THE
ANTHROPOMETRIC AND FITNESS CHARACTERISTICS OF SOUTH AFRICAN FEMALE BASKETBALL PLAYERS

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DECLARATION

I, Lungile Blessed Mtsweni, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

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Signed Date

ABSTRACT

Background

Basketball in South Africa (SA) is viewed as a secondary and social sport, even at national level (Radovic, 2010). The South African female national basketball team is ranked 70 out of 73 countries globally (FIBA, 2014a). There are many possible reasons for the poor success of the team; one contributing factor could be their anthropometric and fitness characteristics. To date, there have been no published research studies investigating the anthropometric and fitness characteristics of female basketball players in SA.

The primary aim of this study was to examine the anthropometric and fitness characteristics of SA female basketball players, in three groups: players in university, provincial leagues and those in the national squad. The secondary aim was to investigate the structures in place for managing and monitoring the strength and conditioning of these players. This research study is the first to examine and compare anthropometric and fitness characteristics of female basketball players at different playing levels in SA.

Methods

The researcher developed two hypotheses that were tested on 55 female basketball players at university, provincial and national team level, founded on the central hypothesis that players at a higher ranked level would fare better in all the tests. A quantitative descriptive design was used on a cross-section of the female basketball playing population. Furthermore, anthropometric and fitness data from previously published basketball studies in other countries were pooled and compared to the results from the current research.

Descriptive and anthropometric data included age, height, mass, sum of seven skinfolds and percentage body fat. The fitness characteristics included flexibility, muscular strength, explosive power (countermovement jump and chest pass), muscular endurance, agility, speed (20m sprint, and suicide run) and aerobic endurance. Questionnaires were administered to participants to investigate the management and monitoring of their fitness via strength and conditioning (S&C) programmes. A one-way analysis of variance (ANOVA) was used to compare the three groups in the study.

Results

Anthropometric data indicate that there were no significant difference in the percentage body fat between the groups but the SA national team players were taller than both the provincial and university players. Of the 11 fitness tests measured, the SA national team players were not better than the provincial players in any of the fitness tests and only better than the university players in three tests. Provincial players actually performed significantly better than the SA players in the aerobic fitness test (bleep-test). SA players were significantly better than the university players in the performance in the hamstring flexibility test (sit and reach), upper body muscle power test (chest pass) and the agility test (T-test). Provincial players were significantly better than the university players in the hamstring flexibility test, agility T-test and the 20m sprint test.

There were few studies investigating the anthropometric and fitness characteristic making comparison often difficult. The SA national players were significantly shorter than their international counterparts, with similar results in % body fat and 20 m sprint times. When the SA national players were compared to the university players abroad, it was found that the SA national players performed significantly worse than the university players abroad for all the fitness tests reported. These tests included the hamstring flexibility, upper body muscle strength, upper body muscle endurance, lower body power and 20m sprint times. Similarly, the university players were also significantly worse than the university players abroad. Limited data on provincial data made a comprehensive comparison difficult but preliminary data indicates that the SA provincial players had better hamstring flexibility but significantly shorter and had significantly worse sprint times in the suicide run.

The results for the management of the S&C of these players were very disappointing. The large majority of the players: 1) do not have access to a S&C trainer or follow a S&C programme (71% of national team, 53% of provincial and 79% of university players); 2) do not do fitness training on weekly basis (71% of national team, 53% of provincial and 58% of university players) and; 3) do not receive any fitness assessments in the year (64% of national team, 88% of provincial and 79% of university players). Despite these poor fitness results and management of their fitness levels, the players generally were satisfied with their fitness status at the start and in the middle of the season. It was promising that there was an effective injury management procedure in place for most of the SA national players and that most players that were on a S&C programme found it to be effective.

Conclusions

Contrary to the central hypothesis, national team players did not fare better in most of the tests. The management of S&C is inadequate at all levels. It is a major concern that the SA national team players have weaker fitness scores than university players in the USA. Given the results, unless significant improvements are made, SA will continue to struggle to compete at an international level.

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DEDICATION

I dedicate this thesis to God, without Whom nothing is possible. I thank Him for giving me the strength, wisdom, knowledge, patience and hope to complete this thesis. To the only God that lives on, there is none like You.

I also dedicate this thesis to my parents, for your patience and support throughout my studies: you were a source of strength through everything. You always reminded me to do better, and that kept my drive, passion and motivation alive: wanting to give up was not an option. You are truly my heroes.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
BNL	Basketball National League
BSA	Basketball South Africa
BTS	Brower Timing Systems
CMJ	Countermovement jump
D I,II, III	Division One, Two or Three
FIBA	International Basketball Federation
g	Gram(s) (unit of measurement of weight)
J	Junior(s)
m	Metre(s) (unit of measurement of height or distance)
min	Minute(s) (unit of measurement of time)
MLB	Major League Baseball (USA)
NBA	National Basketball Association (USA)
NCAA	National College Athletic Association (USA)
NFL	National Football League (USA)
NHL	National Hockey League (USA)
PBL	Premier Basketball League
RM	Repetition maximum
s	Second(s) (unit of measurement of time)
S	Senior(s)
S&C	Strength and conditioning
SA	South Africa(n)
UK	United Kingdom
USA	United States of America
WNBA	Women's National Basketball Association (USA)

