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ANTHROPOMETRIC AND PHYSICAL FITNESS CHARACTERISTICS OF FEMALE BASKETBALL PLAYERS IN SOUTH AFRICA

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ABSTRACT

The anthropometric and physical fitness characteristics of South African (SA) female university-level, provincial-level and national-level players were examined in order to provide possible reasons for their poor performance. Fifty-five participants were recruited for the study. These included 24 university-level, 17 provincial-level, and 14 national team players. Anthropometric data included age, stature, body mass, sum of seven skinfolds and percentage body fat. The fitness characteristics included flexibility, strength, explosive power, muscular endurance, agility, speed and aerobic endurance. The national team players were significantly taller than both the provincial-level and university-level players. Fitness test results indicated that the national team players were significantly better than the university-level players in only three of the tests (hamstring flexibility, upper body muscle power and agility). Provincial-level players performed significantly better than the national team players in the aerobic fitness test. The anthropometric and physical fitness characteristics of female basketball players in SA are poor and could be a major contributing factor to their low international ranking.

***Keywords*:** Performance; Basketball; Physical Fitness; Anthropometric traits; Females; South Africa.

INTRODUCTION

Basketball is played by 213 countries and approximately 450 million people worldwide, ranging from amateurs to licensed players (FIBA, 2016a; Drinkwater *et al*., 2008). It is a massive global business and has millions of fans around the world with the largest fan-bases in North and South America, Europe and more recently, Asia. The National Basketball Association (NBA) is the most prestigious league, however, leagues in Europe and Asia are gaining popularity (Martin, 2012).

Despite the establishment of Basketball South Africa (BSA) in 1953 (Radovic, 2010), poor leadership, an ineffective financial model, lack of facilities and resources have continued to hamper the growth of the sport (PMG, 2013). In addition, the South African national male and female teams are comparatively poor performers internationally. The SA women's national basketball team is ranked 66 out of 77 countries (FIBA, 2016b), while the men's national team is ranked 77 out of 91 countries (FIBA, 2016c). Since BSA was taken under administration by SA Sports Confederation and Olympic Committee (SASCOC) in 2012, the sport has showed the potential to grow. The overall popularity of the sport increased from 16^{th} in 2011 to 12^{th} position in 2014 (BSA, 2015).

Basketball is a physiologically demanding sport played at a high intensity. Contributing factors that enhance performance include body composition, aerobic and anaerobic metabolic capacities, flexibility, strength and power (Foran, 2001; Narazaki *et al*., 2009; Scanlan *et al*., 2012; Puente *et al*., 2016). Stature plays an important role in basketball. Taller players are able to block shots and rebounds more easily (because of their stature and longer arm reach), while on offence they are not easily blocked by opponents and are able to make high percentage shots when playing near the hoop (Drinkwater *et al*., 2008). It is not surprising therefore that some of the best female basketball players in the world are over 1.8 m tall (WNBA, 2014).

In May 2000, the International Basketball Federation (FIBA) placed a 24-second rule, coercing players to execute a strategy and score within the appointed time of 24-seconds (Drinkwater *et al*., 2008; Delextrat & Cohen, 2009). This limited time requires players to possess tactical and technical precision, explosive speed, flexibility, strength and endurance for successful performance (Hoffman *et al*., 1999; Foran, 2001). Although the time spent in high intensity activity is relatively low (15% of actual movement patterns in game) (Hoffman *et al*., 1999), studies have illustrated high physiological demand with elevated lactate levels (approximately 4.6mmol/L) and a sustained high heart rate response (170-186 beats/min) in female elite players (Rodriguez-Alonso *et al.*, 2003). Furthermore, a positive relationship has been shown to exist between aerobic and anaerobic fitness and power, body composition and positional roles in elite basketball players (Ostojic *et al*., 2006). Basketball players also require adequate hamstring flexibility, as it aids the lengthening of the shuffle strides (Basketball Trainer, 2014), and strength and power for powerful passes, slam-dunking, rebounding, blocking and interceptions (Newton *et al*., 1999; Rose, 2013).

PURPOSE OF RESEARCH

It is apparent that appropriate body composition and physical fitness characteristics are essential for successful basketball performance. To the authors' knowledge there has not been any published research on basketball in South Africa (SA). Thus, the aim of this study was to examine the anthropometric and physical fitness characteristics of female basketball players in SA at various levels, namely university-, provincial- and national-level players.

