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THE RELATIONSHIP BETWEEN RUNNING SPEED AND MEASURES OF VERTICAL JUMP IN PROFESSIONAL BASKETBALL PLAYERS: A FIELD-TEST APPROACH

Running Head: Running speed and vertical jump

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ABSTRACT

The purpose of the present study was to examine the relationship between vertical jump measures and sprint speed over 10m, 20m, and 40m in professional basketball players. 33 professional basketball players aged (\pm SD) (27.4 ± 3.3 years), body mass (89.8 ± 11.1 kg) and stature (192 ± 8.2 cm) volunteered to participate in this study. Subjects were randomly selected from a group ($n = 64$) of who have been professionals for at least two years. All participants were tested on Squat Jump (SJ), Counter-Movement Jump (CMJ), and 40m running speed. The results show that all jump measures in absolute terms were correlated significantly to running performance over 10m, 20m, and 40m sprint times. None of the jumping performance peak powers and reactive strength were found to have a correlation to running speed times in absolute term. Furthermore, all jump height measures relative to body mass except reactive strength had a marked and significant relationship with all sprint performance times. The results of this study indicate that while there is a strong and marked relationship between 10m, 20m and 40m sprint, there is also a considerable variation within the factors that contribute to performance over these distances. This may indicate that, separate training strategies could be implemented to improve running speed over these distances.

Key words:

Running speed; CMJ; SJ; Peak power; Reactive strength

INTRODUCTION

In recent years, coaches in different sports and researchers have recognized the importance of speed. In the past, they were convinced that speed was a genetic quality, and no one could improve it (6, 7). Today, genetics is considered to be one factor that can determine the athlete's maximum speed potential. It does not matter if the sport was soccer, team handball, basketball or tennis. Speed is very important and therefore, running speed over short distance would appear fundamental to success in a number of field and court sports. Power is the product of force and velocity (3, 13). Peak power is the highest instantaneous value achieved during a movement. In sports that require sprinting and jumping, peak power during the activity is typically the most important variable associated with success (3, 10). Knowledge of the power outputs and jumping height would therefore, be useful in terms of coaching, and it would be very vital in controlling the outcomes from the training program. However, the validity and reliability of this information are very important to effectively help the coach in improving athletic performance (2, 15). The purpose of this study was to correlate leg power, jumping height, and reactive strength as measures of jumping performance with sprint speed over 10m, 20m, and 40m. These distances are thought to be indicative of the starting speed, initial acceleration, and maximum sprinting speed capabilities, respectively, of the athlete (5, 16).

METHODS

Experimental Approach to the Problem

To test the relationship between running speed and measures of vertical jump, all subjects were called to an information meeting where the tests were presented theoretically. Testing was carried out over one week. Subjects were divided into three groups according to their clubs. Each group was tested as a part of their training at the same place and time of the day. The tests took place on Monday, Wednesday and Friday. Each group had training on one of these days. All tests were carried out in an inside court, which was 70m long and 40m in width. To minimize the testing errors, all subjects were asked to perform familiarization sessions on all tests as a part of their training at the same conditions as the actual test, and before the actual testing took place.

Subjects

The subjects were men ($n = 33$) aged (\pm SD) (27.4 ± 3.3 years), body mass (89.8 ± 11.1 kg) and stature (192 ± 8.2 cm) who volunteered to participate in this study. Subjects were randomly selected from a group ($n = 64$) of professional basketball players who have been professionals for at least two years. They were tested as part of their athletic training program at the completion of their pre-season training. All athletes had been involved in intensive resistance and sprint training three times a week, and were considered to be in peak condition at the time of testing. All participants gave their written voluntary informed consent and the local ethics committee at the Norwegian School of Sport Sciences approved the study.

