International Journal of Physical Education, Sports and Health 2023; 10(6): 104-112

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2023; 10(6): 104-112

www.kheljournal.com
Received: 07-09-2023
Accepted: 12-10-2023

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A review study on the selected physiological parameters of elite male basketball players

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Abstract
In a study differentiating high and low-performance basketball players, various physical and physiological variables were evaluated, including body measurements and muscle girth. The differences were found in certain physical attributes but not in other characteristics like ectomorphic rating, blood pressure, and indices comparing body measurements. The aim of the study is to provide guidance to trainers and coaches in developing training programs for competitive athletes and to identify potential deficiencies in players for remedial measures.
Sport performance heavily relies on both health- and skill-related components of fitness, including power, speed, agility, reaction time, balance, and body composition. Lean body mass contributes to strength and power development, whereas excessive body fat can limit endurance and movement capacity. The study aimed to measure selected fitness tests and physical and physiological variables among national-level basketball players, encompassing grip strength, agility, leg explosive power, aerobic capacity, peak power, and fatigue index.
The findings highlighted the significance of anaerobic power in relation to explosive strength and agility, while aerobic power (VO_2) showed a significant direct relationship with muscular endurance. Interestingly, body fat percentage was found to be indirectly related to anaerobic power.
Research indicates that average $VO_{2\ max}$ values for female and male basketball players vary by position, with guards typically exhibiting higher aerobic capacities than centers.
In summary, these studies underscore the importance of both aerobic and anaerobic capacities, body composition, and various fitness components in evaluating and enhancing the performance of basketball players. The findings provide valuable insights for trainers, coaches, and athletes in designing effective training programs and understanding the physiological demands of basketball.

Keywords: Physiological variable, $VO_{2\ max}$, energy system, physical fitness, aerobic, anaerobic

Introduction
By nature, human beings are competitive and aspire for excellence in every given field. Sports are no exception. Not only individual but nations also want to show their supremacy in the field of sports. This friendly rivalry has inspired, and motivated all to sweat in strive, to run faster jump higher, throw faster, and exhibit greater strength, endurance, and skill in the competition arena. Science applied to sports has enabled modern youth to develop physical capacities beyond Imagination. Sports have become highly competitive, and performances are being surpassed every now and then.
Training has been accepted as a highly specialized science. Sports scientist and Coaches are thriving to understand various factor affecting skeletal and muscular activities, during a variety of man movement with the help of electro-myography and are engaged in analyzing the biomechanics of the performance of top athletes by focusing their attention upon the analysis of sports skills. They are consistently studying factors like strength, limb length, mass, inertia proportions, angular and linear velocity that influence these movements, to get a better insight into the complexities of human motion performance.
Basketball was invented as recreation and physical fitness mean for students in winter seasons at Springfield College of Physical Education. Later it has become one of the most popular and spectacular team sport in the World, which is played and watched through the world. Basketball involves approximately 450 million registered participants from over 200 national federations belonging to the Federation International de Basketball (FIBA).

Along with its popularity, competition and standard of basketball has improved at a fast pace over the years.

The improvement in basketball has not only taken place at International level, but at lower levels also. Reasons at the both levels are many folded. The main improvement factors among them are pertaining to scientific talent identification, improved methods of training, better training and coaching facilities, improved physique, better physical conditions, improved skills, better organization of competitions at various levels and contribution of media etc.

Basketball is highly technical and tactical team sport, which involves many techniques and tactics, like shooting, dribbling, passing, defense, rebounding and individual, group, and team tactics etc. These techniques and tactics were improved in many folds over the years.

Shooting is undoubtedly the most important fundamental technique in the game of basketball. In order to win a game, a team must outscore its opponent. Some basketball players are naturally good shooters and use a smooth, natural, well coordinated motion. Although there are numerous types of shots (jump shot, dunking and hook shots etc.) used in the basketball today but however, the jump shot is the most important shot among them. This revolutionary shot may be taken from any position on the court but best results can be obtained from within twenty feet.

Passing is rated as one of the other most important fundamental technique after shooting. To shoot the ball, a player has to obtain the ball, and this is usually done by one or more passes. A good passer is a valuable asset to any team, because he is able to get the ball by way of a pass to one of his team mate who is in a position to score. Although there are many different types of passes used in the basketball. The chest pass is a good, accurate, swift method of passing the ball. But however, in passing modern players are using vide variety of passes like one hand passes, overhead passes and variety of passes.