METHODOLOGY

Research design

This is a cross-sectional study measuring the anthropometric and physical fitness characteristics of three groups of SA female basketball players at university-level, provincial-level and in the national team.

Participants and ethical clearance

Fifty-five (55) female basketball players at university (n=24), provincial (n= 17) and national (n=14) team level were recruited to participate in this study. The national level players represented the SA national team. Prior to the commencement of testing, all subjects signed an informed consent form explaining the procedure of the performance evaluation. The study was approved by the University's Ethics Committee (clearance number: 2012FBREC0052).

Procedures

All testing was done during the competitive season. Anthropometric measures were taken first followed by the fitness assessments that included sit-and-reach, push-ups and sit-ups, 1-RM bench and leg press, chest pass and countermovement jump (CMJ), agility, 20m-sprint, suicide-run and the 20m multistage shuttle-run test (MST). Between assessments, the players rested until they were ready for the next assessment.

Measures

Anthropometric measures

Descriptive and anthropometric data were measured first and included age, stature, mass, sum of seven skinfolds (biceps, triceps, subscapular, supra-iliac, abdominal, thigh and calf), and body fat percentage (Durnin & Womersley, 1974).

Flexibility

Flexibility of the players was measured using the hamstring sit-and-reach test (Mier, 2011). Subjects were allowed two warm-up attempts, and then the best of three measured attempts was recorded.

Upper body strength

Upper body strength was measured using the 1-repetition maximum (1-RM) bench press. The participants lay supine on a bench, with their hands approximately shoulder width apart while gripping the cross bar. A warm-up of six repetitions starting at 18kg (the weight of the bar with no added weights) was performed first. Following the warm up, 5kg weights were added to each end of the bar (total of 10kg) and another lift was performed. If the participant failed to complete the repetition, the weight was decreased by 2.5kg on each bar. The weights were increased or decreased thereafter by 2.5 kg until the 1-RM was reached.

Lower body strength

Lower body strength was measured using the 1-RM bilateral incline leg press (45^{o} incline). The participants sat on the leg press machine with their legs positioned approximately shoulder width apart in the middle of the foot plate. A warm up of six repetitions starting at 30kg (the weight of the bar with no added weights) was performed first. Following the warm up, 10kg weights were added to each end of the bar (total of 20kg) and another press was performed. If the participant failed to complete the repetition, the weight was decreased by 5 kg on each bar. The weights were increased or decreased thereafter by 5kg until the 1-RM was reached.

Explosive power of the upper body

Upper body explosive power was measured using a two handed chest pass while seated (Johnson & Nelson, 1979; Delextrat & Cohen, 2009). A women's size 6 leather basketball was used (size 6 ball=73.66cm in circumference and weighed 515g). Subjects were allowed two warm-up attempts, and then the best of three attempts was recorded.

Countermovement jump (CMJ)

Explosive leg power was measured using a CMJ (Bobbert *et al.*, 1996). After the standing reach height was measured, the participants were allowed two warm-up attempts. To complete the jump, subjects began in a standing position with their arms at their side, bent down and then had to jump vertically as high as possible and touch the board. The best jump height after three attempts was recorded. Jump height was recorded as the difference between jump height and standing reach height.

Muscular endurance

Muscle endurance of the upper-limbs was measured using the modified push-up test (Hoffman, 2006). Participants were required to start the test with their knees bent on the floor, their hands shoulder width apart touching the floor, with a straight back. The researcher placed his fist on the floor under the chest of each participant. The participants had to touch the fist with their chest and then extend their elbows back to the starting position. The total number of push-ups in 60s was recorded. The total number of push-ups after the 30s was also recorded during this 60s test.

Muscle endurance of the mid-body was measured using sit-ups. Each subject had to lie down on their back with the knees bent and feet on the floor. The participant sat up from this position so that the elbows touched the bent knees and returned back to their shoulder blades touching the floor (Johnson & Nelson, 1979; Hoffman, 2006). The total number of sit-ups in 60s was recorded. The total number of sit-ups after the 30s was also recorded during this 60s test.