GLOSSARY

Basket	A rim attached to a backboard, through which the ball goes when someone shoots it
Blocking	When a defensive player legally deflects a field goal attempt from an offensive player
Centre	Also known as a "5" or "the big man", who is normally the tallest, strongest player who plays close to the basket
Division I, II or III	Level at which players compete; also known as DI, II or III, DI being the highest ranked level of competition
Hoop	Also known as a basket
Lay-up	Two points; scored by leaping and laying the ball up near the basket, using one hand to bounce it off the backboard and into the basket
Line-up	The five players that will start a game
Pivoting	Planting one foot on the floor and spinning on it without dragging it
Point guard (guard)	Also known as a "1". Controls the offence of the team, can handle the ball with ease
Power forward (forward)	Also known as a "4", one of the strongest wide players in the team; handles screens, rebounds and shooting mid-range shots
Rebound	Gaining possession of the basketball after a missed free shot
Shooting guard/Off-guard (forward)	Also known as a "2". Is usually the best shooter in the team and also handles the ball well
Small forward (forward)	Also known as a "3". Can play all positions on the court and sometimes is the best defender in the team
Shuffling	Also known as defense, when a player bends his/her knees, by spreading the legs shoulder-width, or just beyond shoulder-width, and slides side-to-side, backwards and forward, while the gluteus are 90 to 100 degrees above the ground

CHAPTER ONE:
INTRODUCTION AND PROBLEM STATEMENT

This chapter provides a background to the study, the aims and objectives, research design and methodology, data analysis, hypothesis, chapter outlines and conclusion.

1.1 Background and Rationale for the Study

Basketball is a big business venture globally (Bearcats Sports Radio, 2014). It is a complex, technical sport played at different levels by players with varying abilities (Hoare, 2000). Basketball has millions of fans around the world with the biggest fan-bases mainly in North and South America, Europe, Oceania and Asia. The National Basketball Association (NBA) and Euroleague are immense, prestigious leagues globally (Martin, 2012), while the Women's National Basketball Association (WNBA) is a successful women's league in the United States of America (USA) (WNBA, 2015a, b, c, d, e, f, g).

Female basketball globally is managed well and played at international level. Top countries such as America, Australia, and most European and Asian countries have a professional league for women (Euroleague Women, 2015; WNBA, 2015a, b, c, e, f, g). These players do strength and conditioning daily and have assigned physical trainers (Staph, 2010; Stack, 2013; Stein, 2013). These trainers focus on specific individual skills and team dynamics as well. It is also noted that most of these players play basketball professionally and earn a living from the sport. Therefore, it is not surprising that teams from these countries are ranked amongst the best playing teams globally.

Basketball in SA is regarded as a secondary and social sport (Radovic, 2010). There is limited participation by both males and females, despite the establishment of Basketball South Africa (BSA) in 1953, over 60 years ago (Radovic, 2010). Both the national male and female teams are comparatively poor performers in international competition (Radovic, 2010). The SA women's national basketball team is ranked 70 out of 73 countries (FIBA.com, 2014a) globally, while the men's national team is ranked 74 out of 85 countries (FIBA.com, 2014b). Even though the Premier Basketball League was founded in SA in 1992, it was disbanded (1999) then reformed (2007) (Radovic, 2010) and re-named in 2013 as the Basketball National League. This history in itself indicates teething problems with setting up a viable national support structure for the sport (Radovic, 2010). Cohesive structures and development programmes should start from junior to senior level for both female and male basketball players. South African basketball has the potential of growing and competing at a high level, however key aspects need to be addressed in order for this to occur.

There is limited research done on basketball in SA and there are no published articles that look specifically at female basketball players in SA. The poor performance of the SA national team could be associated with poor fitness characteristics, lack of talent identification or under developed skills. This study will mainly focus on the fitness characterises and how their fitness are managed This research study is the first to examine and compare anthropometric and fitness characteristics of female basketball players at different playing levels in SA, as well as investigating the management of the strength and conditioning of these players.

1.2 Aims of the study

The primary aim of this study was to examine the anthropometric and fitness characteristics of SA female basketball players. The secondary aim was to investigate the current structures for managing and monitoring the strength and conditioning of these players.

1.2.1 General objectives

1. Evaluate the differences in anthropometric and fitness characteristics of national, provincial and university female basketball players in SA and compare it to other players playing at same/different levels globally;
2. Determine the managerial structures in place to evaluate and monitor the physical fitness of the players.

1.2.2 Specific objectives

1. To compare the anthropometrical measurements (height and percentage body fat) between national, provincial and university players in SA;
2. Evaluate the fitness characteristics which include flexibility, muscle strength and explosive power, muscular endurance, agility, speed and aerobic

endurance between the national, provincial and university basketball players in SA;

3. To compare these fitness characteristics to teams playing at the same level in other countries;
4. To determine the managerial structures that manage injuries, evaluate and monitor physical fitness and strength and conditioning training habit. Using questionnaires to gather this information in the methodology of the study..

1.3 Significance of the study

The essence of the study was to have data pertaining to anthropometric and fitness characteristics focusing on SA national, provincial and university female basketball players, and to highlight the current fitness status of the players in SA. Also to compare these data to players that play at the same or different levels globally. Furthermore, to provide valuable information to the basketball federation, coaches, managers and players in SA. The importance of the questionnaire was to gain an understanding of whether players followed a strength and conditioning programme, if the programme was effective and if players are physically assessed annually. In addition, it was important to determine if there are management structures in case of injuries and how they managed injuries of players. The results of this study will provide meaningful information to BSA of the anthropometric and fitness status of various levels of players in comparison to players playing in other countries at same/different level.