Dribbling is also a very important part of basketball when used at the proper time and in the correct manner. The dribble is used to drive close to the basket for a lay in shot, to advance the ball from the defensive court, to spread the defense, to obtain proper timing of a play, and as an offensive threat.

Modern basketball players are found to perform the technical skills such as dunking, hook shots, one hand jump shot etc in shooting technique. In dribbling, players are capable to dribble between the legs, behind the back and spin dribble etc. Even modern youth and junior players are capable to perform these skills.

It was mentioned by Basketball experts Subramanian (1981 (Kalley) (1983) [60] that the main basketball skills, essential in modern basketball are overhead passes, chest pass, speed dribble, zigzag dribble, lay-in shooting, jump shot and rebounding.

(2001) while studying junior basketball players mentions that the basketball is a complex technical team game and essential scientific inputs are needed to enhance the varying ability level of junior players so that the multi factorial determinants of success can be profiled latter at senior level.

The game of basketball is characterized by short and intense bouts of activity at medium to high frequency ((Gottlieb), 2009; Meckel *et al.*, 2009) [68, 69]. Such activity requires aerobic and anaerobic capabilities, both of which impact anaerobic performance ((Gottlieb *et al.*) 2014) [44]. The ability to continuously perform intermittent high intensity actions throughout the game is crucial for basketball players (Ben Abdelkrim *et al.*, 2007) [1]. Thus, higher aerobic capacity has been found to be essential for basketball players' performance in games and in practice (Castagna *et al.*, 2008) [17], in order to recover faster. Basketball includes high-intensity movements lasting less than 6 s and moderate intensity exercise of up to 60 s (Stolen *et al.*, 2005) [70].

The duration of physiological responses involving ATP, CP, and glycolysis responses to this type of activity is 5-6 s for a single sprint, and a contribution of the aerobic system is of less than 20%. During recovery from intense activity, when CP must be replenished, blood lactate concentration is used as a source of energy and phosphates accumulated in the cells are removed (Wragg *et al.*, 2000) [71]. For example, in basketball short recovery periods do not last long enough to fill the gap for such high-intensity activities. The ability of basketball players to continue to play well over time depends on rebuilding CP storage and removing waste products – both of which are functions of the aerobic system (Glaister, 2005) [42]. Basketball is one of the fastest team sports, and is characterized by exceptional movements such as sprints, changes of direction, dunks, rebounds and blocked shots (Gottlieb *et al.*, 2014) [44]. This means that basketball players need great athletic ability in order to most proficiently demonstrate speed, strength and power required to produce a successful basketball performance ((Delextrat and Cohen).

The game of basketball has undergone radical changes in the past decade. Coaches believe that the rule changes in May 2000 (Meckel and Gottlieb, 2009; Meckel *et al.*, 2009) [68, 69] that shortened offensive attack time from 30 to 24 s and the time allowed to cross the half court line from 10 to 8 s, as well as subdividing play time into four 10-min quarters instead of two 20-min halves, modified the tactical and physical demands of the game. Basketball players have been found to cover about 4500–5000 m during a 48–min game (Crisafulli *et al.*, 2002) [24], and spend only 34.1% of the time playing, 56.8% walking, and 9.0% standing (Narazaki *et al.*, 2009) [72]. Thus, identifying the physiological requirements of modern basketball is essential in order to develop and prescribe an appropriate physical training program (Abdelkrim *et al.*, 2007) [1].

Many of the key actions performed by basketball players in a game are based on horizontal movements (sprints and changes of direction), vertical movements (jump shots and rebounds) and combinations of movements within both of these planes, mainly when penetrating to the basket and blocking a shot (Meckel and Gottlieb, 2009; Meckel *et al.*, 2009) [68, 69]. These high-intensity movements are usually performed intermittently throughout the game (Gottlieb *et al.*, 2014) [44].

The fitness component and energy system in basketball

Many coaches and players equate athleticism with physical fitness in this type of sport. Being physically fit is essential from a health standpoint but the following fitness components are equally important for elite basketball players (Abdelkrim *et al.*, 2007; Gottlieb *et al.*, 2014; Shaher, 2011) [1, 44, 73] cardio respiratory fitness, muscular strength, muscular endurance, flexibility and body composition.