Agility

Agility was measured using an agility T-test (Pauole *et al.,* 2000). Brower Timing Systems (BTS) speed lights were used and placed at the start and end of the test. Subjects had three attempts and the best of the three attempts was recorded.

Anaerobic work capacity

A suicide run is commonly used in basketball to measure the anaerobic capacity of basketball players. The BTS speed lights were placed on the base line (zero meters). Subjects were asked to sprint continuously for 140 m at maximum speed with a number of direction changes. To complete the 140m, players started at the basketball court baseline then had to sprint with a change in direction at the 5.8m (1^{st} free throw line), 14m (half line), 22.2m (far free-throw line) and 28m (far end baseline). These distances were used as they are sports specific and align with previous basketball studies (Hoare, 2000; Delextrat & Cohen, 2009). Subjects were given one attempt to complete the test and the time taken to complete the test was recorded.

Speed

Speed was measured using the 20m-sprint test using the BTS speed lights. Twenty metres was chosen because it is sport specific, slightly less than a basketball court (28m) and is consistent with previous studies on basketball (Kilinc, 2008; Delextrat & Cohen, 2009). There were no practice attempts. Subjects had three attempts and the best of three attempts was taken.

Aerobic endurance

Aerobic endurance was measured using a MST. The estimated VO_2 max was obtained by cross-referencing the final level and shuttle number completed (Leger & Lambert, 1982).

Statistical analyses

Means±standard deviations of the descriptive data of the fitness characteristics were calculated. This data of the three groups were compared using a one-way ANOVA. Where significant differences were found, a post hoc Bonferroni analysis was performed to determine where the differences were situated. Significance was set at $p \leq 0.05$.

RESULTS

The descriptive anthropometric data of the university-level, provincial-level and national team players are shown in Table 1. There were no significant differences in *body mass* and *body fat percentage* between the three groups. *Age* however differed significantly across the three groups ($F_{2, 52}=3.7$; p=0.031). Bonferroni (post hoc) comparison of the three groups indicates that the national team players were older (24.0±3.5; 95% CI [22, 26]) than the provincial-level players (21.3±2.7; 95% CI [20, 22]; p=0.029). There was no significant difference between the ages for the provincial- and university-level players or between the national team players and university-level players.

Table 1. **CHARACTERISTICS OF SA BASKETBALL PLAYERS**

Variables	**University** (n=24) **M±SD**	**Provincial** (n=17) **M±SD**	**National** (n=14) **M±SD**	**F**	**p-Value**
Age (years)	22.0±3.6	21.3±2.7*	24.0±3.5*	3.7	0.031*
Stature (cm)	164.5±1.0	163.2±1.0	174.2±1.0*	3.2	0.002*
Mass (kg)	65.7±11.9	61.0±7.0	71.1±13.3	3.2	0.051
Body fat (%)	23.9±5.9	19.5±4.8	22.3±5.5	3.1	0.052

M=Mean SD=Standard Deviation * p<0.05

Stature differed significantly across the three groups ($F_{2, 52}=7.4$; p=0.002). Comparison of the three groups indicates that the national team players were taller (174.2±1.0; 95% CI [17, 18]) than both provincial-level players (163.2±1.0; 95% CI [16, 1.7]; p=0.003) and university-level players (164.5±1.0; 95% CI [16, 17]; p=0.005). There was no significant difference between the stature of the provincial- and the university-level players.

Hamstring flexibility, strength, explosive power and muscular endurance measurements for the players are presented in Table 2. Hamstring *flexibility* differed significantly across the three groups ($F_{2, 51}=6.4$; p=0.003). Comparison of the three groups indicates that the provincial-level players (14.5±5.0; 95% CI [12, 17]) were significantly more flexible compared to university-level players (9.1±6.0; 95% CI [7, 12]; p=0.006). The national team players (13.9±3.7; 95% CI [11, 16]) were also significantly more flexible than university-level players, p=0.029. There was no significant difference between provincial-level players and the national team players.

