International Journal of Sports Physiology and Performance, 2013, 8, 630-638

INTERNATIONAL JOURNAL OF
SPORTS PHYSIOLOGY
AND PERFORMANCE
www.IJSPP-Journal.com
ORIGINAL INVESTIGATION

Morphological and Physiological Profile of Elite Basketball Players in Belgium

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Purpose: The current study aimed to gain insight into the physiological profile of elite basketball players in Belgium in relation to their position on the field. ***Methods:*** The group consisted of 144 players, divided into 5 groups according to position (point guards [PGs], shooting guards [SGs], small forwards [SFs], power forwards [PFs], and centers [Cs]). The anthropometrics were measured and the subjects underwent fitness tests (incremental running test, 10-m sprint, 5 ×-10 m, squat and countermovement jump, isokinetic test) to obtain insight into endurance, speed, agility, and power. The parameters of these tests were compared among the different positions by means of 1-way variance analysis (MANOVA). Tukey post hoc tests were performed in case of a significant MANOVA. ***Results:*** It was observed that Cs were taller and heavier and had a higher percentage body fat than PGs and SGs. For the anaerobic sprint test Cs were slower than the other positions. For the 5 × 10-m the PGs and SGs were faster than SFs and PFs. For the jump test Cs displayed a significantly lower absolute performance than the other positions. PGs and SGs had a higher VO_{2peak} and speed at the anaerobic threshold than PFs and Cs. The isokinetic strength test showed that the quadriceps muscle group of Cs could exert a higher torque during knee extension than the other positions. ***Conclusions:*** The current study showed that the physiological profile of elite players in the Belgian first division differs by player position. More specifically, guards were characterized by high endurance, speed, and agility, whereas centers and power forwards had higher muscle strength than the other positions.

Keywords: player position, aerobic performance, anaerobic performance

Basketball is an internationally played team sport of which the outcome is determined by a variety of performance determinants.[1,2] In addition to technical and tactical skills, basketball players need a high level of endurance, strength, speed, power, explosiveness, and agility. Time–motion analyses during a basketball game[1–3] showed that on average 1000 movements were made by basketball players, with an average duration of shorter than 3 seconds. On average, every 2 seconds a different movement was initiated, indicating the importance of agility in basketball. Measurements of the metabolic load during a basketball game have shown that players had an average oxygen consumption of 64.7 ± 7.0% VO_{2peak}[4] and that in 75% of the playing time the players had a heart rate above 85% HRmax and even for 30% to 50% above 90% HRmax.[2,3] As for the contribution of aerobic and anaerobic metabolism during a game, average lactate concentrations of 4 to 6 mmol/L are reported,[3,4] with peaks ranging from 8 to 12 mmol/L.[1] In addition, it has been shown that repeated-sprint ability[5,6] is essential in team sports (eg, soccer and basketball). Therefore, elite basketball players should have a high VO_{2peak} to maintain performance for intrasession and intersession recovery and preservation of performance.

Furthermore, differences among the player positions have been found. The guards had an average heart rate 2 to 3 beats/min higher than forwards and centers and higher average lactate concentrations than centers (± 6.0 vs 4.9 mmol/L).[2] Abdelkrim et al[2] reported that guards and forwards spent more time performing high-intensity movements than centers (± 17% vs 14.5%), whereas players in the latter position spent more time stationary than guards and forwards (± 33% vs. 27.5%).[7] The number of jumps performed during a game did not differ by player position.[2]

Next to these studies examining the physiological profile of a basketball game, differences among playing positions for anthropometric characteristics and aerobic and anaerobic performance in elite (youth) male and female players have been observed. In general, centers have a higher body mass, height, and percentage body fat than forwards, who are in turn heavier and taller than guards.[8–12] Guards have been reported to have the highest level of aerobic fitness, when expressed by means of VO_{2peak}.[8,10,13,14] Anaerobic performance has received less attention, and the results are more equivocal. Some studies have found that guards perform better on the vertical jump[8–10,12] and 10-m sprint[8] than centers, but not better than forwards. Furthermore, it could be argued that jump

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height should be converted to anaerobic power to account for differences in anthropometrics between players for a correct interpretation. In addition, the number of subjects in these studies is generally limited to 20 to 60 players. To have a sufficient number of players for each position, a distinction can only be made between 3 positions: guards, forwards, and centers. Therefore, using a large subject population would allow differentiation between 5 positions: point guards (PGs), shooting guards (SGs), power forwards (PFs), small forwards (SFs), and centers (Cs). A thorough knowledge of the physical and physiological profile of elite players in different competitions is a valuable resource in the domain of talent selection, identification, and coaching.[15-17]

Therefore, the purpose of the current study was to provide insight into the physiological profile of a large group of elite basketball players (ie, from the Belgian first division) and to identify differences among the different playing positions. We hypothesized that this profile would show significant differences among the positional roles of the players.