1.4 Research Design and Methodology

1.4.1 Research design

A quantitative descriptive design was used in this study. Quantitative descriptive studies initiate relationships between variables and enables comparisons across and/or between groups (Jones, 1997). A cross-section of the female basketball playing population (national, provincial and university level) was obtained.

1.4.2 Data collection methods

All descriptive and fitness data were measured using valid and reliable techniques common in basketball. The descriptive data included: age, height, mass, sum of seven skinfolds and percentage body fat. The fitness characteristics included:

flexibility (sit and reach test), muscular strength (one repetition maximum [1RM] bench press and leg press), explosive power (countermovement jump and chest pass), muscular endurance (sit-ups and push-ups), agility (T-test), speed (20m sprint and suicide run) and aerobic endurance (multi-stage fitness test). Questionnaires were also administered to all participating players to investigate the management and monitoring of their physical fitness.

1.5 Data analysis

Mean ± standard deviations of the descriptive data and fitness characteristics were calculated. The descriptive data and fitness characteristics of the three groups were compared using a one-way ANOVA (analysis of variance). Where significant differences were found, a post-hoc Bonferroni analysis was performed to determine where the differences were. A two-tailed T-test was used to compare the fitness characteristics between each group to the anthropometric and fitness characteristics of published data of players playing at a similar level. Furthermore, anthropometric and fitness data from previously published basketball studies in other countries were pooled and compared using a two-tailed T-test (Crombie, 2009) to the results from the current research. This approach was used to get the mean and standard deviation of pooled data from previous studies, in order to determine the averages and compare them with the three groups. Significance was considered when $P \leq 0.05$. Questionnaire data are reported in percentages and absolute values where appropriate.

1.6 Research Hypotheses

The central hypothesis of this research study is that the anthropometric and fitness characteristics of the SA national players are superior to players of both provincial and university teams, and that provincial players in turn are better than players from university teams. Players are selected at a national level, from a pool of players countrywide, based on specific anthropometry, elite fitness characteristics and exceptional basketball skills. Whereas, provincial and university players are selected for the same criteria and similar attributes, yet each cohort of players is limited to geographical and demographical factors.

The test hypotheses are:

Hypothesis 1 – No difference exists between the SA national, provincial and university players with regard to selected anthropometric measures

Stated statistically the null-hypothesis is:

Ho: μ np(a) = μ pp(a) = up(a)

Where:

np = national players,

pp = provincial players,

up = university players,

(a) = anthropometric measures including height and percentage body fat.

Hypothesis 2 – No difference exists between the SA national, provincial and university players with regard to selected fitness characteristics

Stated statistically the null-hypothesis is:

Ho: μ np(f) = μ pp(f) = up(f)

Where:

np = national players,

pp = provincial players,

up = university players,

(f) = fitness characteristics including flexibility, muscle strength, explosive power, muscular endurance, agility, speed and aerobic endurance.

1.7 Chapter Outlines

Chapter One provides an overview of the study: background, aims, general objectives, specific objective, research design and methodology, data collection methods, data analysis, hypotheses and conclusion.

Chapter Two covers a literature review of multiple authors who focused specifically on anthropometry and fitness characteristics of basketball players.

Chapter Three describes the methodology of the study and the instruments used to evaluate them.

Chapter Four presents results of the anthropometry, fitness characteristics and questionnaires of university, provincial and SA national team players. These results were then compared with other players playing at same/different levels globally, using a pooled study to average the results of the international authors. The results of the questionnaires are also presented.

Chapter Five discusses all the results: the comparisons of the three groups locally, and with other players playing at same/different levels globally.

Chapter Six concludes this study with an overview of the results, limitations of the study, and makes recommendations for further research and for improving player performance.

1.8 Conclusion

There are many challenges facing BSA, which include poor fitness and conditioning of players, talent identification, mismanagement, lack of resources, funds and marketing, and poor administration. This thesis, however, only focused on the anthropometric and fitness characteristics, and strength and conditioning management of female basketball players in SA and compared it to other players playing at same/different levels globally.

CHAPTER TWO:
REVIEW OF RELATED LITERATURE

2.1 Introduction

Basketball is a game played at high intensity and players have to be well-conditioned in order to be successful (Alexander, 1976; Foran, 2001). Since May 2000 the International Basketball Federation (FIBA) has placed a 24-second rule, coercing players to execute a strategy and score within the appointed time i.e. 24-seconds (Delextrat & Cohen, 2008). Such a short time limit requires tactical and technical precision, and players to be fast, agile, explosive, flexible and strong and possess stamina. Basketball is a physical game, especially for forwards and centres who must often push opponents to gain a good position to score close to the basket. They are also involved in many screens[1] and box-outs[2] to get rebounds. Guards also require physical conditioning in order to rebound, box-out and withstand a number of screens.

The chapter will discuss the general playing structure in basketball and the anthropometric and fitness characteristics of female basketball players at different skill levels (university, provincial and national level). This will include anthropometric measures such as height, body mass and body fat percentage. The fitness characteristics, such as flexibility, muscular strength, explosive power, muscular endurance, agility, speed and endurance, are also reviewed. These variables will be compared to scientifically published data in basketball.