***Table 2*. DIFFERENCE BETWEEN GROUPS FOR PHYSICAL PARAMETERS**

Physical parameters	University (n=24) M±SD	Provincial (n=17) M±SD	National (n=14) M±SD	F	p-Value
Sit-and-reach (cm)	9.1±6.0*	14.5±5.0	13.9±3.7	6.4	0.003*
1-RM bench press (kg)	31.1±9.4	31.5±6.8	32.5±9.7	0.1	0.896
1-RM leg press (kg)	163.3±45.7	156.5±47.0	162.9±37.3	0.1	0.874
Chest pass (m)	6.8±0.8*	7.2±0.8	7.8±1.0*	7.0	0.002*
Countermovement jump (cm)	33.3±6.8	37.8±5.0	35.8±5.8	2.7	0.077
Push-ups (repetitions in 30s)	20±7	21±6	21±8	0.3	0.752
Push-ups (repetitions in 60s)	30±12	33±10	33±14	0.4	0.656
Sit-ups (repetitions in 30s)	19±4	19±3	21±4	2.0	0.141
Sit-ups (repetitions in 60s)	35±9	36±6	41±7	2.4	0.105

M=Mean SD=Standard Deviation * p<0.05 1-RM=1 repetition maximum

Upper body *strength* (1-RM bench press test) and lower body muscle strength (1-RM leg press test) did not differ significantly between the three groups. Chest-pass data indicates that the three groups differed significantly ($F_{2, 52}$=7.0; p=0.002). Post-hoc comparisons of the three groups indicates that the national team players (7.8±1.0; 95% CI [7.3, 8.4]) threw the basketball ball further than university-level players (6.8±0.8; 95% CI [6.4, 7.1]; p=0.001). However, there was no significant difference between the national team players and provincial-level players or between the provincial and university-level players. *CMJ* data indicated that there were no significant differences across the three groups. *Muscular endurance* (push-ups and sit-ups) also did not reveal significant differences between the three groups.

Agility, speed, anaerobic and aerobic work capacity measurements for university-level, provincial-level and the national team players are presented in Table 3. The t-test *agility* results differed significantly across the groups ($F_{2, 44}$=6.6; p=0.003). The national team players (11.6±1.2; 95% CI [11.0, 12.3]) were significantly more agile than university-level players (13.0±1.5; 95% CI [12.3, 13.7]; p=0.012). There was no significant difference between provincial-level and the national team players. The provincial-level players were significantly more agile than university-level players (p=0.012).

Table 3. **DIFFERENCE BETWEEN GROUPS FOR FITNESS PARAMETERS**

Fitness parameters	**University** (n=24) **M±SD**	**Provincial** (n=17) **M±SD**	**National** (n=14) **M±SD**	**F**	**p-Value**
T-test agility (s)	13.0±1.5*	11.7±1.0	11.6±1.2	6.6	0.003*
20m-sprint (s)	3.8±0.2*	3.5±0.2*	3.6±0.3	5.8	0.006*
Suicide run (s)	35.0±3.1	33.3±1.5	34.4±3.4	1.6	0.220
Estimated VO_2 max (ml/kg/min)	35.4±6.4	37.8±18.2*	32.4±4.9*	3.5	0.039*

M=Mean SD=Standard Deviation * $p<0.05$

Twenty-metre-sprint times differed significantly across the groups ($F_{2, 41}$=5.8; p=0.006). The provincial-level players (3.5±0.2; 95% CI [3.4, 3.6]) were significantly faster than university-level players (3.8±0.2; 95% CI [3.7, 3.9]; p=0.007). There was no significant difference between the national-level and provincial-level players, nor between the university-level and the national players. The results of the *suicide run test* showed no significant differences between the three groups.

Estimated *VO_2 max* differed significantly across the groups. The results indicate that the provincial-level players (37.8±18.2; 95% CI [34.7, 53.4]) had higher estimated levels of VO_2 max than the national team players (32.4±4.9; 95% CI [29.3, 35.4]; p=0.031). There was no significant difference between provincial- and university-level players, and between the national-level and university-level players.

DISCUSSION

The study aimed at investigating the anthropometric and physical fitness characteristics of different levels of players in SA. Although the national team players were significantly taller than the provincial- and university-level players, the physical fitness findings indicate that the national team players were only significantly better than the university-level players in three of the tests measured (sit-and-reach, chest-pass and the T-test), suggesting more similarities in the physical fitness abilities in these groups.

