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

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<sup>2</sup>Department of R & D and Education, DNA Personal Training Studios, Amman, Jordan; <sup>3</sup>Department of Physical Education and Sport Sciences, Hashemite University, Al Zarka, Jordan; <sup>4</sup>Department of Physical Training, Norwegian Olympic Sport Center, Oslo, Norway; and <sup>5</sup>Department of Physical Performance, The Norwegian School of Sport Sciences, Oslo, Norway

## ABSTRACT

Shalfawi, SAI, Sabbah, A, Kailani, G, Tønnessen, E, and Enoksen, E. The relationship between running speed and measures of vertical jump in professional basketball players: A field-test approach. *J Strength Cond Res* 25(11): 3088–3092, 2011—The purpose of this study was to examine the relationship between vertical jump measures and sprint speed over 10, 20, and 40 m in professional basketball players. Thirty-three professional basketball players aged ( $\pm SD$ ) ( $27.4 \pm 3.3$  years), body mass ( $89.8 \pm 11.1$  kg), and stature ( $192 \pm 8.2$  cm) volunteered to participate in this study. All participants were tested on squat jump, countermovement jump, and 40-m running speed. The results show that all jump measures in absolute terms were correlated significantly to running performance over 10-, 20-, and 40-m 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 10-, 20-, and 40-m 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** sprint ability, 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 10, 20, and 40 m. 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 1 week. Subjects were divided into 3 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

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**TABLE 1.** The relationship between measures of jump height in absolute terms and running speed times.\*†‡

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	5,167.2 ± 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	4,609.1 ± 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 ( $r^2 = 0.5$ )

\* $r^2$  = shared variance (%); SJ = squat jump; CMJ = countermovement jump.

†Values are given as mean ± SD.

‡Relationship presented as Pearson  $r$ .§Significant at  $p \leq 0.05$ .

these days. All tests were carried out in an inside court, which was 70 m in length and 40 m 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) ( $27.4 \pm 3.3$  years), body mass ( $89.8 \pm 11.1$  kg), and stature ( $192 \pm 8.2$  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 2 years. They were tested as part of their athletic training program at the completion of their preseason training. All athletes had been involved in intensive resistance and sprint training 3 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 toward testing day. Vertical jump and running speed were estimated using the Newtest Powertimer portable system (Model 300s, Oy, Finland). 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 ( $84 \times 95$  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 a high accuracy using the tetrapolar method and measures to the nearest 0.1 kg. Stature was measured using a wall-mounted stadiometer (Model 206; SECA, Germany) that measures height up to 220 cm. Then, the participants completed a 15-minute general warm-up, which consisted of running at

**TABLE 2.** The relationship between measures of jump height relative to body mass and running speed times.\*†‡

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 ( $r^2 = 5.3$ )

\* $r^2$  = shared variance (%); SJ = squat jump; CMJ = countermovement jump.

†Values are given as mean ± SD.

‡Relationship presented as Pearson  $r$ .§Significant at  $p \leq 0.05$ .

60–70% of maximum heart rate. After the general warm-up, the participants were asked to do 4–5 accelerations over 40 m. Then, the athletes were required to perform 2 maximum effort trials of squat jump (SJ), countermovement jump (CMJ), and 40-m sprint. During SJ, the participants were instructed to hold a knee angle of 90° and perform the test from a semisquat 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 erect. 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 CMJ 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 countermovement 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 extended at an angle of 180°, and the contact with the jump mat started with the toes. Complete recoveries (>3 minutes) were provided between each trial. The difference between the SJ and CMJ heights was considered to be a measure of the ability to use the muscle prestretching during the CMJ, which represent reactive strength (10). The hand-on-hips method was adopted to concentrate on leg and hip explosiveness and minimize jumping technique differences (3,8). Running speed over 10, 20, and 40 m was measured using the Newtest Powerimer start switch (Oy, Finland) 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 40 m.

### Statistical Analyses

Raw data were 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 2-way mixed intraclass correlation (ICC) reliability and the coefficient of variation (CV) between trials were calculated for all measures in this study according to the guidelines 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 intraclass correlated (ICC = 0.98) with a CV of 1.2%, for the CMJ, ICC = 0.98 with a CV of 1.1%, for the 10-m sprint time, ICC = 0.96 with a CV

of 2.8%, for the 20-m sprint time, ICC = 0.99 with a CV of 1%, and for the 40-m sprint time, ICC = 0.99 with a CV of 0.5%.

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

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).

### DISCUSSION

There are 2 purposes for assessing athletic performance. First, and most common, is to quantitatively determine improvements made after 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 using various splits. In this study, splits were used to measure 10, 20 and 40 m. This allows these distances to be analyzed independently and to present the relationship for each of these distances with measures of jump performance.

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

The results in this study indicate that there was no significant relationship between sprint times over 10, 20, and 40 m and measures of peak power in absolute terms (Table 1). The same results were detected by Baker and Nance (1), because 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 40 m and peak power relative to body mass. These findings are supported by Young et al. (15,16) and Baker and Nance (1) who reported a significant relationship between leg power relative to body mass and sprint performance, irrespective of the distance. Moreover, the highest correlation for 10- and 20-m 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 20-m sprint performance. In addition, the results indicate that there are significant relationships between sprint times over 10 and 20 m and all jump height measures (Tables 1 and 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 20 m 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 because 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 (0–10 m) than for the acceleration speed only (10–20 m). Furthermore, the fact that peak power relative to body mass had a higher relationship to 20-m sprint time over 10-m sprint time (Table 2), indicates 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 the 20-m sprint time compared to the 10-m sprint time; this could be explained by a higher force production applied on the ground in the acceleration phase only (10–20 m) compared to the start and acceleration (0–10 m) (11,14). Further explanation for the relationship observed between sprint times (10 and 20 m) 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 toward top speed through 20 m, 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 40 m and exhibited much stronger relationship compared to 10- and 20-m sprint performance (Table 2). However, the relationship between 40-m 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 (10–20 m) and top speed (20–40 m). However, the highest share of variance was between 40-m 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 40-m sprint through CMJ, because the contact phase of sprinting at top speed is an example of stretch-shortening cycle (SSC) contraction of leg extensors. Because CMJ is an SSC movement, it could be expected that it would correlate with top speed (1,16). However, Nance and Baker indicate that test involving high-force SSC movement such as CMJ could be expected to have a stronger relation with top speed than with starting and acceleration.

Reactive strength in absolute and relative terms were not related to any of the sprint times in this study. However, the highest variance was observed between 40-m 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 that reactive strength would become more important because a greater change in direction was required (15–17). Furthermore, Young et al. (16) indicated that reactive strength appears 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 toward the 40-m 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 although there is a strong and marked relationship among 10-, 20-, and 40-m sprints, 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 SSC jump squat testing battery to better analyze and plan the sprint and resistance training.

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