Unexpectedly, there are few recent scientific publications on the anthropometric and fitness characteristics of female basketball players. This is possibly because professional or national teams do not want to reveal their anthropometric and fitness status of their players. Furthermore, the test protocol and type of tests varied among the published research papers. This makes comparison between tests difficult. As a result, only nine (3 international, 4 provincial and 2 university) of the 19 journals

[1] **Screen** – This is a blocking move by an offensive player, by standing behind or beside a defender to free a teammate to receive a pass, to shoot or drive to score. It is also known as a pick (Basketball Glossary, 2014).

[2] **Box-out** – A technique used to secure a rebound by positioning one's body against an opponent, between the basket and opponent (Basketball Glossary, 2014).

available on anthropometric and fitness variables in female basketball players, used the same standards tests that are reviewed and reported in this thesis (meaning some of the results are mentioned in the literature review but may not be mentioned in Chapter Four or Five. Coaching manuals, basketball website and personal communication with coaches were also used to supplement the review. In addition, the management of programmes of a few successful basketball players globally are also explored.

2.2 Playing Structure

A basketball team is made up of 12 players, normally divided into 6 guards, 4 forwards and 2 centres (Sporting-central.com, 2009), but as only 5 players are allowed to play on the court at any one point in time, the remaining 7 team members are substitutes. Positions in the team depend not only upon individual skills, but also players' height and the strategies that coaches decide to employ on the court (Coleman & Ray, 1987). Coleman and Ray argue that in basketball the position given to a player is determined by the area of the court played by the player on attack.

On the basketball court, the 5 players are normally divided into 2 guards (point guard or playmaker, and shooting guard or off guard), 2 forwards (small forward and power forward) and 1 centre. Guards normally play outside the 3-point line (the half circle on each side of the court, see Figure 2.1). A point guard, usually known as "1" on the court, is the playmaker and is also the general of the team who normally directs strategies that are executed on offence; they are generally the quickest, most agile players in the team (Coleman & Ray, 1987; USA Basketball, 2014f). S/he is comfortable handling the ball and normally has possession of the ball more often than other teammates on the court (Coleman & Ray, 1987; USA Basketball, 2014f). An off guard/shooting guard (position 2 in Figure 2.1) has similar attributes to the point guard and is also the best shooter in the team (Coleman & Ray, 1987; USA Basketball, 2014d). Small forwards (refer to position 3 in Figure 2.1) are utility players and are expected to play all the positions on the court; they are usually the best defenders in the team, with good ball handling, good shooting skills and the ability to "post-up"[3] (USA Basketball, 2014e). A power forward (position 4 in Figure 2.1) is the second biggest player on the court. S/he is normally broad, strong and tall

[3] **Post-up –** To put one's body backwards against an opponent and fight for position by pushing them with the back while moving the feet to gain position to score close to the rim/hoop/basket (Basketball Glossary, 2014).

(Coleman & Ray, 1987; USA Basketball, 2014c) and is responsible for screening, blocking shots, playing close to the basket, and rebounding the ball (Coleman & Ray, 1987; USA Basketball, 2014ba). A centre (position 5 in Figure 2.1) is normally the tallest player in the team, sometimes the slowest player and also shares the qualities of a power forward.

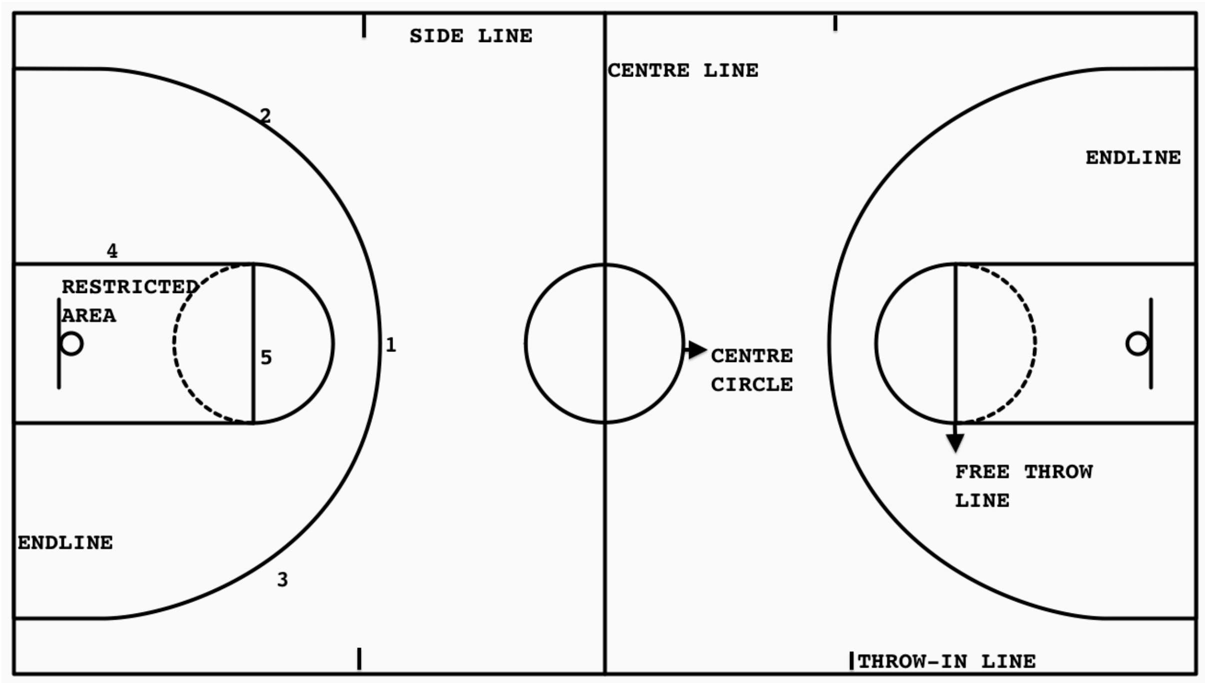

Figure 2.1: Basketball court

(Conceptdraw.com, 2015.)