The national team players were significantly taller than both provincial and university-level players. This stature advantage is a possible reason for their inclusion in the SA national team. However, the SA national team players are shorter than their international counterparts reported in other studies (174±1 vs. 185±9) (Mala *et al.*, 2015), and were approximately 7cm shorter than the average height of the Women's National Basketball Association players (WNBA, 2004). Tall basketball players have an advantage in both offence and defence (Emma, 2014; Kurtus, 2014) and the smaller stature of the SA team will disadvantage them when competing internationally. Furthermore, very few female basketball players play at a senior level in SA, therefore making the pool of players extremely small from which to choose the national team (Ngema, 2014). This problem is further exacerbated by tall females often being lost to other sporting codes, such as netball. In addition, basketball in SA is mostly played by black females (PMG, 2013), who are usually shorter compared to white females (Steyn & Smith, 2007).

SA national team and provincial-level players had significantly better hamstring flexibility than university-level players. Increased flexibility of the hamstring muscles would be beneficial for these players and has been shown to enhance performance on the court when jumping, sprinting, turning and moving in a sideways direction (Henkin, 2002; Rose, 2013).

The development of strength has been an important element to enhance athleticism (Marzilli, 2008) and is also a fundamental component of power. There were, however, no significant differences in the strength of the upper body between the SA national players and the provincial- and university-level players in SA. This suggests that the upper body muscle strength of the national team is poor, as they were on par with the university-level players in SA. In addition, when comparing data reported for university-level players abroad, the university players abroad lifted on average 20kg more (53±9kg) than the SA team players during the 1-RM bench press (Marzilli, 2008).

The SA national team players had better upper body explosive power than university-level players, but similar 1-RM upper body strength values. Explosive power of the upper limbs can be of great significance in dribbling and shooting long-range shots to beat an opponent on offence (Haefner, 2014), when blocking a defender, as well as deflecting or intercepting the ball, and is associated with further and faster passes (Rose, 2013).

Lower body strength and explosive power were similar between the three groups, once again suggesting poor performance of the SA national team as they would be expected to at least out-perform the university players in these tests. The explosive power of the SA national team are also weaker than the university-level players in the USA, who reported jump heights averaging 17cm higher (36±6 vs. 53±5) (Kilinc, 2008). The fact that SA national team players are shorter than their counterparts, in addition to their poor jumping ability, would greatly disadvantage the SA national team players during competition.

The national team players had similar muscular endurance of the upper limbs and mid-body compared to the university and provincial-level players in SA. Yet again, the national team players' push-up and sit-up scores are low compared to university-level players in the USA (Kilinc, 2008). Kilinc, 2008 measured push-ups performed in a prone position (more difficult test), however, the SA national team players could not perform a single conventional push-up in the prone position (more difficult test). The SA national team players were measured using the modified push-up test (ladies push-ups) and scored about nine less push-ups per minute than the university-level players in Kilinc's study, despite performing the easier version of the test. Furthermore, when considering data from the sit-up test, the SA national team players performed about 18 less sit-ups per minute when compared to university-level players in the USA (Kilinc, 2008). This indicates poor upper and mid-body muscle endurance of SA national team players in general. This is significant as muscular endurance is required on offence with dribbling for longer periods of time, the importance for shooting and it helps players maintain a wider stance for longer in defence (Haefner, 2014).

The SA national team players had similar 20m-sprint times and suicide run times when compared to the provincial and university-level players. Basketball is predominantly an anaerobic sport with speed and change of direction being specific factors contributing to basketball performance (Delextrat & Cohen, 2009). The 20m-sprint times of the SA national team players were approximately 0.3s slower than that reported on university-level players in the USA (Kilinc, 2008). This lack of sprinting speed amongst the national team players will potentially impair their performance internationally. Furthermore, their aerobic capacity was found to be relatively low, having an average estimated VO_2 max of 32ml/kg/min (equivalent to a level 5 on the multi-stage shuttle run test).

PRACTICAL APPLICATION

The physical fitness status of female basketball players in SA needs to improve, which would potentially enhance their playing performance. Appropriate monitoring and managing of the players' physical fitness by implementing or improving the strength and conditioning programmes is recommended. This should be a high priority in the development of female basketball in SA.