Methods

Subjects

The test group consisted of 144 players active in the Belgian first division between 2007 and 2011. The subjects played on 1 of the 4 teams that attended the Laboratory of Exercise Physiology of the Center of Sports Medicine of Ghent University Hospital (Belgium) for the physical tests in the preseason phase. Two of the 4 teams finished in the 5 seasons 2007 through 2011 at least 4 times among the 4 best teams in the first division and were therefore also active in the European Competition (Euroleague, Eurocup, and Eurochallenge). The other 2 teams were ranked between places 4 and 8 in the first division in these 5 seasons. The subject population had a wide variety of nationalities (USA 38, Eastern Europe 31, Western Europe 66, Africa 9). We divided these subjects into 5 subgroups according to the position on the field: PGs (n = 30), SGs (n = 29), SFs (n = 31), PFs (n = 30), and Cs (n = 24). The players were asked which position they had been assigned to most frequently in the past year. The mean age of the players was 26.4 ± 5.3 years and did not differ between positions. This study was approved by the ethical committee of Ghent University Hospital. All participants were informed about the contents and risks of the study.

Design and Methodology

The physical tests were performed 2 to 4 weeks before the start of the season. In this period the clubs' training consisted mainly of specific basketball-training sessions (typically starting with technical and tactical drills, followed by more strenuous game exercises, eg, 2–2, 3–3, 5–5) and 2 to 3 times per week strength training (predominantly maximal strength and hypertrophy) and basic running training (eg, 60 min running at 70% of maximal heart rate). The experimental protocol consisted of 4 parts: anthropometric measurements, sprint and jump tests, an incremental exercise test, and an isokinetic strength test. The entire testing battery was conducted in the laboratory, which was air-conditioned at a temperature of 21°C. On the first test day the subjects completed the first 3 parts of the testing battery. The strength test was performed 48 to 72 hours after the first test day. The tests were performed in the same order in each subject. The testing battery has also been used in elite soccer players[18] and allowed differentiation between player positions.

Anthropometrics. Before the physical tests, height (± 0.1 cm), weight (± 0.1 kg; Seca balance), and percentage body fat of the subjects were determined. Percentage body fat was calculated by means of measurements of skinfold thickness using a Harpenden skinfold caliper. The skinfolds were measured at 10 locations.[19] The experienced test leaders assessed the anthropometric measurements throughout the entire study.

Sprint Tests. The sprint exercise consisted of 2 different exercises. First, the subjects had to sprint for 10 m with the time recorded electronically by light sensors at both 5 m and 10 m (Ergo Tester, Globus, Italy). An auditory cue was used as a starting signal. This exercise was performed twice with 3 minutes of rest between the trials, and the best result was retained for data analysis. In the second test the subjects performed a shuttle run in which they had to run 10 m 5 times as fast as possible. They had to cross the 10-m marks with 1 foot while turning. The time at 5 m during the first test was used as a parameter of reaction time and acceleration, whereas the time at 10 m was considered a measure of speed. The time for the shuttle run was used as a measure for speed and agility.

Jump Tests. After the sprint tests the subjects performed the squat jump and the countermovement jump. They performed both jumps without arm movement (ie, with the hands in the hips). For the squat jump the subjects took a deep position with a knee angle of 90°. The flexion of the hips could be chosen freely. The subjects remained in this position for 3 seconds. In the countermovement jump the subjects were instructed to jump as high as possible without further guidelines concerning knee and hip angles. Each jump test was performed twice with 3 minutes of rest between trials. The best result was recorded for data analysis. Jump height was calculated from the flight height from the jumping mat measured with the Ergo Tester (Globus, Italy). From the jump tests the peak power was calculated using the formula of Sayers et al[20]: Power = 60.7 × jump height + 45.3 × body mass – 2055.