Playing structures and strategies on a basketball court are most often determined by coaches as they usually know which positions players must play to execute strategies on court or to better match the opponents. This way playing roles and positioning may change to suit the playing performance, and coaches adapt the type of game they utilise depending on the available players (Coleman & Ray, 1987). For example, coaches that have a team of many short players favour a higher intensity game utilising more guards (4 guards and 1 forward or centre); more tall players in a team will change the strategy to a more physical game utilising more forwards (1 guard, 3 forwards and 1 centre) (Ngema, 2014; Toboti, 2014). Coaches also sometimes prefer to play with 4 guards and 1 forward/centre, as a strategy to make the game faster (Ngema, 2014; Toboti, 2014).

2.3 Anthropometry

Anthropometry is the measurement of the human body in terms of its size, width, length, girth and proportions (Tsang, Chan & Taylor, 1998; Hoffman, 2006). The majority of scientific studies published on female basketball measured height, sum of seven skinfolds and body fat percentage. For this reason these aspects are reviewed below.

2.3.1 Height

Players vary in height depending on their playing positions on the court (Drinkwater, Payne & McKenna, 2008; Kilinc, 2008; Erculj, Blas & Bracic, 2010). Taller players typically have a wider arm span (arm span is measured with the player standing straight with arms wide open, measuring from one end of the longest finger to the other longest finger), which is an advantage on both offense and defence (Okubo & Hubbard, 2014). On defence they are able to block shots and rebound, while on offence they are not usually blocked, are able to make high percentage shots when playing near the hoop and can get offensive rebounds (Drinkwater, Payne & McKenna, 2008; Martin, 2014). Playing positions like forwards and centres are usually taller (Alexander, 1976; Bayios, et al., 2006; Delextrat and Cohen, 2008; Drinkwater, Payne & McKenna, 2008; Erculj, Blas & Bracic, 2010; Gaurav, Singh & Singh, 2010). Bayios et al. (2006) suggested that height is an important aspect as it positively influences the performance of basketball players.

Some of the best female basketball players in the world are tall, such as Sylvia Fowles (1.98m); Elena Delle Donne (1.96m); Candice Parker, Tina Charles and DeWanna Bonner (all 1.93 m); Penny Taylor and Tamika Catchings (1.85m); and Diana Taurasi and Maya Moore (both 1.82m) (WNBA, 2014a). These players were chosen because some are franchise players and they are either the best players in the WNBA or Euroleague. Brittney Griner, a professional basketball player with a height of 2.03m and an arm span of 2.24m (Brittney-Griner.com, 2014), was rated the top player from the National College Athletic Association (NCAA) in the 2013 season. She holds the defensive record in the NCAA for the most blocks by a female collegiate basketball player (Martin, 2013). Her height and arm span enable her to play above the rim[4] by slam dunking[5].

[4] **Rim** – Outer edge of the basketball hoop.

Table 1.1: Height of international female basketball players

Global international players	Authors	Year of publication	Average Height of players
National players	Ackland, Schreiner & Kerr	1997	1.81m
	Stapff	2000	1.84m
	Carter et al.	2005	1.81m
	FIBA America	2009	1.85m
	FIBA Europe	2009	1.85m
	FIBA ASIA	2009	1.85m
	FIBA Oceania	2009	1.85m
	Erculj, Bracic & Jakovljevic	2011	1.85m
	Women's African Basketball Tournament (Afro basket)	2013	1.81m
	World Cup in Turkey	2014	1.84m
	Top twenty players globally	2014	1.80m
	Mala et al.	2015	1.86m
Provincial players	Hakkinen	1993	1.74m
	Bayios et al.	2006	1.75m
	Delextrat & Cohen	2009	1.75m
	Berdejo-del-Fresno & Gonzalez-Rave	2010	1.74m
	Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave	2012	1.74m
	WNBA players	2014	1.82m
	Euro-league players	2015	1.84m
University players	Alexander	1979	1.73m
	Barfield, Johnson, Russo & Cobler	2007	1.73m
	Kilinc	2008	1.73m
	Marzilli	2008	1.67m

Reference for: FIBA, Afro Basket and top twenty players (Federacion Espanola De Baloncesto, 2015; FIBA Archive, 2009)

World cup Turkey (FIBA.com, 2014c, d, e, f, g, h, i, j, k, l)

WNBA and Euro-league was 1.83m (FIBA Europe, 2015a,b,c,d,e,f,g; WNBA.com, 2014a)

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[5] **Slam dunk –** Also known as a dunk, this is a basketball shot that is executed when a player jumps high in the air with control of the ball above the rim, and scores by putting the ball directly through the basket using one or two hands (Basketball Glossary, 2014).

