Volume : 4 | Issue : 9 | Sept 2015 • ISSN No 2277 - 8179

Research Paper

Identification of Trail Leg Recovery Acceleration Curve Profiles For Use in Matching Track and Field Athletes to Events

Physical Education

KEYWORDS : accelerometer, sprint, pelvic tilt, acceleration curve, track and field

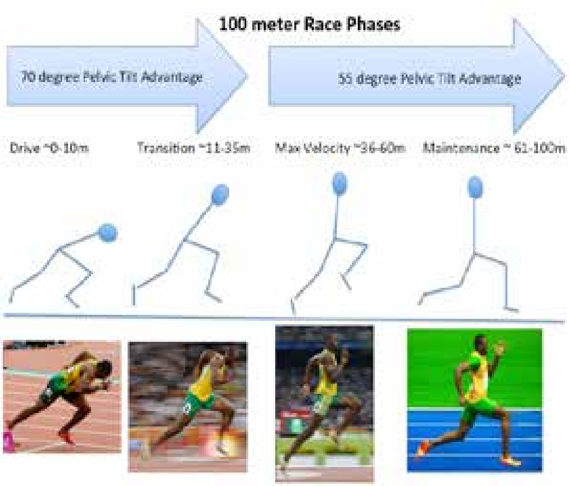
William E. Johnson Department of Human Performance and Sport Sciences, Tennessee State University

ABSTRACT

For many years, coaches and trainers have been looking for athletes that fit the mold of the typical sprint somatotype. Unfortunately the majority of the studies have focused on the "Max Velocity" phase of the sprint, leaving the start (drive and transition phases) relatively uninvestigated. The purpose this study was to identify trail leg recovery acceleration profiles (a key determinant of stride frequency) for use in matching track and field athletes to events. Collegiate track and field athletes with high levels of experience performed a series of trail leg recoveries at two different pelvic tilt angles while wearing an accelerometer. A series of four model acceleration curves were identified and associated with event characteristics and levels of performance: QAHP - Quick Explosive Acceleration with High Peak Force; QAMP - Quick Acceleration with Moderate Peak Force; LAMP - Low Acceleration with Moderate Peak Force; and LALP - Low Acceleration with Low Peak Force.

For many years, coaches and trainers have been looking for athletes, sprinters in particular, that fit the mold of the typical sprint somatotype. There have been a number of studies completed on the ideal sprinter body contour (Heglund, Taylor, & McMahon, 1988; Vucetic', Matkovic' & Sentija, 2008; O'Connor, Olds, & Maughan, 2009; Sedeaud, Marc, Dor, Scipman, Dorsey, Haida, Berthelot & Toussaint, 2014; Knechtle, Knechtle, Schulze & Kohler, 2008; Claessens, Hlatky, Lefevre & Holdhaus, 1994; Howel, 1965; Jeffries, 2011; Blache, Bobbert, & Monteil, 2011; Johnson, 2015; Young, 2006). These studies found that there was a high degree of correlation between a body contour of this type (increased pelvic tilt) in terms of two things, vertical jump (a measure of leg power) and, speed (the ability to sprint). It has been theorized that this body contour puts the body into a more ideal position and thus more adaptable to the sprinting motion, which utilizes a slight forward lean (Miller, 1979). During the phases of acceleration, the body is leaning forward; once maximum acceleration is reached, the body is straight up and down (vertical) (Ecker, 1976). Steve Miller, NCAA Championship track coach notes that when the "pelvis is tilted forward, the body is in more of a natural alignment for the running position itself, it seems to indicate that either it is easier to begin acceleration or acceleration is easier to maintain, and this assists in acceleration itself" (Miller, 1979).

Figure 1: Race Phases and Acceleration Lean



To date, both qualitative and quantitative sprint studies have investigated the activity in two major areas: direct performance descriptors and upper and lower body kinematics. Direct performance descriptors are those variables most often used to describe a sprinter's overall performance (i.e., horizontal velocity, stride rate, etc.). Although these variables give little insight regarding how a performer is physically producing the performance, they are critical in determining the level and nature of the effort. Upper and lower body kinematics include those movement patterns that actually produce the performance [i.e., upper arm angular velocity, lower leg angular position, etc.] (Mann and Herman, 1985). If the proper results in this category are analyzed, insight can be gained into how the direct performance descriptors are produced, and potentially aid in selection of athletes who embody those characteristics.