The first component, cardiorespiratory fitness, refers to the effective delivery of blood, oxygen and nutrients to the active body by the heart and lungs during physical work. Aerobic exercise improves cardiorespiratory function (Meckel *et al.*, 2009) [68] and also strengthens the heart muscle. Aerobic training can be done through any activity requiring continuous low-intensity effort for 20-60 min (Meckel and Gottlieb, 2009) [68]. In this sense basketball requires short and intense

periods of activity, during which players expend a great deal of energy at a rapid rate. Anaerobic pathways are another aspect of cardiorespiratory fitness, and provide energy for high-intensity activities. Thus the anaerobic energy systems must also be well developed (Abdelkrim *et al.*, 2007; Gottlieb *et al.*, 2014; McInnes *et al.*, 2008) [1, 44, 74].

The physiology underlying the aerobic and anaerobic energy systems is complex, and especially so in basketball (Gottlieb *et al.*, 2014; Meckel and Gottlieb, 2009) [44, 68]. On the one hand, the aerobic system, which supplies long-term energy, depends on the presence of oxygen for the production of ATP. This is the preferred energy source for exercise lasting more than 3 min (Castagna *et al.*, 2005; Meckel and Gottlieb, 2009; Meckel *et al.*, 2009) [16, 68, 69]. When basketball players begin exercising, both the aerobic and anaerobic energy systems are involved. However, the relative contribution of each energy source varies according to the demands of the exercise, which in turn vary as functions of the intensity and duration of the activity. Basketball is about 20% aerobic and 80% anaerobic, and therefore many factors influence the exact energy expenditure ratio for individual players (Abdelkrim *et al.*, 2007) [1].

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Successful performance not only requires the skill and techniques to play games, but also a sound physiological profile, with combination of ideal body composition profile. Low body fat, larger muscle mass and superior aerobic, anaerobic capacity and anaerobic power is desirable features when it comes to optimum athletic performance in many kinds of sports (Carter *et al* 1982, Meszarous & Mohacsi 1982, Pollock *et al* 1987) [15, 75, 76]. Over the last two decade's athletes have become more powerful and athletic performances have continued to improve with improvements in training methods. This has resulted in an increased interest in the measurement of anaerobic and aerobic ability. Accurate anaerobic power and capacity assessment is paramount for athletes, as many sports involve rapid rest to high intensity exercise transitions such as sprinting and jumping movements.

Maximal aerobic capacity or $VO_{2\ max}$, the amount of oxygen consumed in one minute of maximal aerobic exercise, is widely considered the standard test for aerobic conditioning. Improving $VO_{2\ max}$ is a crucial step in maximizing endurance performance in any event lasting four minutes or longer. The higher an athlete's $VO_{2\ max}$, the greater the contribution of the aerobic system to energy production. This translates into greater endurance at any intensity.

The most common test of aerobic system is $VO_{2\ max}$. This procedure is used universally because sports scientists can measure oxygen consumption directly. It is a valid procedure and the best indicator of athlete maximal aerobic capacity. (Willmore & Costill, 1994) [77].

The anaerobic formation of ATP system occurs at immediate onset of exercise and also when body's muscle works the oxygen utilization system's capabilities (i.e., very high intensities). The oxygen debt, defined as the recovery oxygen uptake above resting metabolic rates, has been discredited as a valid and reliable measure of the anaerobic capacity as it is generally acknowledged that mechanisms other than the metabolism of lactate also contribute to the post-exercise oxygen uptake. (Medbo *et al*, 1989) [78] (shamim, 2015) [79] investigate to show the difference between high performance and low performance basketball player in relation to their physical and physiological variable, further it aims to find the inborn and nurtured traits of the player which creates difference between them. Certain physical and physiological variable were selected for the study. Two groups were formed each containing 70 subjects. After evaluating the significant difference was found in weight, height, sitting height, femur bi-epicondyle diameter, humerus bi-epicondylar diameter, shoulder width, hips width, upper arm length, thigh length, lower leg length, biceps muscles girth, and calf muscles girth and no difference was found in ectomorphic rating, systolic blood pressure, diastolic blood pressure, ponderal Index, thigh length-lower leg length index, upper arm length-lower arm length Index and shoulder width-stature index of high and low performance basketball player.

Methodology: The review followed the systematic approach to investigate the physiological parameters of the elite basket-ballers. A comprehensive search of literature was done using multiple databases. The search term use was physiological, physiological parameters, $VO_{2\ max}$, elite, performance etc.