The following authors have measured the height of international female basketball players (Ackland, Schreiner & Kerr, 1997; Stapff, 2000; Carter et al., 2005; Erculj, Bracic & Jakovljevic, 2011; Mala et al., 2015). The average height of these international players was 1.84m. The average female basketball height internationally in the 2009 FIBA America, FIBA Europe, FIBA ASIA and FIBA Oceania was 1.85m (Federacion Espanola De Baloncesto, 2015; FIBA Archive, 2009) and at the 2014 World Cup in Turkey, the average measured height was 1.84m (FIBA.com, 2014c, d, e, f, g, h, i, j, k, l). Furthermore, the average height of the top twenty playing teams in the world is 1.80m (Federacion Espanola De Baloncesto, 2015; FIBA Archive, 2009). The average height of female African basketball players playing in the 2013 Afro Basket Championship (Women's African Basketball Tournament) was 1.81m (national players), which is slightly shorter than those players playing outside Africa (1.85m). For a summary of the various measurement of height as discussed above refer to table 1.1.

It appears from the literature and the data presented that the female basketball players playing at a national and provincial level are taller than those playing at university level. This increased height would be an advantage in both offence and defence as discussed above.

2.3.2 Sum of seven skinfolds and percentage body fat

Excessive body fat percentage may be a barrier to athlete's performance. Withers, Craig, Bourdon and Norton (1987) explain that an increase in fat mass that is not related to an increase in force applied by the muscles will decrease acceleration of speed. Too much fat can also make players feel uncomfortable and will not give the required energy (Meltzer & Fuller, 2009). Usually too much fat can slow a player down and reduce peak performance.

Skinfold measurement provides an accurate measurement of fat situated at certain areas of the body; thus it is a common method used to measure body fat percentage (Greene & McGuine, 1998). Body fat percentage can vary from player to player as a result of age, gender, height, playing position, muscle mass, and bone mass (Erculj & Bracic, 2010). Body fat percentage can be measured using the sum of seven skinfolds. The seven skinfold includes the triceps, biceps, subscapular, suprailiac, abdominal, thigh, and medial calf areas (Greene & McGuine, 1998).

There is large variation in the body fat percentages of female basketball players at different skill levels. The average body fat percentage of the Czech Republic national team players who were silver medallists at the World Championship in 2011 was 21% (Mala et al., 2015). The average body fat percentage of England and United Kingdom female provincial basketball players ranged between 22% –27% (Hakkinen, 1993; Bayios et al., 2006; Berdejo-del-Fresno & Gonzalez-Rave, 2010; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012). The average body fat percentage for university players in the USA ranged between 12% – 24% (Kilinc, 2008; Marzilli, 2008). Therefore, there appears to be a large variation of body fat percentage at the different skill level ranging between 12 and 27%.

2.4 Fitness Characteristics

2.4.1 Flexibility

Flexibility is the capacity to move a muscle, or sometimes a group of muscles, through its complete range of motion (Hoffman, 2006). Flexibility is also commonly conveyed and measured relative to a joint (Harvey & Mansfield, 2000). Pain-free mobility of the muscles and bones requires that one maintains a full range of motion at all joints (Hayes, 2004). The value of flexibility lies in that it allows efficiency of movement to perform certain skills more effectively. It also decreases susceptibility to injury and facilitates coordinated movement, which in turn increases speed, power and agility (Harvey & Mansfield, 2000).

Flexibility training is an important factor in basketball (Hayes, 2004). Good flexibility is important in offence and is required when shooting, reaching for a lay-up[6] and/or slam-dunk (Basketball Trainer.com, 2014). Good flexibility is also important in defence as it aids the lengthening of the shuffle strides (Basketball Trainer.com, 2014). Some basketball studies have measured flexibility using the sit and reach test which measures hamstring flexibility (Kilinc 2008; Berdejo-del-Fresno & Gonzalez-Rave, 2010; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012). However, there have been no scientific published articles on hamstring flexibility in international players.

Berdejo-del-Fresno & Gonzalez-Rave (2010) and Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave (2012), measured hamstring flexibility (sit and reach) of English

[6] **Lay-up** – Two points scored in basketball by leaping and laying the ball up near the basket, using one hand to bounce it off the backboard and into the basket (Basketball Glossary, 2014).

provincial players and reported averages of 8cm and 6cm respectively. Kilinc (2008) measured university players in the USA and found their flexibility to average 26.4cm, which appears much bigger than the provincial players measured in England. The researcher is unsure of the reasons for the large differences as both studies reported using the same standard method of measuring (Kilinc 2008; Berdejo-del-Fresno & Gonzalez-Rave, 2010).

2.4.2 Strength and explosive power

Strength is the capacity to produce maximal force and is crucial for the development of most sports (Kraemer & Gomez, 2001) and has been one of the most important elements in enhancement of modern sport and performance (Paish, 1998; Marzilli, 2008).

The main reason for developing strength in basketball is for power and speed (Foran & Pound, 2007; Brittenham & Taylor, 2014). The role of maximum strength may be the essence of power, especially when jumping to get the rebound or block shots (Hakkinen, 1993). Dintiman, Ward and Tellez (1998) suggested that strength and power training aims at providing the body with sufficient force to block an object or opponent at the right time and direction. The authors defined functional strength and power increase as the ability to produce force to complete a task. In addition, athletes with higher leg strength to body weight tend to sprint faster (Dintiman, Ward & Tellez, 1998). Strength training increases muscle force, which is important for stimulation at the beginning of motion (Fleck & Kraemer, 2004). This is seen while jumping for a rebound or blocking a basketball shot.