Incremental Exercise Test. To gain insight into aerobic performance, the subjects performed an incremental running exercise on the treadmill (Woodwax EXLG90, Weill am Rhein, Germany) until exhaustion. The incremental exercise consisted of steps of 3 minutes starting from a speed of 8 km/h. The speed was increased by 2 km/h after each step. During the test, the slope of the treadmill was set at 1.5%.[21] At the end of each step a blood sample was taken from the fingertip to determine the concentration of lactate in the blood by means of a lactate analyzer (1500 Sport, YSI, USA). When the blood lactate concentration passed the threshold of 4 mmol/L, the subjects had to perform a final step to exhaustion in which the speed was increased by 1 km/h but the slope of the treadmill was increased 0.5% each 30 seconds until volitional fatigue. The subjects were encouraged verbally to obtain maximal effort. During the test oxygen uptake was registered by means of a metabolic measurement system (Jaeger Oxycon Pro, Hochenhausen, Germany). The Jaeger Oxycon Pro and the lactate analyzer were calibrated before each exercise test. Peak performance was determined as the maximal speed (Vmax) and slope (Smax) that could be maintained for the full 30 seconds in the final step. Maximal oxygen uptake (VO_{2peak}) was determined as the highest 30-second average of the breath-by-breath values obtained from the metabolic measurement system. The anaerobic threshold (V_{AnT}) was determined at a lactate concentration of 4 mmol/L[22] and was expressed as a speed in km/h.

Isokinetic Strength Test. On the second test day the isokinetic strength test was performed on a Biodex Isokinetic Dynamometer (Biodex Corp, Shirley, NY, USA) to get insight into the strength of the knee extensors. Before the test the subjects warmed up for 15 minutes at 120 W (70–80 rpm) on a cycle ergometer. Throughout the isokinetic test the subjects sat in a chair with a hip angle of 100° and were secured with their back to the chair with straps. The ankle was secured to the mechanical arm, allowing only extension and flexion of the knee. In the first isokinetic test the speed of the Biodex was set at 60°/s, and 5 repetitions were performed. In the second test the speed was set at 300°/s and 15 repetitions were performed. Each test was performed with both the right and the left legs. The mean torque developed with each leg over the 5 and 15 repetitions at 60°/s and 300°/s, respectively, was calculated and was used as an indication of the isokinetic strength of the knee extensors.

Statistical Analysis

For the 5 positions, descriptive statistics (mean ± SD) were calculated for height, weight, percentage body fat, VO_{2peak}, V_{AnT}, maximal lactate concentration, 5-m and 10-m times, shuttle run, squat jump, countermovement jump, and torques at 60°/s and 300°/s for the left and right legs. These parameters were compared between the 5 positions by means of a MANOVA (SPSS 15.0, SPSS Inc, Chicago, IL, USA). If the MANOVA was significant, Tukey post hoc tests were performed. For the isokinetic test the mean torque (± SD) developed at 60°/s and 300°/s was calculated for the 5 positions. A repeated-measures ANOVA (2 × 5) was performed to compare the torques between the legs and the positions at both speeds. Significance was set at $P < .05$.

The reliability of the incremental running test, sprint test, and jump tests was determined by means of the test–retest method. The reliability analysis (Cronbach alpha) and intraclass correlation coefficients showed that these tests were highly reliable. The reliability coefficients (alpha) were, respectively, .95, .94, .91, .92, .88, .90, and .89 for the VO_{2peak}, V_{AnT}, 5-m time, 10-m time, shuttle run, squat jump, and countermovement jump. In addition, the ICCs for the VO_{2peak} (.96), V_{AnT} (.97), 5-m time (.88), 10-m time (.90), shuttle run (.81), squat jump (.87), and countermovement jump (.84) confirm the reliability of the tests.

Results

Anthropometrics

In Table 1 the mean values for body weight, height, and percentage body fat are presented for the different positions in the field. The mean body mass, height, and percentage body fat for the subject population were, respectively, 95.9 ± 11.8 kg, 196.3 ± 7.2 cm and 12.9% ± 3.9%. Cs were bigger (except compared with PFs) and heavier than PGs (P = .012), SGs (P = .018), and SFs (P = .021). PGs were smaller and lighter than SFs (P = .038), PFs (P = .011), and Cs (P < .001). They also had a lower percentage body fat than PFs (P = .029) and Cs (P = .009).