Inclusion Critea

- Articles published in English.
- Research discussing about physiological variables.
- Both qualitative and quantitative studies.
- Research conducted at elite and grass root level.

Exclusion Criteria

- Article not available in full text.
- Studies not directly related to the topic.
- Opinion articles, commentaries and editorials.

Analysis of physiological variables of elite basketball players

Karalejić & Jakovljević, 1998 [62]. Nowadays, basketball has the ability to show the improvements by having a great potential in our country and in the world; moreover, it can also increase the performance which can strengthen the social dialogue amongst people as well as showing developed sport with different training methods. Basketball represents a collective sport which is very popular both in Serbia and worldwide due to its attractiveness and dynamics. According to Roper (1996) [80] 11% of people in the United States are engaged in some form of basketball activity. It is a modern game which must be looked at as a high intensity sport.

Players face different tasks which must be completed at short intervals in the best possible way. Basketball is one of the most dynamic games with a constant change of typical and atypical situations. The player must perceive them quickly, analyze and adequately respond to them.

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Day by day, the increasing number of athletes brings high-level achievements in team sports such as basketball. Therefore, fitness parameters have come to the fore, such as cardio-respiratory fitness is required for basketball, muscular strength, muscular endurance, and flexibility along with body composition parameters. The athletes maintain high level of physical capacity during long periods, which is of great importance in this respect. These physical attributes determine the degree of motor sports items of an individual's body and power capabilities due to the complex power of nature. That's why, players should have particular physical skills to fulfill defense and offense skills in game (Brittenham 1997; Sevim 1991) [14]. Since basketball games are to be based on height due to air dominance, the height is an important physical feature to determine the performance. It is stated that in today's basketball game, it is completely carried out the high performance and as a result of the success achieved with tall and athletic player types (Miller 1996; Smith 1991) [81, 82]. Such features are also a factor in changing several motor characteristics. Although it has a negative effect on the mobility and the related motor properties (Açikada 1990) [3], it is suggested that tall basketball players shooting the rise of the curve can provide less use of force by means of the expenditure shot (Stone 1993) [83]. The required energy for short time and narrow space technical skills applications are produced by anaerobic way; thus it is known that basketball is a game that requires a high level of anaerobic fitness (Karakas 1985; Fox 1988; Günay 1999) [61, 33]. It has been concluded that approximately 20% of basketball consists of aerobic, whereas 80% anaerobic; however, 80% of the total energy contribution of anaerobic energy systems, including anaerobic -aerobic-anaerobic are continuously variable (Dündar 2004) [29]. It is known that high energy formation is needed for the implementation of the movement in a short time span in several sports. The basketball game removes the human organism and its expenditure to the foreground such as; leap, jump and sprint, especially through the applications of anaerobic energy (Fox 1988; Dündar 2004) [33, 29].

Kerketta and Singh (2016) [52] A study was conducted to compare Basketball and Kabaddi players concerning specific anthropometric measurements. Sixty male inter university players (30 Basketball players 30 Kabaddi players) GGV Bilaspur were selected for the research all aged between 18 to 25 years. The researcher focused on certain anthropometric parameters such as height weight, arm length, and forearm girth. Mean standard deviation and t ratios were calculated to compare these measurements between Basketball and Kabaddi players. The result indicated significant differences between both the groups in their selected anthropometric variables. The study found notable variation between the two groups in terms of height, weight, arm length and forearm girth. This suggests that Basketball and Kabaddi players exhibit significant differences in these specific physical characteristics.

(Kumar) (2016) [84] a comparative study was conducted to assess the physical and physiological profiles of basketball and handball players from Jammu University in Jammu and Kashmir state. The study involved 30 male players, 15 from each sport, with ages ranging from 20 to 25 years. All participants were actively engaged in regular practice and competitive play in their respective sport, having volunteered for the study after being informed about its aims and methodology.

The assessment focused on physical fitness components such as speed measured by the 50-yard dash and agility evaluated through the shuttle run. For physiological fitness components, pulse rate and blood pressure were measured using a digital sphygmomanometer. The significance level was set at o.05.

The results of the study indicated that handball players exhibited greater speed abilities compared to basketball players. However, in terms of agility, pulse rate and blood pressure, no significant differences were observed between handball and basketball players at Jammu University in Jammu and Kashmir State. The only significant disparity was identified in the speed component, while other measured factors did not show substantial variation between the two groups of players.

