



Relationship between Jump Test Results and Acceleration Phase of Sprint Performance in National and Regional 100m Sprinters

by

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The purpose of this research was to identify the relationship between jump test results and acceleration phase of sprint performance in national and regional 100m sprinters. Fifteen male (age 21.89 ± 3.26 years; body height $1.72.66 \pm 3.20$ m; body mass 61.35 ± 11.40 kg; 100 m personal best: $11.67 + 0.46$ s {11.00 - 12.19}) track sprinters at a national and regional competitive level performed 10 m sprints from a block start. Anthropometric dimensions, along with squat jump (SJ), countermovement jump (CMJ), continuous straight legged jump (SLJ), single leg hop for distance, and single leg triple hop for distance measures of power were also tested. Pearson correlation analysis revealed the single leg hop for distance with front and back leg (respectively, $r = -0.74$ and $r = -0.76$; $p = 0.021$ and $p = 0.017$), and the single leg triple hop for distance with front and/or back leg (respectively, $r = -0.84$ and $r = -0.89$; $p = 0.004$ and $p = 0.001$), generated capabilities to be strongly related to sprint performance. Further linear regression analysis predicted an increase in the single leg hop for distance with front and back leg of 10 cm, to both resulted in a decrease of 0.07 s in 10 m sprint performance. Further, an increase in the single leg triple hop for distance with front and/or back leg of 10 cm was predicted to result in a 0.08 s reduction in 10 m sprint time. The results of this study seem to suggest that the ability to gain more distance with the single leg hop and the single leg triple hop for distance to be good indicators for predicting sprint performance over 10 m from a block start.

Key words: Anthropometry, horizontal jumps, sprint performance, vertical jumps

Introduction

Both high level forces and angular velocities can produce high performance sprint running from a block start (Harland, 1997, Mero, 1983, 1992). Specifically, large forces generated by the leg musculature while in the starting blocks can lead to a performance edge over the other competitors in the race (Harland, 1997). An explosive sprint start requires a powerful angular drive of the arms, hips and legs (Hoster, 1979, Korchemny, 1992). On and off-track resistance training, therefore, underpins the athletic program of the competitive sprinter (Delecluse,

1995). In the gymnasium, the weighted squat jump (SJ), for example, is employed to increase the power of the hip and lower limb musculature (Harland, 1997). On the track, standard block start training is utilized to increase the athlete's hip drive a propulsive force generation while constructing a sound movement model to produce superior start performance (Korchemny, 1992). Interestingly, the effect of these resisted training methods on sprint start performance (from blocks) is not well documented and therefore, the effects of jump training, strength training or standard block start training methods on the start and early acceleration phases are not well understood (Harland, 1997, Korchemny, 1992). This

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is confusing as many methods are employed in the field without any experiential evidence to demonstrate their effectiveness for improving these phases of sprint running (Korchemny, 1992). Seemingly fundamental to the employment of these training tools is objective evidence that, firstly, confers these specific tasks are related to superior sprint performance and, secondly, these methods are suitable for each individual athlete regardless of their current physical power and sprinting performance capabilities (Harland, 1997, Mero, 1983, Korchemny 1992).

There is a paucity of published research into the relationship of strength and power measures with sprint performance using a block start. Abernethy and colleagues (1995) believed this to be reflective of the low priority given to publishing research of this nature by editors and researchers (Abernethy, 1995). However, such research is essential, as it allows predictors of functional performance to be identified, which aid talent identification, program development and may provide direction for biomechanical research. The majority of research studies that have examined the relationships between leg power and sprint ability have often used vertical or horizontal jump displacements as an indirect power measure with high correlations (Mero, 1983, Bret, 2002, Kukolj, 1999, Nesser, 1996). However, Bradshaw and Le Rossignol (2004) reported that the use of vertical height measures to gauge performance level in gymnasts was insufficient (Bradshaw, 2004). Actually, the few studies that have used more sensitive measures, such as force and power developed during the jump task, all have reported stronger correlations with sprint performance. For example, Liebermann D.G. and Katz L. (2003), Morin J.B. and Belli A. (2003), and Young W. and et al (1995) was found very strong correlations of $r = -0.88$ and $r = -0.86$ have been reported between sprint performance and countermovement jump (CMJ) and weighted SJ jump kinetics, respectively (12, 13, and 14). Whereas, Mero A. and et al (1983), Bret C. and et al (2002), and Kukolj M. and et al (1999) was found low to moderate correlations ranging from $r = 0.44 - 0.77$ have been reported by other researchers between sprint performance and jump height ability from a CMJ and SJ (Mero, 1983, Bret, 2002, Kukolj, 1999). Therefore, identifying the predictive ability of more sensitive kinetic jump measures with sprint performance, guarantees further research. Understanding jump training methods will better assist training prescriptions for track coaches and athletes.