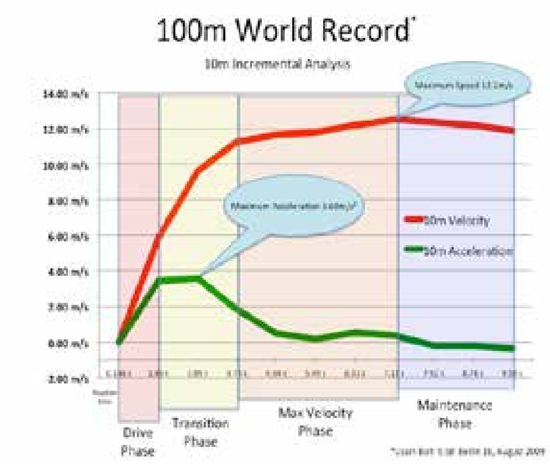
A number of variables that describe a sprinter's performance (stride rate and stride length, support and nonsupport time) have frequently been the focus of previous investigations. Sinning and Forsyth (1970) and Hoshikawa, Matsui, and Miyashita (1973) both found that increases in running velocity were accompanied by a combination of increases in stride length and stride rate, with stride rate becoming the more important factor at higher running velocities. However, in both studies, the subjects were tested on a motorized treadmill that enabled them to run only at a maximum of 6.6 m/s and 8.33 m/s, respectively. In a study that investigated maximum sprint effort (9.3 m/s), Luhtanen and Komi (1978) found that stride length leveled off at high velocities, whereas stride rate continued to increase.

These findings were later supported by Mehrikadze and Tabatschnik (1982) utilizing performance data collected on leading Soviet sprinters. Kunz and Kaufrnann (1981), using a small group of world-class sprinters (n = 3), found a combination of greater stride length, higher stride rate, and a significantly shorter ground support time for the sprinters when compared to a group of decathletes (n = 16) performing a maximal sprint effort. Comparing collegiate level sprinters and elite-level sprinters, Herman and Mann (1985) found a significant difference in the stride rate (elite higher) and support time (elite lower). However, no significant differences were found in stride length or nonsupport time.

It is important to note that nearly all of theses studies examined the sprint mechanics during the maximum velocity phase only, that is >50 meters into a race, where the acceleration has returned to near zero and the athlete is in a full upright, vertical running stance and where stride length is at maximum (see figure 2: 100m World Record 10m Incremental Analysis). The focus of this paper is to identify acceleration somatic characteristics (pelvic tilt and resultant trail leg recovery) which facilitates faster stride frequency (turn over), enabling rapid acceleration up to maximal velocity (i.e., distances less than 50 meters).

Volume : 4 | Issue : 9 | Sept 2015 • ISSN No 2277 - 8179

Figure 2: 100m World Record 10m Incremental Analysis.



As Herman and Mann (1985 & 1982-83) note, the most consistent success factor identified in the sprint results of elite athletes is the action of the upper leg to terminate the nonproductive latter portion of ground contact, the better sprinters end ground contact early and quickly begin leg recovery. In his video analysis of Olympic sprinters, Mann (1982-83) identified that silver medalists accomplished this goal in both the nonfatigue and fatigue conditions. And that this abbreviated leg extension is one major factor in decreasing the critical ground contact time. During the recovery phase, all three sprinters produced similar full extension, followed by excellent flexion (high knee) positions. This flexion result is critical in initiating the production of upper leg velocity into and during ground contact. He continues, noting that while although all three performers (Olympic medalists) produced comparable results at touchdown, a major difference in this race was produced due to the ability of the medalists to increase the leg speed to a greater degree during the support phase. Since these velocity results have been identified as additional factors by which the critical ground time can be reduced (Mann et al., 1982-1983), it is evident that the success of the medalists was due in large part to the ability to produce this result.

Purpose

The purpose this study was to identify trail leg recovery acceleration/force profiles for use in matching track and field athletes to events.

Subjects

Ten male NCAA varsity (nationally ranked) track and field athletes attending a California State University and whose ages ranged from eighteen to twenty-six, and their sprinting experience varied from high school champions to NCAA Champions and world record holders. The group represented a heterogeneous collection of heights, weights, ages, and musculature.

Methodology / Instrumentation

Each subject was instructed to step down on a predetermined starting point so that the entire foot was flat on the floor. The subject was then instructed to bring his thigh to a position parallel with the floor as rapidly as possible. Each subject was instructed to perform this trail leg recovery three times in each position, the first position with the pelvis in 55 degrees of anteroposterior tilt, and the second position with the pelvis in 70 degrees of tilt. The third trial for each position was photographed and recorded for comparison.