Sprint Tests

The mean times for the 5-m, 10-m, and 5 × 10-m are presented in Table 2. For the subject population the times to cover the 5-m, 10-m, and 5 × 10-m were, respectively, 1.45 ± 0.09, 2.23 ± 0.11, and 12.17 ± 0.59 seconds. Cs had lower reaction time and explosiveness (5-m) than PGs (P = .038) and SGs (P = .041). For 10-m sprint, as an expression of sprinting speed, Cs were slower than PGs

Table 1 Height, Weight, and Percentage Body Fat for the 5 Positions, Mean (± SD)

	PG	SG	SF	PF	C
Height (cm)	187.9 ± 3.3[a]	193.5 ± 5.3[a,b]	196.2 ± 3.3[b]	200.4 ± 2.5[b,c]	206.6 ± 3.3[c]
Body mass (kg)	83.2 ± 5.3[a]	89.6 ± 6.6[a,b]	96.6 ± 4.9[b]	103.8 ± 9.1[c]	111.2 ± 8.3[c]
Body fat (%)	11.2 ± 2.8[a]	12.0 ± 4.9[a,b]	13.1 ± 3.4[a,b]	14.7 ± 3.7[b]	15.2 ± 4.0[b]

Abbreviations: PG, point guard; SG, shooting guard; SF, small forward; PF, power forward; C, center. Significant differences are indicated by different superscripts, $P < .05$. The same superscript indicates that the parameter did not differ between the positions.

($P = .021$), SGs ($P = .029$), and SFs ($P = .033$). For the agility test (5 × 10-m), PGs and SGs were faster than SFs ($P = .024$ and $P = .043$, respectively) and PFs ($P = .009$ and $P = .015$, respectively), whereas SFs and PFs were also faster than Cs ($P = .012$ and $P = .043$, respectively).

Jump Tests

The mean values for the squat jump and countermovement jump (ie, jump height and peak power) for the 5 positions are presented in Table 3. The mean jump heights for the subject population were, respectively, 38.8 ± 4.7 cm and 41.5 ± 5.2 cm. Cs had lower jump heights for both the squat jump and countermovement jump than PGs ($P = .028$), SGs ($P = .029$), and SFs ($P = .034$). However, PFs and Cs developed a higher peak power[20] than PGs ($P = .017$ and $P = .012$, respectively) and SGs ($P = .021$ and $P = .019$, respectively).

Incremental Exercise Test

In Table 4 the mean values for VO_{2peak}, maximal lactate concentration, and V_{AnT} are presented for the different positions. PGs and SGs had higher VO_{2peak} (in mL · min^{-1} · kg^{-1}) than PFs ($P = .019$ and $P = .042$, respectively) and Cs ($P = .007$ and $P = .008$, respectively) and PGs also than SFs ($P = .039$). However, when differences in anthropometrics where taken into account by expressing VO_{2peak} in mL · min^{-1} · kg$^{-0.75}$, only PGs had higher VO_{2peak} than SFs ($P = .038$), PFs ($P = .017$), and Cs ($P = .035$). Furthermore, PFs had significantly lower VO_{2peak} than SGs ($P = .021$), SFs ($P = .040$), and Cs ($P = .041$). Maximal lactate concentration did not differ significantly between positions ($P = .76$). For running speed at the anaerobic threshold, PFs and Cs had significantly lower values than PGs ($P = .019$ and $P = .011$, respectively), SGs ($P = .033$ and $P = .011$, respectively), and SFs ($P = .038$ and $P = .049$, respectively).

Table 2 Sprint (5-m and 10-m Times) and Agility (5 × 10-m Time) Test Times (s) for the 5 Positions, Mean (± SD)

	PG	SG	SF	PF	C
5-m	1.40 ± 0.03^{a}	1.40 ± 0.09^{a}	1.45 ± 0.09^{a,b}	1.47 ± 0.08^{a,b}	1.51 ± 0.07^{b}
10-m	2.16 ± 0.09^{a}	2.19 ± 0.08^{a}	2.23 ± 0.09^{a,b}	2.25 ± 0.08^{a,b,c}	2.34 ± 0.11^{c}
5 × 10-m	11.93 ± 0.31^{a}	11.92 ± 0.28^{a}	12.25 ± 0.24^{b}	12.29 ± 0.27^{b}	12.71 ± 0.29^{c}

Abbreviations: PG, point guard; SG, shooting guard; SF, small forward; PF, power forward; C, center. Significant differences are indicated by different superscripts, $P < .05$. The same superscript indicates that the parameter did not differ between the positions.

Table 3 Jump Height and Peak Power of the Squat Jump and Countermovement Jump for the 5 Positions, Mean (± SD)

	PG	SG	SF	PF	C
Squat jump (cm)	41.0 ± 3.8^{a}	39.5 ± 3.6^{a}	40.2 ± 3.7^{a}	39.1 ± 4.2^{a,b}	35.7 ± 3.2^{b}
Squat jump (W)	4203 ± 371^{a}	4402 ± 358^{a,b}	4761 ± 381^{b,c}	5021 ± 423^{c}	5149 ± 399^{c}
Countermovement jump (cm)	42.7 ± 3.8^{a}	41.3 ± 3.2^{a}	42.5 ± 3.8^{a}	42.4 ± 3.7^{a}	36.2 ± 4.1^{b}
Countermovement jump (W)	4306 ± 373^{a}	4510 ± 322^{a}	4901 ± 387^{b}	5221 ± 364^{b}	5180 ± 451^{b}

Abbreviations: PG, point guard; SG, shooting guard; SF, small forward; PF, power forward; C, center. Power was calculated by means of the formula of Sayers et al[20]: Power = 60.7 × jump height + 45.3 × body mass – 2055. Significant differences are indicated by different superscripts, $P < .05$. The same superscript indicates that the parameter did not differ between the positions.