Procedures

All participants had been given nutritional directions and were informed about the importance of upholding a normal diet and fluid intake towards testing day. Vertical jump and running speed were estimated using the Newtest Powertimer portable system (Model 300s). The Newtest Powertimer used in this study consists of a hand-held computer that is the control unit for the system, a contact mat that has a high density of sensors with a large measurement surface (84 X 95 cm), start switch, photocells that have a narrow infrared beam and no reflectors, and a portable briefcase with in-built connections and rechargeable batteries. On the testing day and before the testing took place, the participants' body mass and stature were measured. Body mass was measured using a body composition analyzer (Olympia 3.3 Model DT-1616); the Olympia 3.3 has high accuracy using tetra-polar method, and measures to the nearest 0.1 kg. Stature was measured using a wall mounted stadiometer that measures height up to 225cm. Then, the participants completed a 15 minute general warm up, which consisted of running at 60–70% of maximum heart rate. After the general warm-up, the participants were asked to do 4–5 accelerations over 40m. Then, the athletes were required to perform two maximum effort trials of Squat jump (SJ), Counter movement jump (CMJ), and 40m sprint. During SJ, the participants were instructed to hold a knee angle of 90° and perform the test from a semi-squat position which represents a pure concentric contraction. At the start, the knee was restricted to approximately 90° with the plantar part of the foot contacting the jump mat. The hands were on the hips, and the trunk was erected. After the jump, at the moment of impact, the knee was kept extending at a knee angle of 180° and the contact with the jump mat started with the toes. The counter movement jump was performed from a standing position with the plantar part of the foot contacting the jump mat with the hands on the hips and from an erect standing position with a knee angle of 180°, a counter movement was performed until the knee angle reached

approximately 90°. Then, immediately the athlete jumped. After the jump, at the moment of impact, the knee was kept extending at a knee angle of 180° and the contact with the jump mat started with the toes. Complete recoveries (greater than three minutes) were provided between each trial. The difference between the SJ and CMJ heights was considered to be a measure of the ability to utilize the muscle pre-stretching during the CMJ, which represent reactive strength (10). The hand-on-hips method was adopted in order to concentrate on leg and hip explosiveness and minimize jumping technique differences (3, 8). Running speed over 10m, 20m, and 40m was measured using the Newtest Powerimer start switch and photocells; the photocells used have a narrow infrared beam and no reflectors. The start switch and the photocells were connected through cables to the Newtest Powertimer portable briefcase that was connected to the hand-held computer. The participant started from a standing-up position placing the front foot on the starting switch. The time started automatically when athletes left the starting switch and stopped when they passed the photocells at 10, 20 and 40m.

Statistical Analyses

Raw data was transferred to SPSS 13.0 for Windows for analyses. Correlations were determined by using Pearson's *r*. Pearson correlation was computed to observe the relationships between all variables from jumping and sprinting speed time. The 0.05 level of significance was adopted for all statistical tests. A two-way mixed Intra-class Correlation (ICC) reliability and the coefficient of variation (CV) between trails were calculated for all measures in this study according to the guide lines provided by Hopkins (9).

RESULTS

The P-value for all reliability measures was $p < 0.01$. In addition, the between trial reliability for SJ was intra-class correlated (ICC) = 0.98 with a CV of 1.2 %, for the CMJ was ICC = 0.98 with a CV of 1.1%, the 10m sprint time was ICC = 0.96 with a CV of 2.8%, for the 20m sprint time was ICC = 0.99 with a CV of 1% and for the 40m sprint time was ICC = 0.99 with a CV of 0.5 %.

Measures of running speed times \pm SD were 1.88 ± 0.21 s, 3.20 ± 0.33 s and 5.39 ± 0.21 s for 10m, 20m and 40m, respectively. All jump height measures in absolute terms were correlated significantly to running performance over 10m, 20m, and 40m sprint times. However, no statistically significant relationship was observed when comparing running speed times to peak power or reactive strength (Table 1).

Table 1 about here

All jump height measures and peak power relative to body mass had a marked and significant relationship with all sprint performance times. Furthermore, no statistically significant relationship was observed between running speed times measures and reactive strength relative to body mass (Table 2).