Power is a result of force and distance divided by time and is a feature of movement as a function of time (Paish, 1998; Chu, 2001). Explosive action (power) is a term used when athletes take advantage of the elastic quality of the muscle (Paish, 1991). Hakkinen (1993) suggests that an increase in explosive power has positive consequences on playing performance. An increase in power can mean an improvement in vertical jump height and sprinting ability (Paish, 1998; Rose, 2013). It is also important for power passes, slam-dunking, rebounding and blocking (Newton, Kraemer & Hakkinen, 1999). Power training has been recommended as an integral part of basketball training (Castagna et al., 2009).

2.4.2.1 Upper body strength and explosive power

Strength of the upper body is important in setting screens (Rose, 2013); securing a rebound (Manfredi, n.d; PowerCranks.com, 2013); posting-up (playing with your back to the basket fighting for position to score); and maintaining position (PowerCranks.com, 2013). This way when the player has the rebound, s/he has enough strength to protect the ball (PowerCranks.com, 2013).

Basketball players need strength of the upper body due to the games high intensity (Drinkwater, Payne & McKenna, 2008), and Marzilli (2008) argues that upper body strength specific to the skills required in basketball needs to be developed and trained for. Upper body strength and power is important for a number of different aspects in basketball (Hayes, 2004) including dribbling the ball; short and distance passing at speed (Hoare, 2000; Cronin & Owen, 2004; Lockie et al., 2013); shooting from far ranges (Zatsiorsky & Kraemer, 2006; Lockie et al., 2013); and blocking a shot. Explosive power of the upper limbs can enable offensive players to make difficult passes by forcing defensive players to close the passing line and making the pass difficult to catch (Coleman & Ray, 1987). On offence, the player can penetrate between defenders and still have control (Rose, 2013). Explosive power of the upper limbs assists in intercepting the ball and continuing to score lay-ups on the attacking basket (Coleman & Ray, 1987; Rose, 2013).

Bench press is one of the ways to measures strength of the upper body. Stapff (2000) presented data on 1RM bench press for the Australian national female basketball team that participated in the 1994 FIBA World Cup, and found that the players benched a mean of 57kg. There are no published data from scientific articles on strength characteristics of female provincial players. The assessment of 1RM bench press for university players in the USA, examined by Kilinc (2008) and Marzilli (2008), revealed that on average the females benched 43kg (pooled data from both studies). According to Hoffman (2006), who reported 1RM bench press values for 120 female university female basketball players in the USA, the absolute values ranged between 37kg to 56kg. This represented the 10% to 90% rank respectively. Comparing these studies, it appears that national players tend to have higher upper body muscle strength than university players.

Most authors who have measured fitness characteristics have not measured explosive power of the upper limbs. As far as the researcher could determine, the only published study investigating female upper body power was performed by

Delextrat and Cohen (2009) who measured chest pass distance using a basketball in female provincial basketball players in the United Kingdom (UK). They found an average measurement of 7m for the chest pass using a basketball. However, the actual weight of the basketball was not provided and it is assumed that the ball was a standard size 6 female basketball (similar to the one used in this thesis).

2.4.2.2 Lower body strength and explosive power

In basketball, strength production of the lower limbs and explosive power are key values for neuromuscular (Hakkinen, 1993) and basketball performance (Loakimidis et al., 2004). Lower body strength affects performance, as it enhances the level of play (Hakkinen, 1993; Haefner, 2014), improves speed when trained correctly (Tobin, 2014) and decreases the chance of injuries (Greene and McGuine, 1998; Arendt, Agel, & Dick, 1999). Players often require strength and power in order to set screens to free their teammates, penetrate to the hoop to score ("driving to the hoop"), and box-out to rebound both on defence and offence (Ziv & Lidor, 2010; Rose, 2013). Lower body strength and power also helps to shoot long-range shots generating power from the legs (Haefner, 2014). The benefits of lower body strength and power, will positively affect sporting career to be longer and also to withstand the high intensity of the game. In addition, strength and power of the lower limbs would be advantageous in order to penetrate between defenders and shoot the ball, while holding ones balance.

Regular strength and power training has been shown to improve vertical jump height in female athletes (Hakkinen, 1993) and it is an important component that contributes to leg power and jump height (Hori et al., 2008). Jumping height in basketball is of particular importance as the higher the player can jump, the easier it is scoring closer to the hoop. .

Appropriate strength and power of the lower limbs may prevent injuries, which are more common in women, such as to the anterior cruciate ligament (ACL) (Greene and McGuine, 1998; Arendt, Agel, & Dick, 1999; Fleck and Kraemer, 2004; Willson, Ireland & Davis, 2006). Basketball also requires a lot of pivoting (planting a foot on the ground while rotating to the left or right when catching the ball) and change-of-direction game, where the ACL can tear if not strong enough. It has been suggested that a reason for this is that men have greater ACL thickness than women, and when pivoting, the trochanteric notch, which gets bigger with taller men but not with taller women is less liable to tear in men (Fleck & Kraemer, 2004). Strength training enhances bone strength and reduces the risk of osteoporosis, produces stronger connective tissue to increase joint stability, and helps prevent injuries. Furthermore, it increases lean body mass and decreases non-functional body fat (Fleck & Kraemer, 2004).