The goal of this research was to identify the relationship between jump test results and acceleration phase of sprint performance in national and regional 100m sprinters. It was assumed that athletes who produced large force and power outputs relative to body mass during jump activities will obtain high levels of sprinting performance. It is expected that this relationship will be greater in the horizontal than the vertical jumps, due to the direction of force application and take-off angles.

Materials and methods

Fifteen male (mean \pm SD: age 21.89 ± 3.26 years; height $1.72.66 \pm 3.20$ m; body mass 61.35 ± 11.40 kg; 100 m personal best: 11.67 ± 0.46 s {11.00 - 12.19}) Iranian track sprinters at a national and regional competitive level participated in the current study. Each participant gave written informed consent to participate in this study prior to testing. Ethics approval was obtained for all testing procedures from the Shahid Chamran University, Iran of Technology Ethics Committee.

Testing was conducted at Takhti stadium with a Tartan track surface in Ahwaz city, Iran. Each athlete completed their own individual warm-up under the supervision of their coach. The athletes were then asked to perform four 10 m sprints from a block start. An experienced starter was used to provide standard starting commands to the athletes. The sprints were separated by a 3 minute rest period to ensure sufficient recovery. Athletes performed sprints in tight fitting clothing and track spike shoes. The two fastest trials for each condition were selected for the data analysis, with the average time from these trials used as the outcome performance measure.

Prior to jump data collection, anthropometric testing was conducted by an International Society for the Advancement of Kinanthropometry (ISAK) level 2 anthropometrist. Physical dimensions of height, mass, shoulder (biacromial) width, hip (biiliocrystal) width, femur (trochanterion-tibiale laterale) length, tibia to floor length (tibiale laterale), and tibia (tibiale mediale-sphyrion) length were measured. Upon completing the anthropometric assessment, each athlete completed their own individual warm up under the supervision of their coach.

Five types of jump assessments were performed by each athlete; squat jump (SJ), countermovement jump (CMJ), continuous straight legged jumps (series of 5 jumps; SLJ), single leg hop for distance, and

single leg triple hop for distance, all of which have been used extensively in the literature (Mero, 1983, Kukolj, 1999, Nesser, 1996, Bradshaw, 2004, Young, 1995, Arteaga, 2000, Markovic, 2004, Ross, 2002). All jump assessments were administered in a randomized order, with three trials of each jump assessment being performed. All vertical jumps which have are used extensively in evaluation of power variables were performed bilaterally, whereas the horizontal jumps were performed unilaterally, with each leg being tested in a randomized order.

For the SJ, the athletes started with their hands on their hips. They were then instructed to go down and hold a knee position (approximately 120° knee angle) for four seconds. On the count of four, the athlete was instructed to then jump as high as possible. A successful trial was one where there was no going down or countermovement prior to the execution of the jump.

The CMJ assessment required the athletes to start with their hands on their hips. They were then instructed to go down as quickly as possible and then jump as high as possible in the ensuing concentric phase.

The SLJ involved a series of approximately five jumps with straight knees using the ankles to jump. Athletes were permitted to hold their arms loosely by their side during the SLJ test, but were not allowed to use an arm swing to aid the jumps. Instructions were to jump for maximum height and to minimize their ground contact time in between jumps.

The single leg hop for distance required the athlete to begin standing on the designated testing leg with their toe touching the starting line, and their hands on their hips. Athletes were instructed to go down quickly and then jump as far forward as possible and land on two feet.

For the single leg triple hop for distance, athletes began by standing on the designated testing leg with their toe touching the starting line and hands on their hips. The athletes were instructed to take three maximal jumps forward as far as possible on the testing leg and land on two legs of the final jump.

Participants were given 2 practice jumps before the specific jump test was conducted. The jumps were separated by a 2 minute rest period to ensure sufficient recovery. Athletes performed jumps in comfortable clothing and running shoes. All trials were averaged and used in the data analyses.

Data collection

Swift timing lights (Swift Performance, University of Shahid Chamran, Iran) were utilized to record the time (80Hz) from the start signal, to when the athlete reached the 10 m line and broke the double beam of the timing lights. A microphone attached to a wooden start clapper was connected to the timing light handset, which triggered when the appropriate sound threshold was broken. A portable Kistler Quattro force plate (Kistler, Switzerland) operating at 500Hz was used to assess leg power for all vertical jumps. Horizontal jump assessments for distance were performed into a jump sandpit. The horizontal distance was measured from the start line to the jump landings closest point to the start line using a metal tape measure.