(Kaira, 2016) [59] A study was conducted to compare selected anthropometric variables among basketball and volleyball players in pune city, A total of 24 male subjects, 12 from each sport, were randomly selected using the Simple Random sampling. With age ranging from 20*25 years. The study focused on specific anthropometric measurements: Leg length, thigh and calf circumference and upper body length. Statistical analysis using an independent t-test with a significance level set at 0.05 was employed to evaluate the data. The findings revealed that the calf muscle measurements of basketball players and volleyball players were quite similar, showing no statistically significant difference. However, volleyball player's demonstrated better calf girth compared to basketball players. In terms of thigh circumference, basketball players and volleyball players displayed similar measurements, with no statistically significant difference. Nonetheless, basketball players exhibited better thigh girth compared to volleyball players. The upper body measurements between basketball players and volleyball players were fairly similar, with no statistically significant difference observed. Despite this, volleyball players showed a slightly better upper body compared to basketball players. Regarding leg length, basketball players and volleyball players had relatively similar measurements, with no statistically significant difference detected. However, volleyball players demonstrated slightly longer leg lengths compared to basketball players. In summary, while there were no significant differences in most measured anthropometric variables between the basketball and volleyball players, volleyball players tended to exhibit better calf girth, upper body, and slightly longer leg lengths compared to volleyball players.

(Chaouachi) *et al.* (2009) [22] conducted a study on anthropometric, physiological and performance characteristics of an elite international handball team. Twenty-one elite handball players were tested and categorized according to their playing positions (goalkeepers, backs, pivots, and wings). Testing consisted of anthropometric and physiological measures of height, body mass, percentage body fat and endurance ($VO_{2\ max}$), performance measures of speed (5, 10, and 30 m), strength (bench press and squat), unilateral and bilateral horizontal jumping ability, and a 5-jump horizontal test. In conclusion, performance abilities between positions in elite team-handball players appeared to be very similar. Single leg horizontal jumping distance could be a specific standardized test for predicting sprinting ability in elite handball players.

(Ziv and Lidor) (2009) [85] conducted a study on reviewed a series of studies (N=51) examining physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male elite basketball players. These studies included relevant information on physical and physiological variables, such as height, weight,

somatotype, relative size, aerobic profile, strength, anaerobic power, agility and speed. It was concluded that the data emerging from these studies, combined with the knowledge already obtained from the studies on physical and physiological characteristics of elite basketball players, should be applied by basketball and strength and conditioning coaches when planning training programmes for elite basketball players.

(Jurimae) (2008) [86] conducted a study on the relationships between basic body and specific hand anthropometric parameters with some specific and non-specific throw test results in young male handball and basketball players. The subjects included 34 handball and 38 basketball players of the 10-11 years old age group, 39 handball and 22 basketball players of the 12-13 years old age group and 39 handball players of the 14-15 years old age group. It was concluded that the basic anthropometric parameters are slightly more important than hand anthropometry that influenced different throw tests results in young handball and basketball players.

(Zampagni) *et al.* (2008) [87] Determined the relationships between performance times and age, body mass, height, arm length, forearm length, forearm muscle volume, and hand grip strength were examined in 135 elite master swimmers. Pearson's simple correlation coefficients were calculated and then prediction equations were developed. Age, height, and hand grip strength were the best predictors in short-distance events, whereas only age and height were predictors in middle- and long-distance events. It was concluded that, differences between sexes were not found in 50-m event, but were present in all other events. These models might be useful to determine individual performance times by contributing to improving the individual's training program and the selection of master swimmers.

(Georgieff) (2007) [34] conducted a study on the physiological and anthropometric characteristics of junior volleyball players competing at the elite, semi-elite, and novice levels and to establish performance s (Georgieff) standards for these athletes. One hundred and fifty-three junior national (N=14 males; N=20 Females), state (N=16 Males; N = 42 Females), and novice (N=27 Males; N=34 Females) volleyball players participated in this study. Subjects underwent measurements of standard anthropometry, lower-body muscular power (vertical jump and spike jump), upper-body muscular power (overhead medicine ball throw), speed (5m and 10m sprint), agility (T-Test), and estimated maximal aerobic power (multistage fitness test) during the competitive phase of the season, after obtaining a degree of match fitness. These findings provide normative data and performance standards for junior volleyball players competing at the elite, semi-elite, and novice levels.