CONCLUSIONS

Physical fitness test results indicate that the national team players were only significantly better than the university-level players in three of the tests measured (sit-and-reach, chest-pass and the T-test). Surprisingly, the SA national team players were not significantly better than the provincial-level players at any of the physical fitness tests, and were significantly inferior in the multi-stage shuttle run test compared to the provincial-level players. Furthermore, in contrast to university-level players abroad, the physical fitness results of the SA national team players were poor, suggesting a major gap in their physical fitness characteristics when compared to other teams globally.

REFERENCES

BASKETBALL TRAINER (2014). "Basketball stretching – 5 benefits that enhance your performance". Hyperlink: [http://Basketballtrainer.com/basketball-stretching-5-benefits-that-enhance-your-performance]. Retrieved on 18 November 2014.

BOBBERT, M.F; GERRISTEN, K.G; LITJENS, M.C. & VAN SOEST, A.J. (1996). Why countermovement jump height greater than squat height jump? *Medicine & Science in Sports and Exercise*, 28(11): 1402-1412.

BSA (Basketball South Africa) (2015). "Presentation to the portfolio committee on Sport and Recreation National Assembly". Hyperlink: [http://pmg-assets.s3-website-eu-west-1.amazonaws.com/150818basketballsa.pdf]. Retrieved on 23 November 2016.

DELEXTRAT, A. & COHEN, D. (2009). Strength, power, speed, and agility of women basketball players according to playing position. *Journal of Strength and Conditioning Research*, 23(7): 1974-1981.

DRINKWATER, E.J.; PYNE, D.B. & MCKENNA, M.J. (2008). Design and interpretation of anthropometric and fitness testing of basketball players. *Sports Medicine*, 38(7): 565-578.

DURNIN, J.V.G.A. & WOMERSLEY, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 years. *British Journal of Nutrition,* 32(1): 77-97.

EMMA, T. (2014). “Smaller basketball players: Perhaps the best athletes of all”. *Coach’s Clipboard*. Hyperlink: [www.coachesclipboard.net/Basketballsmallplayers.html]. Retrieved on 24 October 2014.

FIBA (2016a). “International Basketball Federation”. *FIBA.* Hyperlink: [http://www.fiba.com/presentation]. Retrieved on 23 November 2016.

FIBA (2016b). “FIBA world ranking: Ranking women after the 2014 FIBA World Championship for Women”. *FIBA.* Hyperlink: [http://www.fiba.com/rankingwomen]. Retrieved on 10 August 2016.

FIBA (2016c). “Ranking men after the 2014 FIBA World Championship for Men”. *FIBA.* Hyperlink: [http://www.fiba.com/rankingmen]. Retrieved on 10 August 2016.

FORAN, B. (2001). *High-performance sports conditioning*. Champaign, IL: Human Kinetics.

HAEFNER, J. (2014). “How to develop long distance basketball shooting range”. *Breakthrough Basketball.* Hyperlink: [www.breakthroughbasketball.com/fundamentals/shooting-range.html]. Retrieved on 19 November 2014.

HENKIN, J. (2002). “Increasing your vertical jump”. *Body Building.* Hyperlink: [Bodybuilding.com]. Retrieved on 22 April 2014.

HOARE, D. (2000). Predicting success in junior elite basketball players: The contribution of anthropometric and physiological attributes. *Journal of Science and Medicine in Sport,* 3(4): 391-405.

HOFFMAN, J.R. (2006). *Norms for fitness, performance, and health*. Champaign, IL: Human Kinetics.

HOFFMAN, J.R.; EPSTEIN, S.; EINBINDER, M. & WEINSTEIN, Y. (1999). The influence of aerobic capacity on anaerobic performance and recovery indices in basketball players. *Journal of Strength and Conditioning Research,* 13(4): 407-411.

JOHNSON, B.L. & NELSON, J.K. (1979). *Practical measurements for evaluation in physical education* (3rd ed.). Minneapolis, MN: Burgess Publishing Company.

KILINÇ, F. (2008). An intensive combined training program modulates physical, physiological, biometric, and technical parameters in women basketball players. *Journal of Strength and Conditioning Research,* 22(6): 1769-1778.

KURTUS, R. (2014). “Factors in winning basketball games”. *School for Champions*. Hyperlink: [www.school-for-champions.com/competition/factors_in_winning_basketball_games.html]. Retrieved on 23 October 2014.