Force-time curves of the SJ, CMJ and SLJ were analyzed to determine the vertical displacement, peak and average take-off force, ground contact time (SLJ only), and peak take-off power (Kistler software, Switzerland).

Statistical analysis

Means and standard deviations were calculated for each variable. A linear regression analysis was used to quantify the relationships between the dependent variables and selected anthropometrical, force and power independent variables. The predictive strengths of each variable were ranked according to the product of the regression coefficient – beta (β) -- and the standard deviation for repeated measurements of each variable. The slope of the regression line is known as the regression coefficient beta (β) (i.e., straight line equation is $y = \beta X + a$, where y = outcome measure, X = predictor measure, and a = the constant intercept). The regression coefficient beta indicates the amount of difference (increase or decrease) in the outcome measure (y) with a one unit difference in the predictor measure (X). Pearson's product-moment correlation coefficient was also used to establish relationships between independent variables. Statistical significance was set at $p < 0.05$ for all analyses. All statistical procedures were performed using SPSS for Windows (version 17).

Results

The results for all sprint, anthropometric and jump measures are presented in Table 1 and 2. Sprint times for the early acceleration sprint (10 m) ranged from 1.71 s to 1.97 s. The strongest overall linear re-

Table 1

Means \pm standard deviations for sprint performance, anthropometric measures

| Parameters | Mean \pm SD |
|------------------------------------|-----------------|
| <i>Sprint performance measures</i> | |
| 10 m sprint (s) | 1.90 \pm .07 |
| <i>Anthropometric measures</i> | |
| Shoulder width (cm) | 40.0 \pm 3.53 |
| Hip width (cm) | 32.6 \pm 2.9 |
| Femur length (cm) | 41.0 \pm 5.3 |
| Tibia to floor length (cm) | 49.3 \pm 3.4 |
| Tibia length (cm) | 41.8 \pm 2.94 |

s (seconds), cm (centimeters)

gression that predicted 10 m sprint performance at-tested to the sprinters explosive ability to gain more distance with the single leg hop and the single leg triple hop for distance test. The following formulas present the best predictors of 10 m sprint performance, which was gained from regression analysis:

$$10 \text{ m Sprint time (s)} = 2.47 - [(0.74) \text{ the single front leg hop (m)}]$$

$$r = 0.75, r^2 = 0.56, p < 0.02, \text{ SEE} = 0.05$$

$$10 \text{ m Sprint time (s)} = 2.53 - [(0.76) \text{ the single back leg hop (m)}]$$

$$r = 0.76, r^2 = 0.58, p < 0.01, \text{ SEE} = 0.05$$

$$10 \text{ m Sprint time (s)} = 2.65 - [(0.84) \text{ the single front leg triple hop (m)}]$$

$$r = 0.84, r^2 = 0.71, p < 0.04, \text{ SEE} = 0.04$$

$$10 \text{ m Sprint time (s)} = 2.68 - [(0.89) \text{ the single back leg triple hop (m)}]$$

$$r = 0.89, r^2 = 0.79, p < 0.01, \text{ SEE} = 0.04$$

Pearson correlation analysis revealed the single leg hop for distance with front and back leg (respectively, $r = -0.74$ and $r = -0.76$; $p = 0.021$ and $p = 0.017$), and the single leg triple hop for distance with front and or back leg (respectively, $r = -0.84$ and $r = -0.89$; $p = 0.004$ and $p = 0.001$), generated capabilities which strongly related to sprint performance.

Predictors of 10 m sprint performance

Linear regression analysis predicted an increase in the single leg hop for distance with front and back leg of 10 cm, which resulted in a decrease of 0.07 s in 10 m sprint performance. Further, an increase in the single leg triple hop for distance with front and or back leg of 10 cm was predicted to result in a 0.08 s reduction in 10 m sprint time.

Table 2

Means \pm standard deviations for jump performance measures

| Parameters | Mean \pm SD |
|---|----------------------------------|
| <i>Squat Jump measures</i> | |
| Peak power (W/kg) | 64.28 \pm 21.88 |
| Average force (N) | 798.61 \pm 108.73 |
| Peak force (N) | 2455.73 \pm 546.02 |
| <i>Countermovement Jump measures</i> | |
| Peak power (W/kg) | 73.16 \pm 7.54 |
| Average force (N) | 730.18 \pm 118.73 |
| Peak force (N) | 2490.02 \pm 282.58 |
| <i>Continuous jump measures</i> | |
| Peak power (W/kg) * | 43.27 \pm 7.3 |
| Peak force (N)* | 2999.49 \pm 725.76 |
| Average force (N) * | 1178.37 \pm 357.71 |
| Contact time (ms) * | 49.08 \pm 2.73 |
| <i>Single leg hop for distance</i> | |
| Block front leg (m) | 1.97 \pm .02 |
| Block back leg (m) | 1.93 \pm .18 |
| <i>Single leg triple hop for distance</i> | |
| Block front leg (m) | 6.63 \pm .57 |
| Block back leg (m) | 6.50 \pm .57 |