Table 4 Aerobic Performance Test Results for the 5 Positions, Mean (± SD)

	PG	SG	SF	PF	C
VO_{2peak} (mL · min^{-1} · kg^{-1})	57.4 ± 4.8^{a}	55.3 ± 3.6^{a,b}	52.9 ± 5.6^{b,c}	50.4 ± 5.2^{c}	50.9 ± 5.2^{c}
VO_{2peak} (mL · min^{-1} · kg$^{-0.75}$)	173.4 ± 8.2^{a}	170.1 ± 9.4^{a,b}	165.8 ± 7.3^{b,c}	160.9 ± 6.9^{c}	165.3 ± 8.8^{b,c}
[La]max (cm)	9.0 ± 0.7	8.5 ± 1.6	8.6 ± 2.0	8.7 ± 1.4	8.4 ± 1.2
V_{AnT} (km/u)	14.2 ± 0.7^{a}	14.5 ± 0.7^{a}	14.1 ± 0.6^{a}	13.1 ± 0.9^{b}	12.8 ± 1.0^{b}

Abbreviations: PG, point guard; SG, shooting guard; SF, small forward; PF, power forward; C, center; VO_{2peak}, peak oxygen uptake; [La]max, maximal lactate concentration; V_{AnT}, anaerobic threshold. Significant differences are indicated by different superscripts, $P < .05$. The same superscript indicates that the parameter did not differ between the positions.

Isokinetic Strength Test

The mean values for the isokinetic knee-extension tests (60°/s and 300°/s) for the different positions are presented in Table 5. The statistical analysis showed that there was a main effect of leg in the 60°/s condition ($P = .012$). In the entire population the torque developed by the right leg was higher than that in the left leg at 60°/s, whereas this main effect was not significant in the 300°/s condition ($P = .371$). In the right leg the torques developed at 60°/s and 300°/s were, respectively, 258 ± 30 and 150 ± 20 Nm. For the left leg the torques developed in the respective protocols were 244 ± 27 and 147 ± 17 Nm.

For both the 60°/s and 300°/s conditions there was a significant main effect of position ($P = .044$ and $P = .034$, respectively). Post hoc analysis revealed that PGs had lower torque in the quadriceps muscle group in the 60°/s condition than SGs ($P = .048$), SFs ($P = .037$), PFs ($P = .021$), and Cs ($P = .012$), whereas the Cs were able to develop a higher torque than PGs ($P = .012$), SGs ($P = .034$), and SFs ($P = .040$). In the 300°/s condition SFs, PFs, and Cs had a higher torque than PGs ($P = .032$) and SGs ($P = .041$). When the torque was expressed as a function of body mass (Nm/kg) there were no significant differences ($P = .451$) between the positions at 60°/s and 300°/s.

Discussion

The purpose of the current study was to gain insight into the general fitness level of elite basketball players active in the Belgian first division according to playing position. As hypothesized, the results of the current study clearly show that the anthropometric, physical, and physiological characteristics differ according to the specific demands inherent to the position on the court.

In Table 6 an overview is provided of studies in which the physical and physiological profiles of basketball players were examined by player position. It should be noted that these measures (eg, VO_{2peak}) were not all recorded following the same protocol. Therefore, the differences between the studies could be attributed in a large part to differences in experimental procedures. It can be argued that the tests performed in the current study were not all specific to basketball. Repeated-sprint ability, which is important in team sports, cannot be addressed with our test battery. A specific test designed Castagna et al[23] (ie, 10 × 15-m sprint interspersed by 30 s passive recovery) for repeated-sprint ability in basketball players has been used. Nevertheless, the test battery applied in the current study enabled us to analyze the strengths and weaknesses of the individual players. It was especially able to distinguish between the physiological profiles of the 5 player positions.