*** Table 2 about here ***

DISCUSSION

There are two purposes for assessing athletic performance. First, and most common, is to quantitatively determine improvements made following a training cycle. This allows the athlete and sport performance professional to examine if a training stimulus was sufficient to cause a positive adaptation. This method does not however lead the professionals in the direction that they should focus the training on (2). Therefore, a second purpose of athletic assessment is to point out specific weaknesses in performance that utilizing various splits. In this study, splits were used to measure 10m, 20m and 40m. This allows these distances to be analyzed independently, and to present the relationship for each of these distances with measures of jump performance.

Reliability

The ICC reliability found in this study indicates a high repeatability between the trials' results. The variations for all measures were less than 5%, which indicate a small variation (9). However, this was expected as it has been found that reliability for SJ, CMJ and 20m sprint can be achieved through test-retest and without the need for familiarization sessions with physically active men (12).

Relationship between jump performance and running speed

The results in this study indicate that there was no significant relationship between sprint times over 10, 20, and 40m and measures of peak power in absolute terms (Table 1). The same results were detected by Baker & Nance (1), as they found that there is no relationship between sprint times and power in absolute terms. This is not unexpected, as sprinting involves high force production during support of the body weight. However, the results in this study show a

significant relationship between sprint times over 10, 20, and 40m and peak power relative to body mass. These findings are supported by Young et al. (15, 16) and Baker & Nance (1) who reported significant relationship between leg power relative to body mass and sprint performance, irrespective of the distance. Moreover, the highest correlation for 10 and 20m sprint times was with peak power relative to body mass, which was assessed through SJ, with a variance of 26.0 % and 30.3 %, respectively, as determined by the coefficient of determination (Table 2). Although the variance was large, it indicates that there are other factors that contribute in 10 and 20m sprint performance. In addition, the results indicate that there are significant relationships between sprint times over 10 and 20m and jump height in both absolute terms and relative to body mass (Table 1 & 2) which was also found in other study (1, 10, 16). However, the highest share of variance was observed between sprint times over 10 and 20m and jumping height in absolute terms assessed by SJ (Table 1) with a 28.1 % and 32.5 %, respectively. This could be explained by the concentric contraction only as it involves a higher support of the body weight compared to CMJ (16). These results show the importance for concentric contraction in the starting and acceleration speed. However, from the results in this study, we observed that the concentric contraction is more important to start and acceleration speed (0-10m) than for the acceleration speed only (10-20m). Furthermore, the fact that peak power relative to body mass had a higher relationship to 20m sprint time over 10m sprint time (Table 2), indicate that the more the athlete increases in acceleration speed the more important relative power becomes to performance during acceleration (1, 4). The jump height had a stronger relationship to 20m sprint time compared to 10m sprint time, this could be explained by a higher force production applied on the ground in the acceleration phase only (10 to 20m) compared to the start and acceleration (0 to 10m) (11, 14). Further explanation for the relationship observed between sprint times (10m and 20m) and measures of jump performance would be that the athlete at the start of the sprint needs to apply

maximal muscle effort action. As the subject starts to sprint, the body accelerates forward to a maximum velocity. This velocity is determined by the force that the muscle can generate against the ground, multiplied by the time during which the forces are applied which in turn equals power. As the athlete accelerates towards top speed through 20m, the foot contact time on the ground becomes relatively short, which makes force and leg strength more important than power in this phase (11, 14, 16).

All measures of peak power relative to body mass were significantly related to sprint performance over 40m, and exhibited much stronger relationship compared to 10 and 20m sprint performance (Table 2). However, the relationship between 40m sprint and measures of peak power in absolute terms indicates that as the subject reaches top speed, the need for power in absolute terms becomes less important, this could be caused by the shorter contact time between the foot and the ground (16). This shortening in contact time indicates that a larger portion of low-velocity strength is accessible for high-velocity sprinting. Therefore, the relationship between power in absolute terms and starting speed is stronger than between acceleration only (10 to 20m) and top speed (20 to 40m). However, the highest share of variance was between 40m sprint time and peak power relative to body mass assessed by CMJ 56.3 % (Table 2). The variance explains the need for stretch-shortening strength as the athlete reaches top speed. It is not surprising in this study to observe a higher variance for 40m sprint through CMJ, because the contact phase of sprinting at top speed is an example of stretch-shortening cycle (SSC) contraction of leg extensors. Since CMJ is a SSC movement, it could be expected that it would correlate with top speed (1, 16). However, Nance & Baker indicate that test involving high-force SSC movement such as CMJ, could be expected to have stronger relation with top speed than with starting and acceleration.