* = average across the three series of five continuous jumps

Discussion

A greater understanding of the requirements of competitive male sprint athlete start and acceleration performance is required before effective testing; monitoring and training can be developed. The purpose of the research was to identify the relationship between jump test results and acceleration phase of sprint performance in national and regional 100m sprinters. The results of the present study revealed strength/power qualities (the single leg hop and the single leg triple hop for distance) to be significantly related to 10 m sprint performance from a block start. This indicates the importance of power production from the leg musculature in sprint performance. This jump assessment is performed with a rapid stretching of the lower limb musculature, while also contracting at a high velocity. This suggests that an athlete's relative explosive ability of their hip and knee extensors is critical to sprint performance. In fact, the stored elastic energy has been suggested to be necessary to sprint performance (Mero,1992).

In the first few steps of sprint running, the propulsion (concentric action) phase has been reported to be 81.1% of the total step duration (Mero, 1988). Therefore, it is no surprise that strong correlations

were revealed between the single leg hop and the single leg triple hop for distance and 10 m sprint time in the present study. The findings of the present study further emphasize the important association between the generation of high levels of concentric power and acceleration sprint running. It was expected that the relationships between jump tasks and sprint acceleration would be greater in the horizontal than the vertical jumps, due to the direction of force application and take-off angles.

Findings of this study were in accordance with the Nesser and colleagues (Nesser, 1996) findings, which reported a strong relationship ($r = 0.81$) between a horizontal 5-step jump and 40 m sprint time. Maulder and Cronin (Maulder, 2005) also reported strong relationships between 20 m sprint performance and horizontal single leg hop and single leg triple hop for distance ($r = -0.74$ and $r = -0.86$, respectively).

It has been suggested that particular anthropometric measures are pre-requisites for good athletic performance in various sports (Kukolj, 1999). Interestingly, the anthropometric dimensions measured in this study revealed poor, insignificant relationships with sprint acceleration. Hunter and coworkers reported height and leg length to be good predictors of acceleration phase velocity (Hunter, 2004) ($r = -0.64$ and $r = -0.56$, respectively). It is still unclear whether possessing longer lower limbs is advantageous to acceleration performance, as it is possible that the longer leg length would lead to an increased step length (via a longer stance distance), but it may have an adverse effect on step frequency due to a greater moment of inertia about the hip joint (Hunter, 2004). The lack of statistical strength to identify the leg length measures as predictors of acceleration performance in the present study compared to that of Hunter and coworkers (Hunter, 2004), may be due to the smaller subject pool used (36 vs. 15 subjects), or types of subjects used (male and female sports participants vs. competitive male sprinters).

Kyrolainen, Komi and Belli (1999) reported that in order for the running speed to increase so must force

production particularly in the horizontal direction. The authors suggested that these horizontal ground reaction forces (GRF) were primarily a result of the activity of the hip extensor muscles (Kyrolainen, 1999).

The ability to develop large horizontal forces in short time as to generate large horizontal impulses will result in high horizontal velocity when exiting the starting blocks (Kyrolainen, 1999).

Also the horizontal assessments commonly used in research and predominantly by coaches and physical conditioners are the triple hop and single hop for distance (Ross, 2002, Bandy, 2004, Bolgla, 1997). When sprinter located in acceleration phase (first 10m), his gravity center putted forward of his legs positions. Also, sprinter stature does not been orthostatic during first 10m after takeoff start block. Then, sprinter produced horizontal forces more than vertical forces to run forward, which is similar to the single and single triple leg hop jumping (Kukolj, 1999). So, probably the relationships between single and single triple leg hop jumping and acceleration phase time can be due to similar directions of produced forces in both two types of jumping and acceleration phase. More research is required to gain a better understanding as to whether or not physical statures, particularly limb lengths, are important for sprint acceleration performance.

Conclusion

The results of this study seem to suggest that the ability to gain more distance with the single leg hop and the single leg triple hop for distance are good indicators of predicting sprint performance over 10 m from a block start. However, the single leg hop and the single leg triple hop for distance need to be incorporated into a training study to validate the effectiveness of these exercises in attempting to improve sprint acceleration performance. Future research directions should include larger samples of elite sprinters.

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