The anthropometric characteristics of the players in the current study are in line with other studies in elite players. Ostojic et al,[10] Sallet et al,[11] and Cormery et al[13] made a distinction between centers, forwards, and guards in the Serbian[10] and French[11,13] first division and observed body weight, height, and percentage body fat similar to those in the current study. Also in these studies the centers were taller (203–214 cm) and heavier (104–111 kg) than the forwards (194–201 cm, 89–96 kg) and the guards (184–190 cm, 82–89 kg). Similar to the current study, some studies[9–11] found that centers have a higher percentage body fat than the other positions, although this was not unequivocally found in all studies.[13,24]

Table 5 Isokinetic Strength Test Results for the 5 Positions, Mean (± SD)

Speed	Leg	Unit	PG	SG	SF	PF	C
60°/s	right	Nm	219 ± 30^{a}	248 ± 29^{a,b}	267 ± 27^{b,c}	271 ± 29^{b,c}	286 ± 34^{c}
		Nm/kg	2.63 ± 0.24	2.77 ± 0.22	2.76 ± 0.22	2.61 ± 0.25	2.57 ± 0.26
		$Nm/kg^{0.75}$	7.94 ± 0.61^{a}	8.53 ± 0.58^{a,b}	8.66 ± 0.57^{b}	8.33 ± 0.62^{a,b}	8.35 ± 0.71^{a,b}
	left	Nm	212 ± 28^{a}	241 ± 23^{a,b}	245 ± 34^{b,c}	259 ± 28^{b,c}	264 ± 22^{c}
		Nm/kg	2.55 ± 0.23	2.69 ± 0.17	2.54 ± 0.26	2.49 ± 0.24	2.38 ± 0.18
		$Nm/kg^{0.75}$	7.70 ± 0.56^{a}	8.29 ± 0.49^{b}	7.96 ± 0.63^{a,b}	7.95 ± 0.60^{a,b}	7.72 ± 0.56^{a}
300°/s	right	Nm	125 ± 19^{a}	133 ± 20^{a}	159 ± 21^{b}	161 ± 20^{b}	172 ± 20^{b}
		Nm/kg	1.50 ± 0.21	1.48 ± 0.21	1.64 ± 0.22	1.55 ± 0.18	1.55 ± 0.17
		$Nm/kg^{0.75}$	4.54 ± 0.62	4.56 ± 0.64	5.16 ± 0.66	4.93 ± 0.59	5.02 ± 0.56
	left	Nm	124 ± 16^{a}	133 ± 19^{a}	158 ± 19^{b}	160 ± 15^{b}	162 ± 16^{b}
		Nm/kg	1.48 ± 0.17	1.48 ± 0.19	1.61 ± 0.20	1.54 ± 0.14	1.46 ± 0.13
		$Nm/kg^{0.75}$	4.48 ± 0.58	4.55 ± 0.62	5.05 ± 0.63	4.92 ± 0.53	4.73 ± 0.49

Abbreviations: PG, point guard; SG, shooting guard; SF, small forward; PF, power forward; C, center. Significant differences are indicated by different superscripts. The same superscript indicates that the parameter did not differ between the positions, $P < .05$. Positions with different superscripts differ significantly.

Table 6 Overview of the Studies in Which the Physiological Profiles of Basketball Players by Player Position Have Been Addressed