Reactive strength in absolute term and relative to body mass was not related to any of the sprint times in this study. However, the highest variance was observed between 40m sprint time and reactive strength relative to body mass (Table 2). Furthermore, several studies have found no relationship between reactive strength and straight sprint performance, those studies agreed on that reactive strength would become more important as a greater change in direction was required (15-17). Furthermore, Young et al. (16) indicated that reactive strength appear to be relatively more important for fast sprinting than for starting speed. This conclusion by Young et al. (16) could explain the results found in this study where the highest variance for reactive strength was towards the 40m sprint time determined by the coefficient of determination. However, different results were found by Young et al. (17), reactive strength was significantly and negatively related to straight sprint, indicating some relevance of this form of muscle power to straight sprint.

PRACTICAL APPLICATIONS

The results of this study indicate that while there is a strong and marked relationship between 10m, 20m and 40m sprint, there is also a considerable variation within the factors that contribute to performance over these distances. This may indicate that, separate training strategies should be implemented to improve running speed over these distances. Furthermore, it is recommended that when attempting to increase running speed, special attention should be paid to power per kilogram of body mass of the athlete. However, strength and conditioning coaches may need to implement a concentric only and stretch shortening cycle (SSC) jump squat testing battery to better analyze and plan the sprint and resistance training.

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Table 1. The relationship between measures of jump height in absolute terms and running speed times. (Relationship presented as Pearson r)				
Variable	Measures of jump height	Relationship to 10-m	Relationship to 20-m	Relationship to 40-m
CMJ	52.0 ± 7.5 cm	0.45* (r ² = 20.0 %)	0.49* (r ² = 24.0 %)	0.74* (r ² = 54.8 %)
CMJ Peak power	5167.2 ± 418.9 W	0.19 (r ² = 3.6 %)	0.18 (r ² = 3.2 %)	0.11 (r ² = 1.2 %)
SJ	43.1 ± 7.2 cm	0.53* (r ² = 28.1 %)	0.57* (r ² = 32.5 %)	0.74* (r ² = 54.8 %)
SJ Peak power	4609.1 ± 418.7 W	0.27 (r ² = 7.3 %)	0.24 (r ² = 5.8 %)	0.10 (r ² = 1.0 %)
Reactive strength	8.9 ± 3.5 cm	-0.13 (r ² = 1.7 %)	-0.11 (r ² = 1.2 %)	0.07 (r ² = 0.5 %)
* = Significant at p ≤ 0.05 r ² = shared variance				

Table 2. The relationship between measures of jump height relative to body mass and running speed times. (Relationship presented as Pearson r)				
Variable	Measures relative to body mass	Relationship to 10-m	Relationship to 20-m	Relationship to 40-m
CMJ	0.6 ± 0.1	0.41* (r ² = 16.8 %)	0.46* (r ² = 21.2 %)	0.74* (r ² = 54.8 %)
CMJ Peak power	58.1 ± 5.9	0.44* (r ² = 19.4 %)	0.49* (r ² = 24.0 %)	0.75* (r ² = 56.3 %)
SJ	0.5 ± 0.1	0.48* (r ² = 23.0 %)	0.52* (r ² = 27.0 %)	0.74* (r ² = 54.8 %)
SJ Peak power	51.8 ± 5.4	0.51* (r ² = 26.0 %)	0.55* (r ² = 30.3 %)	0.73* (r ² = 53.3 %)
Reactive strength	0.1 ± 0.0	-0.05 (r ² = 0.3 %)	-0.02 (r ² = 0.0 %)	0.23 (r ² = 5.3 %)