An accelerometer was attached to a small aluminum plate and held firmly to the subjects' thigh with a Velcro strap. The subject's thigh was attached to the Orthotron swing arm with a padded thigh flexion attachment strap. The accelerometer was connected by a coaxial cable to a Tektronix T912 10 MHz storage oscilloscope upon which the acceleration of the limb produced an acceleration curve that was recorded for comparison.

The viewing screen of the oscilloscope was divided into sectional grids from which, once the speed through each grid was selected, the impulse time could be accurately read. The speed was set at 50 milliseconds each division. The voltage per division was set at 0.2 volts/division.

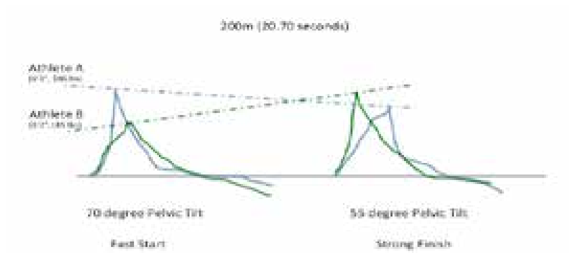
The triggering system was set at the internal source setting and at the normal mode. With this setting, the acceleration curve was recorded the instant any movement was initiated by the subject. The deceleration peak was initiated by a stop mechanism designed specifically for this investigation by the author. The pelvic tilt angle was measured with the aid of Johnson tilt-o-meter, also designed by the author.

Results

In comparing the oscilloscope tracings of the acceleration curves for pelvic tilts of 55 and 70 degrees, together with the event specialty and the individual's performance characteristics, a common feature was revealed. That being that those athletes whose performance characteristics included rapid, explosive force, and acceleration early in their event performance had a rapid high peak force curve while in the 70 degrees of pelvic tilt position. While those athletes whose performance characteristics included rapid, explosive force, and acceleration later in their event performance had a rapid high peak force curve while in the 50 degrees of pelvic tilt position. By viewing the shapes of the acceleration curves and the investigator was able to blind match individual athletes and their performance characteristics to their acceleration curve tracings.

Figure 3 depicts the tracing comparison of two athletes, one who has very fast start and one who has a very strong finish; both athletes have the same personal best time of 20.70 for 200 meters.

Figure 3: Athlete Performance Characteristics And Curve Profile



Four pelvic tilt curve profiles (at 70 degrees of anterior posterior pelvic tilt) were identified for use by coaches for (potential) talent identification and event assignment. Each curve profile corresponds to specific event characteristics, athlete performance characteristics, and level of competition categories. They are as follows:

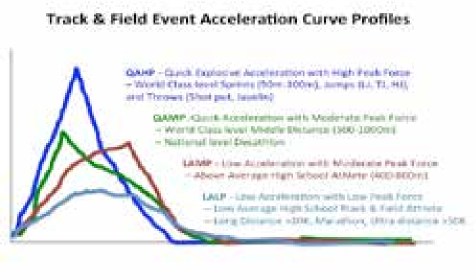
QAHP - Quick Explosive Acceleration with High Peak Force. Athletes with this profile were those athletes who were successful at the world-class level sprints (50m-100m), world-class level horizontal and vertical jumps (long jump, triple jump, high jump), and world-class level explosive throws (Shot put, Discus, Javelin)

QAMP -Quick Acceleration with Moderate Peak Force. Athletes with this profile were those athletes who were successful at the world-class level middle distance events (500-1000m), and national level decathlon

LAMP - Low Acceleration with Moderate Peak Force. Athletes with this profile were those athletes who were successful high school athletes (400-800m)

LALP - Low Acceleration with Low Peak Force. Athletes with this profile were those athletes who were successful low to average high school track & field athletes, and or national class long distance >20K, marathon, or ultra distance >50K athletes (events which do not require rapid acceleration of the production of great forces)

Figure 4: Track & Field Event Acceleration Curve Profiles



Conclusions

It is hoped that the identification of an additional tool for use by sport professionals in better identifying track and field athlete potential as well as in refinement of event assignment will bring about greater success for the athlete, while at the same time raise the level of performance. Most certainly, a greater understanding of the performance characteristics (limitations and advantages) of individual athletes' enable coaches to create more effective training programs and performance plans that address athlete performance deficiencies and maximize athlete efficiencies.

Additionally, this study serves to add to the body of knowledge regarding sprint performance, in that it focuses on the acceleration phase rather than the maximum velocity and maintenance phases. It has been said, "that you win a sprint race with the start and loose the race with the finish". A review of the 10-meter incremental analysis of Olympic and world championship 100meter races bears this out.

