



PHYSIOLOGIC PROFILE OF BASKETBALL ATHLETES

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INTRODUCTION

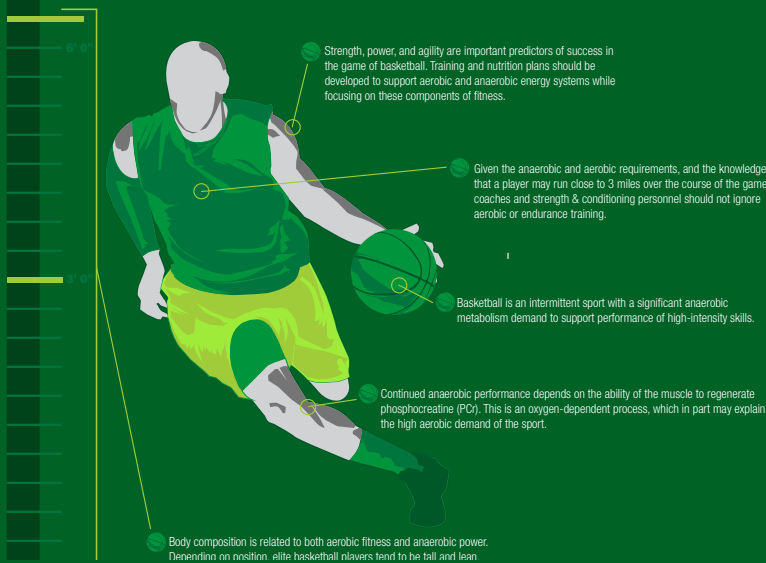
The sport of basketball requires specific skills that can be completed under dynamic conditions, in most cases while moving at a high speed or while changing directions. As a result, successful basketball athletes tend to possess high strength, power and agility while maintaining a fairly lean body composition. While most of the skill work is performed at a high intensity, a certain level of endurance is important to meet game demands throughout the duration of the contest. In comparison to other team sports, the aerobic demand

basketball players have been found to cover about 4500–5000 m (2.8–3.1 mi) during a 48-minute game.⁴ Also, in a simulated practice game, players were found to spend only 34.1% of the time playing, 56.8% walking, and 9.0% standing.²⁰ Therefore, both the aerobic and anaerobic metabolic systems are required.^{3,4,24} When designing training and nutrition programs, it is important to note that the overall physical load, based on heart rate, and oxygen demand are greater for games than scrimmage practice situations.¹⁹ Analyses of physiological requirements of basketball in the past 20 years showed a major reliance on the anaerobic metabolism across positions,⁷ with secondary reliance on the aerobic energy system.

The anaerobic energy systems supply energy for high-intensity, short-duration muscle contractions, and are composed of the ATP/PCr system and anaerobic glycolysis. The first, ATP/PCr, generates the energy molecule adenosine triphosphate (ATP) from phosphocreatine (PCr) and is dependent on the ability of the muscle to regenerate the PCr molecule. The second, anaerobic glycolysis, relies on glucose derived from muscle glycogen. Overall, the anaerobic energy systems are responsible for success in the large volume of jumps, sprints, accelerations and decelerations that occur during a game.^{14,16} Research has found that a player will have 1,000 changes of movement patterns, those changes occurring on average every 2 s;⁶ relying on the ability of the muscle to produce a large amount of energy quickly. It is clear that training the anaerobic energy system is a key to success in the game of basketball.

The aerobic energy system uses oxygen to convert glucose and fat to energy and helps maintain the lower intensity and longer duration movements, which represent about 65% of the active game time.¹⁶ Coaches often overlook the contribution of the aerobic energy system for success in basketball; however, aerobic capacity is related to successful performance of high-intensity work over a period of time. For example, a positive correlation was found between basketball-specific repeated sprint ability from game results to maximal oxygen uptake (VO_{2max}), indicating aerobic system maintenance during the last stages of the game.¹⁷ In other studies, VO_{2max} was correlated to the duration of running and jumping during a simulated game²⁰ and to oxygen uptake and intensity during game play.^{16,24} Average VO_{2max} values for female and male basketball players have been reported in the range of 44.0–54.0 and 50–60 mL/kg/min, respectively,²⁶ although values vary by position, with guards tending to have a higher aerobic capacity than centers.²³ One study suggests that monitoring the heart

Key findings



is less than soccer, but more than baseball and volleyball. While the demands and characteristics of the athletes differ by position, they are not as drastically different as a sport like football. This paper explores scientific data on structural and functional demands of elite basketball players to establish the physiological profile of successful athletes.

ENERGY DEMANDS

The game of basketball is characterized by frequent starts, stops, and changes of direction, all maintained over a period of time. While a quarter of game play for a high school athlete lasts 8 minutes of clock time, an average segment of play may last only 12–20 s.²⁰ However,

rate of players during practice is related to VO_2 max and could help to enhance the quality of practice in establishing and maintaining a level of aerobic fitness.⁸

The relatively high level of aerobic demand, despite the high percent of playing time spent walking and standing, suggests aerobic metabolism is critical in the removal of lactate and the restoration of PCr, which are known to be oxygen-dependent processes.²² The regeneration of PCr provides the muscle with energy to continue high-intensity contractions. Overall, the intermittent activity pattern in basketball demands aerobic capabilities sufficient to sustain repeated short bouts of high-intensity exercise.² The rules of the game, which allow ample substitution and provide rest periods during time-outs, halftime and between quarters, help promote the ability of the aerobic energy system to replenish the anaerobic system for sustained-high intensity efforts.