(Pezet) (2007) [88] conducted a study on the physiological, anthropometric, and skill characteristics of rugby league players and determined the relationship between physical fitness and playing ability in these athletes. Eighty-six rugby league players underwent measurements of standard anthropometry, muscular power, speed, agility (L run), and estimated maximal aerobic power (multistage fitness test). The results of this study demonstrated that selected skill characteristics but not physiological or anthropometric characteristics discriminate between successful and less successful rugby league players. These findings suggest that while physiological and anthropometric characteristics do not discriminate between successful and less successful rugby league players, a high level of physical fitness contributes to effective playing ability in these athletes.

(Jelicic, 2002) [54] conducted a study to assess anthropometric status of European high-level junior basketball players and to determine anthropometric differences between the players playing in different game positions (guards, forwards, centers). The sample consisted of 132 young basketball players, participants of the European Junior Basketball Championship, Zadar, 2000. Participants were measured with 31 measures (Anthropometric Variables), on the basis of which two body composition measures (BMI and relative body fat) and somatotype were calculated. The basic statistical parameters were computed. The analysis of variance and discriminant canonical analysis were employed to determine the differences between positions in play. Results indicate that prominent longitudinal and transversal skeletal dimensions as well as circumference measures characterize players on the position of centers, but they do not have significantly larger skinfold measures in relation to forwards. Centers are also predominantly ectomorphic compared with other players. Guards achieved significantly lower values in all spaces and they are predominantly mesomorphic. The results also shows that when centers were compared with centers, guards with guards and forwards with forwards there were insignificant differences for their body mass index. Further investigations are necessary in order to assess potential changes in status of these parameters when the participants will reach the age of senior players and afterwards, as well as to determine relations between anthropometric status and skill related variables.

(Keogh *et al.* (2000) [89] conducted a study to assess the performance of senior female field hockey players (both regional representatives and amateurs) on a number of physical fitness, anthropometric and hockey-related skill tests. Physiological tests included 10m and 40m sprint, 6 X 40 m repeated sprint test (5), multistage aerobic test, standing long jump, agility test, body mass, height and sum of four skin folds. Skill levels were assessed using pushing power, as well as dribbling and accuracy tests. Results showed that differences in a number of measurements occurred between the two groups. No differences were found on performance measurement between subjects in the follicular or luteal stage of the menstrual cycle. The present Study demonstrated that both physical characteristics and technical skill were important components of performance in senior female hockey players.

(Toby Edwards), 2018 [90] studied about the sport of basketball exposes athletes to frequent high intensity movements including sprinting, jumping, accelerations, decelerations and changes of direction during training and competition which can lead to acute fatigue. Fatigue may affect the ability of the athlete to perform over the period of the season. The ability of practitioners to quantify the workload and subsequent fatigue in basketball athletes in order to monitor and manage fatigue levels may be beneficial in maintaining high levels of performance and preventing unfavorable physical and physiological training adaptations. There is currently limited research specifying training or competition workload outside of time motion analysis in basketball. In addition, systematic research investigating methods to monitor and manage athlete basketball. In addition, systematic research investigating methods to monitor and manage athlete fatigue in basketball throughout a season is scarce. To effectively optimize and maintain peak training and playing performance throughout a basketball season, potential workload and fatigue monitoring strategies need to be discussed.

(Mindaugas Balciunas) identify in his study about the effect of 4 months of different training modalities on power, speed, skill and anaerobic capacity in 15-16 year old male basketball players. Thirty five Lithuanian basketball players were randomly placed into three groups: Power endurance group, general endurance group and control group.

The power endurance model was based in basketball game external structure whereas the general endurance model was based in continuous actions that frequently occur during the basketball game. The training models were used for 16 weeks in sessions conducted 3 times a week during 90 minutes each in the competition period. The following tests were performed: 20 m speed run, Squat jump, Countermovement jump, Running-based Anaerobic Sprint Test, 2 min. shooting test and the Shuttle ball-dribbling test. A 3×2 repeated measures ANOVA revealed no statistically significant differences in the 20 m speed run, Squat jump and Countermovement jump. On the other hand, the four test showed significant increases in PE, with greater increases during the 5^{th} and 6^{th} runs. The PE training model also produced a significant improvement in the shuttle ball-dribbling test. Globally, our results suggest that both training modalities were able to maintain initial values of speed and power, however, the anaerobic capacity and skill increased only in the players from the power endurance group. Therefore, the power endurance training may be more beneficial to prepare junior players according to the game cardiovascular and metabolic specific determinants.

