Physiological and physical attributes in elite basketball: 
CORRELATES OF SUCCESS

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Introduction

- 450 million registered participants
- 213 national federations belonging to FIBA
- Monetary value of basketball
  - NBA paying 1.93 billion USD in salaries
  - Annual salaries frequently reaching over 500,000 euros in Europe
  - Minimum annual salary in 2009/2010 NBA season between 458,000 and 1,306,000 USD
- 2003-04 NBA season: average point difference 10.3 ± 6.6 points
- Small difference between winning and losing game

Enhanced physical fitness become important element of success

Aims

In this lecture we will compile scientific data considering structural and functional characteristics of elite basketball players with special reference to factors found to be highly correlated to performance.

Establishing the physiological profile of successful players could give coaches, trainers, and exercise scientists better working knowledge of this particular group of athletes.

Biographical data and correlations

- The biographical profile of basketball players can be characterized by the heterogeneity expressed within teams, between players’ competitive levels and across nationalities (Bolchuk et al. 1991, Hoffman et al. 1991, Viviani 1994).
- However, in modern sport, particularly basketball, professional experience and mature tactical judgement became important factors of performance excellence (Ostojic et al. 2006).
- The average age of top players is about 25 years (Parr et al. 1978, McInnes et al. 1995) with guard players being older and with significantly higher professional experience than other positional roles (Ostojic et al. 2006).
The fact that the guards are the oldest and most experienced players may be related to the specific requirements of the position, and unique tasks during the game (e.g., play-making, commanding, assisting) could play a role in mentioned difference. Yet, correlation between age and learning effects, skills and abilities requires more investigation.

Nowadays professional players do seem prepared to stay in the game for longer than was traditional. This is probably due to fact that professional level of game-play requires competent and well-trained players and commercial attractions of maintaining players’ career as long as possible.

Table 1. Characteristics of elite female basketball players (n = 20)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Guards (n = 10)</th>
<th>Forwards (n = 10)</th>
<th>Centers (n = 10)</th>
<th>Total (p = 20)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>25.5 ± 3.27</td>
<td>21.4 ± 3.12</td>
<td>23.2 ± 3.71</td>
<td>23.9 ± 3.6</td>
<td>18.4-26.4</td>
</tr>
<tr>
<td>Professional experience (y)</td>
<td>9.0 ± 2.01</td>
<td>6.0 ± 1.97</td>
<td>7.0 ± 2.11</td>
<td>7.0 ± 1.97</td>
<td>4.0-12.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>201.4 ± 6.04</td>
<td>200.2 ± 1.64</td>
<td>207.4 ± 2.61</td>
<td>206.4 ± 2.6</td>
<td>198.5-218.0</td>
</tr>
<tr>
<td>Wing size (cm)</td>
<td>180.5 ± 6.15</td>
<td>180.7 ± 1.32</td>
<td>181.2 ± 1.15</td>
<td>180.9 ± 1.21</td>
<td>176.6-192.2</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>8.5 ± 0.31</td>
<td>10.2 ± 2.61</td>
<td>13.4 ± 3.61</td>
<td>11.5 ± 2.6</td>
<td>5.1-13.1</td>
</tr>
<tr>
<td>Body mass index (BMI)</td>
<td>23.7 ± 1.69</td>
<td>23.3 ± 1.64</td>
<td>23.1 ± 1.67</td>
<td>23.0 ± 1.63</td>
<td>19.8-24.7</td>
</tr>
<tr>
<td>Waist circumference (%)</td>
<td>65.0 ± 6.04</td>
<td>64.0 ± 0.66</td>
<td>62.0 ± 0.66</td>
<td>62.0 ± 0.66</td>
<td>59.0-64.0</td>
</tr>
<tr>
<td>Vastus lateralis strength (p = 47.5 kg)</td>
<td>12.9 ± 2.01</td>
<td>10.7 ± 2.61</td>
<td>14.2 ± 4.09</td>
<td>11.8 ± 2.6</td>
<td>42.3-10.0</td>
</tr>
<tr>
<td>Vertical jump height (m)</td>
<td>0.9 ± 0.66</td>
<td>0.9 ± 0.68</td>
<td>1.0 ± 0.68</td>
<td>0.9 ± 0.68</td>
<td>0.7-1.0</td>
</tr>
<tr>
<td>Vertical jump power (N)</td>
<td>1,840.9 ± 200.6</td>
<td>1,754.8 ± 187.3</td>
<td>1,901.5 ± 197.3</td>
<td>1,891.5 ± 186.5</td>
<td>1,701.5-2,190.5</td>
</tr>
<tr>
<td>Fast running (s)</td>
<td>6.1 ± 0.62</td>
<td>4.4 ± 0.09</td>
<td>6.2 ± 0.81</td>
<td>6.4 ± 0.81</td>
<td>5.4-7.9</td>
</tr>
</tbody>
</table>