REFERENCE

Blache, Y., Bobbert, M., & Monteil, K., (2011). Influence of Initial Pelvic Tilt on Vertical Jump Height. http://homepages.ulb.ac.be/~labo/ISB2011/ISB2011_ScientificProgram_files/566.pdf | Claessens, A.L., Hlatky,S., Lefevre, J., & Holdhaus, H., (1994). The Role of Anthropometric Characteristics in Modern Pentathlon Performance in Female Athletes. J Sport Sci. August; 12(4):391-401 | Ecker, T. (1976). Track and Field Techniques Through Dynamics. Los Altos, California: Tafnews Press. | Heglund, N. C., Taylor, C. R., & McMahon, T. A., (1988). Speed, Stride Frequency and Energy Cost Per Stride: How Do They Change With Body Size And Gait? J Exp Biol 138:301–318 | Hoshikawa, T., Matsui, H., & Miyashita, J., (1973). In S. Cerquiglini, A. Venerando, and J. Wartenweiler (Eds.), Biomechanics III. Baltimore: University Park Press. | Howel, A. B. (1965). Speed in Animals: Their Specialization For Running and Leaping. New York: Hafner Publishing Co | Jeffries, K., (2011). Effects of Q-Angle and Pelvic Tilt on Broad Jump, Vertical Jump and 40-yard dash in NCAA Division I Athletes. ETD Collection for Tennessee State University. Paper AAI1497835. http://digitalscholarship.tnstate.edu/dissertations/AAI1497835 | Johnson, W. E., (2015). The Relationship Between Anteroposterior Pelvic Tilt and Trail Leg Recovery: An Accelerometer Study. International Journal of Scientific Research, July; 4(7):53-56 doi:10.15373/22778179 | Knechtle, B., Knechtle, P., Schulze, I., & Kohler, G., (2008). Upper Arm Circumference Is Associated With Race Performance In Ultra-Endurance Runners. Br J Sports Med. Apr;42(4):295-9; discussion 299. Epub 2007 Jun 28. | Luhtanen and Komi (1978). Luhtanen, P., & Komi, P.V. (1978). In P.V. Komi (Ed.), Biomechanics VI-B. Baltimore: University Park Press. | Mann, R. (1986). The biomechanical analysis of sprinters. Track Technique, 3000-3003. | Mann, R. (2005). The Mechanics of Sprinting. CompuSport: Primm, NV. | Mann, R. and Herman, J. (1985). Kinematic analysis of Olympic sprint performance: men's 200 meters. International Journal of Sport Biomechanics, 1, 151-162. | Mann, R.V., Herman, J., Johnson, B., Schultz, C., & Kotmel, J. (1982-83). The elite athlete project: Sprints and hurdles. USOC Technical Reports 1-1 1, USOC Training Center, Colorado Springs, CO. | Mehrikadze and Tabatschnik (1982) Mehrikadze, V., & Tabatschnik, B. (1982). An analysis of sprinting. Legkaja Atletika, pp. 8-10. | Miller, S., (1979). Personal Interview, Head Track and Field Coach, California Polytechnic State University, San Luis Obispo, California., November 20, 1979. | Nagahara, R., Matsubayashi, T., Matsuo, A., and Zushi, K., Kinematics of transition during human accelerated sprinting. Biology Open (2014) 3, 689–699 doi:10.1242/bio.20148284 | O'Connor, H., Olds, T., and Maughan, R. J., (2009), Physique and performance for track and field events. J Sports Sci. 2007;25 Suppl 1:S49-60. | Sedeaud, A., Marc, A., Marak, A., Dor, F., Scipman, J., Dorsey, M., Haida, A., Berthelot, G., and Toussaint, J. F., (2014) BMI, a performance parameter for speed improvement. PLoS One. 2014 Feb 25;9(2):e90183. doi: 10.1371/journal.pone.0090183. eCollection 2014. | Sinning, W.C., & Forsyth, H.L. (1970). Lower limb actions while running at different velocities. Medicine and Science in Sports 2:28-34. | Vucetic', V., Matkovic', B.R., and Sentija, D., (2008), Morphological differences of elite Croatian track-and-field athletes. Collegium Antropologicum, Sep;32(3):863-8. | Young, M., Swanson, S., and Li, L. (2004, June). Pelvic tilt kinematics change with increased sprint speed. Presentation at the ACSM Annual Meeting: Indianapolis, IN. | Young, M., (2015). Maximal Velocity Sprint Mechanics, HPC Sport.com 12/19/2006