisRotZ=-80 degree; // Degree rotation around the Z axis

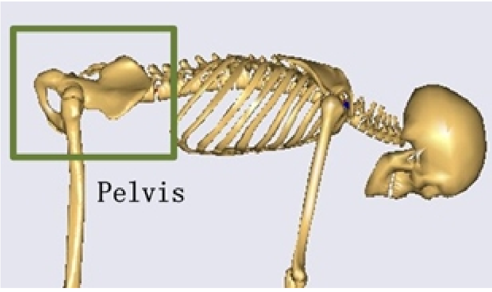

Figure 6. Pelvis position parameter setting

- PelvisThorax

PelvisThoraxExtension = -25; // the angle of bending down
PelvisThoraxLateralBending =0;
PelvisThoraxRotation = 0;

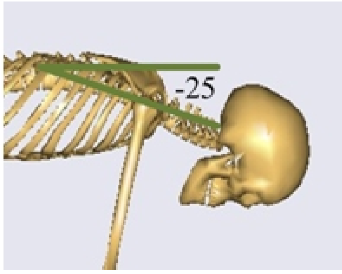

Figure 7. Pelvis Thorax position parameter setting

- Neck

NeckExtension = 20;

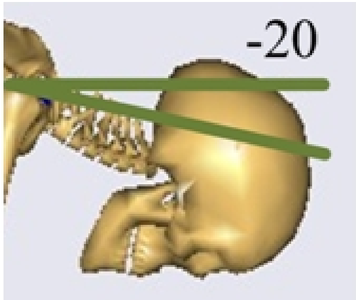

Figure 8. Neck position parameter setting

- SternoClavicular
  SternoClavicularProtraction = 0;
  SternoClavicularElevation =0;
  SternoClavicularAxialRotation = 0;
- Glenohumeral
  GlenohumeralFlexion = 90 degree
  GlenohumeralAbduction = 0;
  GlenohumeralExternalRotation = 0;

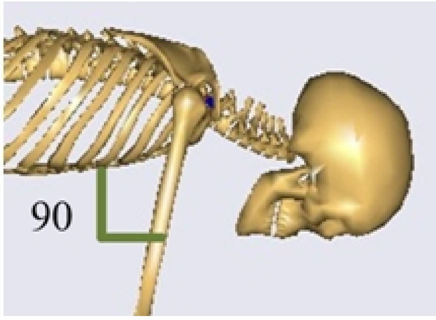

Figure 9. Glenohumeral position parameter setting

- Elbow
  ElbowFlexion = 0;
  ElbowPronation = 0;
- Wrist
  WristFlexion =90;
  WristAbduction = 0;

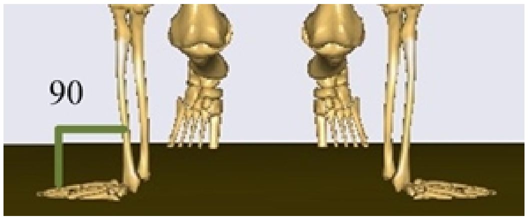

Figure 10. Wrist position parameter setting

Hip
HipFlexion = 80; degree
HipAbduction = 0;
HipExternalRotation = 0;

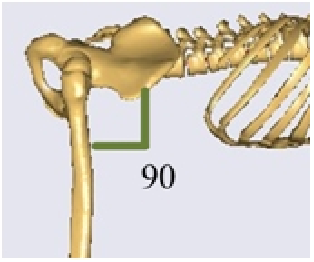

Figure 11. Hip position parameter setting

- Knee
  KneeFlexion = 80

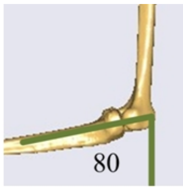

Figure 12. Knee position parameter setting

- Ankle

  AnklePlantarFlexion = 20;

  AnkleEversion = 0;

Figure13 shows the musculoskeletal simulation results of the crawl stroke by the developed simulator.

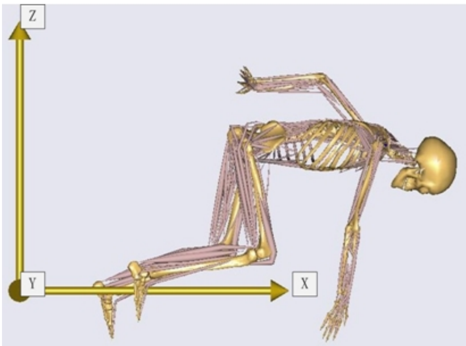

Figure 13. The building the musculoskeletal model of a crouch start posture using AnyBody modeling system

4. Compute the Forces in Crouch Start

The different muscles do indeed have very different forces. Muscle activity has been shown to increase during stress. At this place you can apply three-dimensional load vectors to any of the listed points. These load vectors are in global coordinates, which means that X is forward, Y is vertical, and Z is lateral to the right. To enable the model to actually carry the load we must equip it with muscles. This is done by selecting a body model with muscles. The results of musculoskeletal model simulation show in figure.14.