*Values are expressed as mean ± SD. BMI = body mass index; Vastus lateralis = vastus lateralis muscle; Vertical jump = vertical jump height.

Body size and composition in elite players

- Unique types of body size and composition may constitute important prerequisites for successful participation in basketball.
- Recent research on elite male basketball players has illustrated the development of the trend towards an increase in height and the variation in height and weight for playing positions in basketball (Vieari & Casagrande, 1990; Laten et al., 1994; Octopus, 2006).
- Morphological playing position differences between guards, forwards, and centers are more frequently observed in top level players (Sodhi, 1985), then in junior or university squads (Torota et al., 1987), implying the existence of unique playing-position-morphology at the top-level basketball.

Body size and composition in elite players

- The players (guards) with the lower mass, height and body fat percentage are the most skilled players and are used to set up the attacks which are sometimes completed by the taller players.
- Data on height, body mass and body composition of basketball teams from other studies suggests that players vary widely in body size (William 1985; Hoffman et al., 1991; Octopus, 2006), with recent studies found no significant differences in height, weight, and body fat among the four Greek basketball divisions (Metaxas et al., 2008).
- Thus, these parameters may not be essential factors for success in basketball although they strongly determine the playing positional role. A particular body size may be an advantage in certain match-play situation while disadvantage in other.

Energy requirements for basketball: clue to physiological profiling

- A question concerning whether to characterize basketball as an aerobic or anaerobic sport has been a subject of debate.
- Time-motion analysis done in the past (MCInnes et al., 1995) showed that during a basketball game players cover several thousand meters with frequent high speed multidirectional movements; variable in time and distance, further saturated with accelerations and continuous jumping efforts.
- Although it is evident that in order to execute such movement pattern both aerobic and anaerobic metabolic systems must be involved throughout the game, most investigators classify basketball as a sport relying primarily on anaerobic energy systems (Seeger et al., 1978; Hoffman et al., 1991).
- This almost universally accepted opinion has been substantiated with certain researchers which confirm a large amount of jumps and sprint occurrence during a game, demonstrating the importance of anaerobic power (Jarden & Mia, 1998), and the fairly high average blood lactate values recorded in competition implying a significant glycolytic energy system contribution (MCInnes et al., 1995).

Body size and composition in elite players

- Centers are usually significantly taller, heavier and with higher body fat
- Since the game involves body contact with the intention of getting the ball in a basket elevated 3.05 m above the ground level, physical attributes of centers could help them to dominate in low-post position which involves box-outs, picks and rebounding.
- The shorter the center, the higher he has to jump in order to play successfully in this aerial zone
- However, although height is an important predictive factor of whether center will reach the sports top level, it seems that it is not a relevant predictor of success in the sample of top level players, confirmed by the proposed minimal stature of 2.05 m (Sadlet, 2005).
In addition, Latin et al. (1994) proposed that a higher level of anaerobic power would be preferable and would reduce the risk for injuries and allow for more powerful rebounds, shooting and shuffling among other factors.

However, the change in FIBA rules in May 2000 seems to have a profound effect on game inducing a higher total time spent in high-intensity activities and greater number of actions per game thus making the game faster, and affecting the physiological characteristics of the players (Abdelkrim et al. 2007).

As far as anaerobic energy system is of concern, it seems that top level performance in basketball today heavily depends on players anaerobic power, while anaerobic capacity importance declined for "does not play a major role" (Delextrat & Cohen, 2008).