Study	Subjects	Position	Height (cm)	Weight (kg)	Body fat (%)	VO_{2peak} (mL · min^{-1} · kg^{-1})	Vertical jump (cm)	5-m (s)	10-m (s)
Current study	Belgian first division	PG	188 ± 3	83 ± 5	11.2 ± 2.8	57.4 ± 4.8	42.7 ± 3.8	1.40 ± 0.08	2.16 ± 0.09
		SG	194 ± 5	90 ± 7	12.0 ± 4.9	55.3 ± 3.6	41.3 ± 3.2	1.40 ± 0.09	2.19 ± 0.08
		SF	196 ± 3	97 ± 5	13.1 ± 3.4	52.9 ± 5.6	42.5 ± 3.8	1.45 ± 0.09	2.23 ± 0.09
		PF	200 ± 3	104 ± 9	14.7 ± 3.7	50.4 ± 5.2	42.4 ± 3.7	1.47 ± 0.08	2.25 ± 0.08
		C	207 ± 3	111 ± 8	15.2 ± 4.0	50.9 ± 5.3	36.2 ± 4.1	1.51 ± 0.07	2.34 ± 0.11
Ben Abdelkrim et al[2]	Tunisian elite competition <19 y	PG/SG	183 ± 4	76 ± 6	6.1 ± 3.7	53.8 ± 1.9			
		SF/PF	188 ± 4	77 ± 5	7.8 ± 4.1	53.4 ± 2.3			
		C	193 ± 4	87 ± 5	10.4 ± 7.8	51.4 ± 2.4			
Ben Abdelkrim et al[8]	Tunisian national teams	PG	186 ± 5	78 ± 6	11.2 ± 0.7	60.6 ± 5.1	50.2 ± 5.9	0.88 ± 0.09	1.74 ± 0.12
		SG	194 ± 4	86 ± 5	8.3 ± 1.6	54.8 ± 5.2	48.4 ± 5.1	1.10 ± 0.17	1.98 ± 0.11
		SF	196 ± 3	88 ± 4	8.6 ± 0.7	55.7 ± 6.2	52.5 ± 5.0	1.12 ± 0.07	1.96 ± 0.12
		PF	202 ± 3	96 ± 4	11.6 ± 2.5	55.9 ± 6.0	40.9 ± 3.7	1.15 ± 0.20	1.98 ± 0.22
		C	204 ± 5	97 ± 5	14.8 ± 1.9	49.9 ± 3.5	41.6 ± 4.2	1.17 ± 0.14	2.00 ± 0.16
Cormery et al[13]	French first division	PG/SG	185 ± 1	82 ± 2	13.7 ± 0.5	54.0 ± 1.6			
		SF/PF	200 ± 1	96 ± 1	13.5 ± 0.4	45.5 ± 0.7			
		C	207 ± 2	111 ± 2	14.1 ± 0.7	41.7 ± 1.1			
Latin et al[9]	NCAA	PG/SG	187 ± 6	83 ± 7	8.4 ± 3.0	55.0	73.4 ± 9.6		
		SF/PF	198 ± 4	95 ± 8	9.7 ± 3.9	56.0	71.4 ± 10.4		
		C	206 ± 6	111 ± 2	11.2 ± 4.5	56.0	66.8 ± 10.7		
Ostojic et al[10]	Serbian first division	PG/SG	191 ± 6	89 ± 8	9.9 ± 3.1	52.5 ± 4.8	59.7 ± 9.6		
		SF/PF	200 ± 3	96 ± 7	10.1 ± 3.2	50.7 ± 2.3	57.8 ± 6.5		
		C	208 ± 3	105 ± 12	14.4 ± 5.6	46.3 ± 4.9	54.9 ± 6.9		
Parr et al[24]	NBA	PG/SG	188 ± 10	84 ± 6	10.6 ± 2.9	50.0 ± 5.4			
		SF/PF	201 ± 5	97 ± 7	9.0 ± 3.6	45.9 ± 4.3			
		C	214 ± 5	109 ± 14	7.1 ± 2.8	41.9 ± 4.9			
Sallet et al[11]	French first and second divisions	PG/SG	186 ± 7	82 ± 9	11.4 ± 1.7	57.5 ± 9.2			
		SF/PF	196 ± 5	89 ± 7	11.4 ± 2.3	55.2 ± 6.5			
		C	204 ± 5	104 ± 12	14.4 ± 3.7	52.9 ± 6.2			
Soares et al[12]	Brazilian national	PG/SG	185 ± 8	79 ± 7		74.4 ± 6.8	61.6 ± 8.5		
		SF/PF	197 ± 5	92 ± 7		59.9 ± 5.1	66.8 ± 8.3		
		C	207 ± 4	102 ± 18		59.7 ± 6.9	55.9 ± 8.1		

Abbreviations: PG, point guard; SG, shooting guard; SF, small forward; PF, power forward; C, center; NBA, National Basketball Association; NCAA, National Collegiate Athletic Association.

Although the offensive and defensive actions determining the outcome of the game are highly anaerobic (jumping, sprinting, sudden accelerations, etc), a basketball game sets high demands on the aerobic metabolism, so the endurance component should not be ignored. The mean VO_{2peak} reported in the current study (53.4 ± 4.8 mL · min^{-1} · kg^{-1}) is in line with most studies reporting values in the range 50 to 60 mL · min^{-1} · kg^{-1}.[8,10,14,24,25] In the current study it was observed that guards had a higher VO_{2peak} than forwards (–8.5%; especially the power forwards) and centers (–9.8%). Also the running speed at the anaerobic threshold, which can be considered an indication of aerobic conditioning, was higher in the guards and small forwards than the power forwards (–9.0% and –7.1%, respectively) and centers (–11.1% and –9.2%, respectively). Unlike in soccer, there are only few motion-analysis studies in basketball allowing a distinction of the physical demands between positions on the court. Still it was observed that centers spent more time stationary than did guards and forwards (33% vs 28% and 27%, respectively).[2,7] Furthermore, guards engaged in more moderate-intensity movements than forwards and centers.[2] Measurements of the distance covered on the field have not been performed in the cited studies. Nonetheless, it can be suggested that the aerobic load during a basketball game is higher in guards, especially in point guards, than in the other positions. In line with this suggestion, Rodriguez-Alonso et al[26] found in professional Spanish female players that guards had higher heart rates during a game than the other positions.