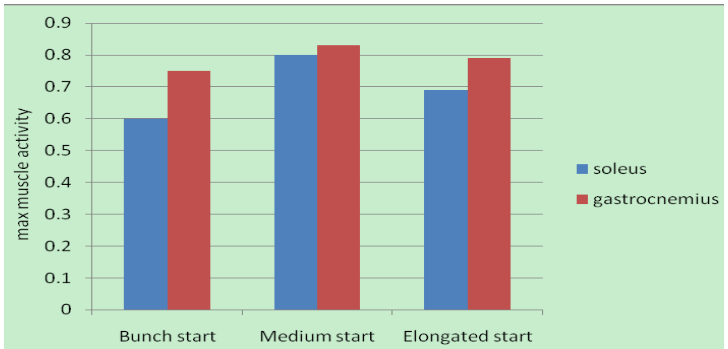

Figure 14. The max muscle activity of the soleus and the gastrocnemius in three types of crouch starts

This bunch show that to crouch start and carry the 60 N load in the soleus, the model is using 6.00e-001= 60% of its maximum voluntary contraction. This means that the relative load of the muscle with the max muscle activity in the system is 60% of the muscle's strength [4]. That sprinter obtains larger forward momentum, the soleus and the gastrocnemius of max muscle activity also increases accordingly [5]. So we see the bar illustrating the max muscle activity in three types similar to the picture below. The medium start that the soleus and the gastrocnemius of max muscle activity increases accordingly.

5. Conclusion and Future Work

In this paper, describes the importance in modeling and simulation technique with advanced level of development on crouch start. We aims to explore the best position of crouch start according to biomechanical characteristics. The results show that the medium start has been proven superior over both the bunch and elongated starting positions in terms of values of the sprinters. The medium start, compared to the other two starts, allows the sprinter to exert a higher force against the start blocks, which in turn produces the max muscle activity so that the sprinters leaves the start blocks with the greatest possible velocity. The future works will be testing more motions to the physical training, sport training and so on.

6. Acknowledgements

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7. References

[1] http://www.brianmac.co.uk/sprints/starts.htm
[2] PO Sigerseth, VF Grinaker, Effect of foot spacing on velocity in sprints , Research Quarterly, 1962
[3] http://www.iaaf.org/
[4] http://www.AnyBodytech.com/
[5] Guissard, N., Duchateau & Hainaut. EMG and mechanical changes during sprint start at different front block obliquities. Medicine and Science in Sport and Exercise, 1992,24 (11), 1257-1263
[6] Winnie Tsang, Karan Singh, Eugene Fiume. Helping Hand: An Anatomically Accurate Inverse Dynamics Solution for Unconstrained Hand Motion. Eurographics/ACM SIGGRAPH Symposium on Computer Animation 2005, pp. 1–10
[7] SI Wen YAN Zhuang-Zhi LIU Shu-Peng. Analysis of the Three-dimensional Impact Force between Shoe Sole and Starting Blocks in Sprint. Chinese Journal of Biomedical Engineering 2010, 29(4),pp.578-582
[8] Wen-Ming Chen, Peter Vee-Sin Lee, Seung-Bum Park. A novel gait platform to measure isolated plantar metatarsal forces during walking. Journal of Biomechanics 2010.43,pp.2017–2021
[9] Tao Liu, Yoshio Inoue, Kyoko Shibata. A wearable force plate system for the continuous measurement of triaxial ground reaction force in biomechanical applications. Meas. Sci. Technol 2010
[10] Razian MA. A miniature piezoelectric triaxial force transducer and a novel charge multiplexing technique for biomedical applications (gait analysis) [D]. Kent：University of Kent, Canterbury, 2000.10-15.
[11] Hopker JG, Coleman DA, Wiles JD. Familiarization and reliability of sprint test indices during laboratory and field assessment [J]. Journal of Sports Science and Medicine, 2009, 8(3): 528-532
[12] Mackey JR, Davis BL. Simultaneous shear and pressure sensor array for assessing pressure and shear at foot/ground interface[J]. Journal of Biomechanics 2006, pp. 2893-2897, doi:10.1016/j.jbiomech.2005.10.001
[13] Chinese Athletics Association. The regulations of the Athletics 2008[D]. People's Sports Publishing House. 2008,pp.107-109.
[14] Vitor Tessutti, Francis Trombini-Souza, Ana Paula Rsibeiro. In-shoe plantar pressure distribution during running on natural grass and asphalt in recreational runners[J]. Journal of Science and Medicine in Sport 2010, pp.151-155, doi:10.1016/j.jsams.2008.07.008.