LEGER, L.A. & LAMBERT, J. (1982). A maximal multistage 20m shuttle run test to predict VO2 max. *European Journal of Applied Physiology,* 49(1): 1-12.

MALA, L.; MALY, T.; ZAHALKA, F.; BUNC, V.; KAPLAN, A.; JEBAVY, R. & TUMA, M. (2015). Body composition of elite female players in five different sports games. *Journal of Human Kinetics,* 45(1): 207-215.

MARTIN, J. (2012). “Power ranking the best basketball leagues in the world outside of the NBA”. *Bleacher report*. Hyperlink: [m.bleacherreport.com/articles/1291287-power-ranking-the-best-basketball-leagues-in-the-world-outside-of-the-nba]. Retrieved on 26 May 2015.

MARZILLI, S.M. (2008). The effects of a preseason strength training program on a Division II college women’s basketball team. *International Journal in Fitness,* 4(1): 7-14.

MIER, C.M. (2011). Accuracy and feasibility of video analysis for assessing hamstring flexibility and validity of the sit and reach test. *Research Quarterly Exercise and Sport*, 82(4): 617-623.

NARAZAKI, K.; BERG, K.; STERGIOU, N. & CHEN, B. (2009). Physiological demands of competitive basketball. *Scandinavian Journal of Medicine and Science in Sports*, 19(3): 425-432.

NEWTON, R.U.; KRAEMER, W.J. & HAKKINEN, K. (1999). Effects of ballistic training on preseason preparation of elite volleyball players. *Medicine and Science in Sports and Exercise,* 31(2): 323-330.

NGEMA, M. (2014). Personal interview with the Head Coach of the University of Johannesburg Female Basketball Team, 24 September 2014, Cape Town.

OSTOJIC, S.M.; MAZIC, S. & DIKIC, N. (2006). Profiling in basketball: Physical and physiological characteristics of elite players. *Journal of Strength and Conditioning*, 20(4): 740-744.

PAUOLE, K.; MADOLE, K.; GARHAMMER, J.; LACOURSE, M. & ROZENEK, R. (2000). Reliability and validity of the t-test as a measure of agility leg power, and leg speed in college-aged men and women. *Journal of Strength and Conditioning Research*, 14(4): 443-450.

PMG (Parliamentary Monitoring Group) (2013). "Challenges facing basketball South Africa: Briefing". *PMG*. Hyperlink: [https://pmg.org.za/committee-meeting/16040/]. Retrieved on 25 October 2014.

PUENTE, C.; ABIÁN-VICÉN, J.; ARECES, F.; LÓPEZ, R. & DEL COSO, J. (2017). Physical and physiological demands of experienced male basketball players during a competitive game. *Journal of Strength and Conditioning Research*, 31(4): 956-962.

RADOVIC, Z. (2010). "FIBA report on Basketball in South Africa". *My Basketball*. Hyperlink: [Mybasketball.co.za/2010/05/fiba-report-on-basketball-in-south-africa]. Retrieved on 14 July 2014.

RODRIGUEZ-ALONSO, M.; FERNANDEZ-GARCIA, B.; PEREZ-LANDALUCE, J. & TERRADOS, N. (2003). Blood lactate and heart rate during national and international women's basketball. *Journal of Sports Medicine and Physical Fitness*, 43(4): 432-436.

ROSE, L.H. (2013). *Winning basketball fundamentals*. Champaign, IL: Human Kinetics.

SCANLAN, A.T.; DASCOMBE, B.J.; REABURN, P. & DALBO, V.J. (2012). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of Science and Medicine in Sport*, 15(4): 341-347.

STEYN, M. & SMITH, J.R. (2007). Interpretation of ante-mortem stature estimates in South Africans. *Forensic Science International*, 171(2-3): 97-102.

WNBA (Women's National Basketball Association) (2004). "Working out with WNBA players". Hyperlink: [www.wnba.com/archive/wnba/statistics/survey_height_2004.html]. Retrieved on 25 January 2017.

WNBA (Women's National Basketball Association) (2014). "Working out with WNBA players". Hyperlink: [www.wnba.com/features/working_out_index.html]. Retrieved on 17 May 2014.

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