(Abdelkrim) examined basketball game blood hormonal and metabolite responses in 38 (8 guards, 18 forwards, and 12 centers) male national elite-junior players (age, 18.2±0.5 years, height, 1.89±0.1 m; body mass, 80.3±6.7 kg; body fat, 8.2±5.6%; maximum oxygen uptake $\dot{V}o_{2max}$. At the moment of the investigation, players had 8±1.6 years of competitive experience. Blood samples were collected at the beginning, at halftime, and at fulltime of 6 junior competitive games (Tunisian under 19 basketball championship).

Basketball game demands seem to induce significant metabolic-hormonal changes on players. Higher values of HR and glycemia were observed in the first half, but a more important increase of lipolytic variables was recorded in the second half. Changes in metabolic markers are role-dependent.

(Maria Reina) Evaluated how playing position, game period and playing time influenced the physical demands of youth basketball players. Six measures of external load (total distance covered, high-speed distance, number of accelerations, decelerations, jumps and player load) were collected from 48 youth basketball players, over the course of a short tournament, through the use of a local positioning tracking system (WIMUPRO^{TM}).

(Humberta M. Carvalho) studied the Relationships among chronological age (CA), maturation, training experience, and body dimensions with peak oxygen uptake ($VO_{2\ max}$) were considered in male basketball players 14-16 y of age. Data for all players included maturity status estimated as percentage of predicted adult height attained at the time of the study, years of training, body dimensions, and $VO_{2\ max}$. Proportional allometric models derived from stepwise regressions were used to incorporate either CA or maturity status and to incorporate years of formal training in basketball. Estimates for size exponents from the separate allometric models for $VO_{2\ max}$ were height, body mass, and fat-free mass. Body dimensions explained 39% to 44% of variance. The independent variables in the proportional allometric models explained 47% to 60% of variance in $VO_{2\ max}$. Estimated maturity status and training experience were significant predictors with either body mass or estimated fat-free mass but not with height. Biological maturity status and training experience in basketball had a significant contribution to $VO_{2\ max}$ via body mass and fat-free fat mass and also had an independent positive relation with aerobic performance. The results highlight the importance of considering variation associated with biological maturation in aerobic performance of late-adolescent boys.

(Markus J Klusemann) Differences in physiological, physical, and technical demands of small-sided basketball games related to the number of players, court size, and work-to-rest ratios are not well characterized. A controlled trial was conducted to compare the influence of number of players (2v2/4v4), court size (half/full court) and work-to-rest ratios (4x2.5 min/2x5 min) on the demands of small-sided games. Sixteen elite male and female junior players (aged 15–19 years) completed eight variations of a small-sided game in randomized order over a six-week period. Heart rate responses and rating of perceived exertion were measured to assess the physiological load. Movement patterns and technical elements were assessed by video analysis. There were ~60% more technical elements in 2v2 and ~20% more in half court games. Heart rate (86±4% & 83±5% of maximum, Mean ± SD) and RPE (8±2 & 6±2; Scale 1-10) were moderately higher in 2v2 than 4v4 small-sided games, respectively. The 2v2 format elicited substantially more sprints (36±12%; mean ±90% confidence limits) and high intensity shuffling (75±17%) than 4v4. Full court games required substantially more jogging (9±6%) compared to half court games. Fewer players in small-sided basketball games substantially increases the technical, physiological and physical demands.

Conclusion

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.

Significance of the Study

1. The study would reveal the basic physiological and fitness measures of the male basketball players.
2. The study may help the physical education teachers and coaches to scan the prospective of male basketball players.
3. In future, due consideration may be given by the selectors to the selected physiological and fitness characteristics which are directly related to the playing ability.
4. Results may be helpful for self-assessment of the male basketball players.
5. The prediction and conclusions of this study will pave a way to create a new model that can be applied to the men in selecting Basketball players.
6. The findings of the study might be used as a screening tool and technique in analyzing and classifying the

players.
7. This study may enable the coaches and the trainers to develop sound training.
8. This study might motivate other sports lovers and scholars to take up similar studies.

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