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Furthermore, it has been demonstrated that the players who played more time were also the ones who have highest values of vertical jump (Hoffman et al. 1996).

Since the ability to jump seems to be of great significance in basketball, it is of great importance to establish normative values that should be met by players in order to reach a top level performance.

Vertical jump is the most frequently employed test to assess anaerobic power, since jumping acts are part of various offensive and defensive skills performed by basketball players.

Several studies showed significant difference in vertical jump performance between different performance-level basketball players (Narazaki, 2000; Delextrat & Cohen 2008), suggesting that the best players tend to jump higher than others.

The average values of \( V_\text{O}_2 \max \) for elite basketball players tend to be lower compared to endurance athletes, with the most values ranging between 50-55 ml\( \cdot \)kg\( \cdot \)min\( ^{-1} \) (Par et al. 1978; Latin et al. 1994; Hoffman et al. 1999; Castrission et al. 1997; Ostojic et al. 2006).

Results of some recent studies indicate that \( V_\text{O}_2 \) values are most likely reaching 60 ml\( \cdot \)kg\( \cdot \)min\( ^{-1} \) (Narazaki et al. 2008; Abdelkrim et al. 2010), which suggests that this level of aerobic capacity could be considered optimal for elite basketball players, particularly guards and forwards.

Since the ability to jump seems to be of great significance in basketball, it is of great importance to establish normative values that should be met by players in order to reach a top level performance.
Other determinants of success

- Several studies evaluated muscular strength of the lower extremities in basketball players, with only few of them done in elite players with various types of strength tests were used thus providing little comparison data for its existence (Liègeois et al., 2000).
- In that regard, although lower body strength has been shown to be a strong predictor of playing time (Hoffman et al., 1994) and together with upper body strength is responsible for successful under the basket movement execution, considering the paucity of data, minimal lower body strength requirements for elite basketball players, not general nor by playing positions, cannot be provided.
- Future research is definitely needed in order to establish strength normative data for top level basketball players.

Other determinants of success

- There does not appear to be any widely accepted test for measuring basketball agility, with most frequently used test (Lancaster) being questioned for its basketball specificity (Liègeois et al., 2001).
- Moreover, sprint testing is saturated with similar methodological issues with different sprint distances used, thus preclude compiling large amount of data and concomitant establishment of reference values for different age and levels of play.
- In this respect, available data provide no firm background to make relevant suggestion considering sprint and agility performance requirements for top level basketball performance.
- Further research are needed on agility and speed in order to both clarify its relationship with basketball success and provide normative values for top level performance.

Other determinants of success

- Beyond vertical jump and maximal oxygen consumption, several other fitness parameters has been linked to basketball performance, with strength (both upper and lower body), speed and agility being most frequently studied (Liègeois & Liègeois, 2000).
- It has been generally accepted that elite basketball player should pose a high level of lower and upper body strength. In addition, extensive use of strength exercises in elite level professional basketball players (Simmons et al., 2001) have been reported.
- One repetition maximum (1RM) bench-press strength test appears to be most frequently used upper-body strength testing procedure in basketball, with surprisingly limited data published in scientific journals.
- Results presented by Delisi et al. (2008) showed that, compared to average-level players, elite players achieved significantly better performances in the 1RM bench press (+18.0%, p < 0.01), reaching 283.4 kg.
- Few other studies (Latin et al., 1994; Hoffman et al., 1996; Abdelkrim et al., 2010) reported a mean of 102.3 kg, 97.2 kg, and 87.7 kg respectively, with similar values among players playing different positions.
The success of the basketball team depends on how different individuals are blended into an effective playing unit. The coach could decide to alter the team's style of play according to the physical condition of the players, opponent or the circumstances in a game and these strategic differences in play style could have a large impact on the physiological requirements of the basketball player and athlete's training regime (Hoffman 2003).

More research work has to be done before definitive inference can be made; however, the results of the previous studies demonstrated relationship between aerobic and anaerobic power and positional roles in basketball.

Such qualities are prerequisite and advantage for playing basketball on elite level. From a practical standpoint, this information is important for coaches and trainers to adjust training regimes and concentrate on the variables that are specific to improve performance and achieve success in basketball.