BODY COMPOSITION

Body composition, or the amount of lean muscle mass as compared to fat mass, is usually a consideration for most sports, and different compositions may predict success in different sports. While height, of course, is determined by genetics, changes in body composition can be achieved through proper training and nutrition.

For many basketball players, maintaining their weight and lean mass through the long competitive season is often the biggest issue.

Most elite basketball athletes tend to be relatively tall and lean. A specific body composition may not be an essential factor for success in basketball as in other sports, although it strongly determines a player's position. The guard position is usually characterized by a lower body mass, body fat percentage, and height, while the forward and center positions are usually taller, heavier, and have a higher percent of body fat.²³ A strong relationship exists between body composition, aerobic fitness, anaerobic power, and positional roles in elite basketball.^{5,20}

Little data exists on the typical body composition of high school basketball players. One study has been published in which high school male ($n=61$) and female ($n=54$) players in Madison, WI, were described.⁹ The female athletes weighed an average of 61.54 ± 8.68 kg (135.39 ± 19.10 lbs) with 20.45 ± 4.65 % body fat, and the males weighed an average of 74.95 ± 12.02 kg (164.89 ± 26.44 lbs) with 11.98 ± 4.30 % body fat. Vertical jump, sprint times, and agility testing were performed; however, the results were not analyzed in relation to body composition.⁹ On the professional level, **Table 1** summarizes the average anthropometrics of draftees and free agents in the NBA from 1997 to 2012.²⁵ Overall, the data on height, body mass and composition of basketball teams suggests that players vary widely in

| | Vertical Height (in) | Weight (lbs) | Percent Body Fat | Wingspan (in) |
|----------|----------------------|--------------|------------------|---------------|
| Guards | 74.68" | 199.32 | 7.57% | 79.26" |
| Forwards | 79.14" | 232.9 | 9.05% | 84.36" |
| Centers | 82.99" | 247.23 | 9.8% | 86.37" |

Table 1. NBA Draft/Free Agent Average Measurements 1997—2012 (N = 4196)²⁵

body size independent of success rates.^{14,18,21}

STRENGTH, POWER, AND AGILITY

Strength, power, and agility are important predictors of basketball performance.^{12,15,26} For example, lower body strength has been

shown to be a strong predictor of playing time,¹² and together with upper body strength is responsible for successful under-the-basket movement execution. Delextrat et al⁵ showed that elite players achieved significantly better performances in the 1-repetition maximum (1-RM) bench press (+18.6% or 223 lbs) as compared to average-level players. Interestingly, there appears to be a steady

decline in upper body strength over the past six years as observed in NBA Pre-Draft Combine workouts, where 10% of draft-eligible players could not bench press the minimum 185 lbs.²⁵

Agility is the ability to move quickly and change directions under control to execute sport skills, whereas power is the ability to rapidly combine speed and strength, the best example of which may be sprinting and jumping abilities. Elite players have been found to have superior agility and sprint times compared to average-level players.⁵ By position, point guards were found to be faster than forwards and centers in agility tests with surprisingly no differences among these players in sprint tests.¹⁰ Significant differences have been found in vertical jump performance between different levels of basketball players,^{5,10} suggesting that the best players tend to jump higher than others. Some basketball players have vertical jump values as high as 35" in order to fulfill requirements for top-level performance.^{1,15,21} **Table 2** shows Combine assessment data of NBA players illustrated by position.²⁵ Overall, to meet the demands of the game, basketball athletes should

focus on strength, agility and power development, using short and intense exercises. However, as described above, aerobic fitness should not be ignored, so a training program should also include work to build the cardiovascular base.

SUMMARY

Basketball combines a variety of individual and collective skills that are executed in the context of competitive play. Ideal physique and physiology are not sufficient for excellence in basketball.¹⁵ However, understanding these components and using this knowledge to create training and nutrition plans can benefit athletes of all skill levels. While strength, power and agility may predict success in basketball, the sport does have an endurance component and the aerobic and anaerobic systems contribute to the overall energy demands. Lastly, game and strategic differences in playing style could impact the physiological requirements of the basketball player and should not be discounted.¹¹

| | Vertical Leap (in) | Run Vertical Jump (in) | Bench Press (185 lbs) | Box Agility (sec) |
|----------|--------------------|------------------------|-----------------------|-------------------|
| Guards | 29.06" | 34.62" | 9.9 reps | 9.48 |
| Forwards | 27.37" | 32.77" | 11.2 reps | 10.44 |
| Centers | 25.72" | 30.29" | 12.3 reps | 11.35 |

Table 2. Average Combine Assessment Data of NBA Players by Position 1997—2012 (N = 4196)/25

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