It is important to gain insight into the anaerobic performance of players, since this is an important determinant of game outcome. It was observed that the guards had higher reactivity, explosiveness (5-m time) and speed (10-m time) than the centers (–7.9% and –7.8%, respectively). Although the guards appeared to be faster than the forwards (–4.3% and –3.2% for 5-m and 10-m times, respectively), these differences were not significant. Abdelkrim et al[8] reported faster times for the 10-m sprint in all positions due to differences in experimental procedure. However, more important, a similar trend with regard to player position was detected. For the 5 × 10-m on the other hand, the guards were faster than the forwards (–2.8%) and the centers (–6.5%), indicating that the guards are generally characterized by higher agility. This is probably related to anthropometric differences. Guards are generally smaller than the other positions. Therefore, their center of mass is closer to the ground, allowing more efficient sudden changes in direction. Although there is no evidence from motion-analysis studies, visual inspection of a basketball game shows that these players often penetrate to the basket to score, and, therefore, these sudden accelerations with changes in direction are frequently performed by guards. Therefore, agility is an important characteristic for players occupying the guard positions. In the center position, on the other hand, the offensive and defensive actions under the basket with the opponent are heavier in contact, so the movements are more related to strength. The results of the current study are in line with these visual observations of a basketball game since it was found for the isokinetic test that torque development in the centers was higher than in the guards (–18.1%) and the small forwards (–5.9% for the 60°/s condition). The differences in strength among the different playing positions have not been equivocally reported in literature. Theoharopoulos et al[27] did not observe any differences among the positions using a similar isokinetic knee-strength test compared with the current study, whereas Latin et al[9] observed higher power clean values in forwards than in guards and higher squat values than in centers. Ben Abdelkrim et al,[8] on the other hand, reported higher 1RM values for the bench press in power forwards and centers and lower 1RM squat values for the point guards than for the other positions. It should be noted that strength is necessary to a different extent in the different positions and that a distinction should be made between the upper and lower body and different muscle groups. Furthermore, it should be argued that it is likely that the specific characteristics of player positions in the laboratory tests are also the consequence of the specific tasks on the basketball court during the years of training and competition and are not only related to inherent physical and physiological characteristics.[28]

Practical Applications

In elite team sports the impact of individualized and specialized training according to player position in combination with the individual physiological profile (ie, strengths and weaknesses) grows. The information in the current study obtained from a large sample of elite basketball players in the Belgian first division can be used in the individual evaluation of the different basketball-related aspects of physical fitness in elite competitions around the world. In this way physical coaches can individualize training programs based on the specific strengths and weaknesses and in light of a player's position on the field. Furthermore, trainers of youth basketball players can start to differentiate the properties of physical training between subjects once the preferred position on the court is determined. The results of the current study, in line with motion-analysis studies, suggest that guards should focus a large amount of training on agility and explosiveness (plyometric drills) in combination with specific aerobic conditioning. Centers, on the other hand, would benefit more from resistance training in combination with specific jump drills. The current study also shows that the physiological profile of small forwards tends toward that of the guards, whereas the profile of power forwards more closely resembles that of centers.

It should be noted, however, that the results of the current study should be interpreted in light of the level of Belgian competition in the world. In Europe, the Belgian teams sporadically qualify for the Euro League, but generally they perform well in the Eurocup and Euro Challenge. Therefore, it can be concluded that the level of the Belgian competition is probably not among the highest in Europe (eg, Spain, Turkey, etc) but should be situated in the second category (eg, Germany, France, etc). Furthermore, one should take into account that the benchmarks reported in the current study were obtained in the precompetition period (ie, 2–4 wk before the start of the season). It has been shown in soccer players that fluctuations of 4% to 7% may occur in VO_{2max} and sprint performance depending on the period of the year in which the test battery is performed.[29,30]

In addition, time-motion-analysis studies in elite basketball games, which are currently limited in number, are necessary to gain insight into the physiological demands of a basketball game,[2,3] with a specific focus on position on the court, level of the players, differences between the halves (or quarters) in the games, and so on, to further develop these individualized training programs.

Acknowledgments

The results of the current study do not constitute endorsement of any product by the authors or the journal.

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