Lower body muscle strength can be measured using the leg press. Leg press is a reliable and valid test to measure lower body extremity (Johnson & Nelson, 1979) and has been a common test used by many researchers (Born, 2004; Beaven et al. 2008; Furlong et al., 2014; King, 2014). However, there have not been any published scientific studies of female or male basketball players that have used the leg press. In this study the leg press was used to get the base of the lower body strength of players because most of the participants were not familiar with power clean and squad exercise which other authors measured (Kilinc, 2008; Marzilli, 2008; Chaouachi et al., 2009).

A countermovement jump (CMJ) is one of the ways to measure explosive power of the lower limbs (Bobbert, Gerristsen, Litjens & Van Soest, 1996; Kilinc, 2008; Koklu et al., 2011). Explosive power in basketball has been investigated from amateur junior level to senior professional level in basketball players, illustrating that explosive power is a key element for a basketball player to possess (Hoare, 2000; Drinkwater et al., 2007; Delextrat & Cohen, 2008; Castagna et al., 2009; Chaouachi et al., 2009; Delextrat & Cohen, 2009; Drinkwater Payne & McKenna, 2008; Schiltz et al., 2009; Koklu et al., 2011; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012; Gaida, et al., 2012). However, only one study reported CMJ results on female adult basketball players (Kilinc, 2008), while other studies evaluated a squat jump and vertical jump. . The squat jump is performed where you lower your body slowly to a squat position, stop and hold the position, then jump from there to maximum height (Bobbert, 1996). A countermovement jump was sport specific as players had to start the test standing with their feet slightly apart, then go to a squat position and jump as high as possible with their hand touching the measurements against the wall, all in one movement. This movement is the same as jumping to catch a rebound, can be after boxing out or shooting three-pointers.

Kilinc (2008) reported a mean CMJ height for university players in the USA of 53cm. There were no published data for international and provincial female players. The following results are some of the authors that evaluated jump height in males: Chaouachi et al. (2009) measured the CMJ in the Tunisian national mens team who had an average jump height of 62cm. The average jumping height of average NBA players is 71cm, while the best jumpers in the NBA jump over 90cm (Topendsports, 2014). Koklu et al. (2011) measured Turkish professional (provincial/state) basketball players by division (first and second divisions) and found the average jumping height was 41cm (first division) and 36cm (second division). Castagna et al. (2009) measured division 6 junior and senior amateur basketball players (equivalent to university and club players) who jumped an average of 47cm (Senior) and 48cm (Junior). From these results it appears players that play in better leagues jump higher.

2.4.3 Muscular endurance

Muscular endurance refers to the body's ability to continue using muscular strength and endure repeated contractions for long periods of time (Hoffman, 2006). There are generally two types of muscular endurance: dynamic endurance and static endurance (Udermann, Mayer, Graves & Murray, 2003). Dynamic endurance is the ability of the muscle to contract and relax repeatedly (Udermann et al., 2003). This usually measures the number of times (repetitions) one can perform a contracting exercise over a given period of time. Static endurance is the ability of the muscle to remain contracted for a long period of time (Udermann et al., 2003). This is usually measures the length of time one can hold a body position. In this thesis the researcher focused on dynamic muscle endurance using push-up and sit-ups.

2.4.3.1 Push-ups

Push-ups are a basis to build strength in the upper body and also improve core strength (MDhealth.com, 2015). A number of muscles work in the upper body throughout push-ups circuit. The major muscle tissues targeted are: pectoralis major, deltoids, triceps brachii, serratus anterior, abdominal muscles and coracobrachialis (MDhealth.com, 2015). Upper body muscular endurance can be measured using push-ups (Hoffman, 2006). Push-ups in males and females can be performed in the same way, or women can perform modified (ladies push-up) push-ups. In basketball push-ups help with passing faster, longer and harder passes, shooting range and dribbling (Haefner, 2014).

Kilinc (2008) measured t;he maximum repetition of push-ups in 30 seconds (s) for university players, and found participants averaged 35 repetitions in 30s. There are no published data on upper muscle endurance for female national or provincial players thereby making comparison difficult. However, according to American

College of Sport Medicine (1995) the normal female population (n= 579) (between age 20-29), push-ups scores in one minute range between 9 and 70. This represented the 5% to 99% rank respectively.

2.4.3.2 Sit-ups

In basketball muscular endurance of the mid-body section can provide stamina in keeping up with the fast pace of the modern game. A defensive player can maintain the defensive stance for longer periods of time, and when being bumped a player is able to handle the impact. Mid-body muscle endurance also helps with jumping for the rebound both on defence and offence, shooting range and boxing out. Muscular endurance may assist in reduction of lower back injuries (Leetun et al., 2004). Basketball requires quick-sprints, sudden-stops, and changes-of-direction: these activities might cause injuries to the knees, and muscular endurance of the mid-body stabilises the body assisting in the prevention of these injuries (Brittenham & Taylor, 2014).

Sit-ups are one of the most common methods used to measure muscular endurance of the abdominal muscles (Hoffman, 2006; Kilinc, 2008). There is only one published paper that reported sit-ups scores in female basketball players (Kilinc, 2008). In this study, Kilinc (2008) evaluated muscular endurance at university level and found that players averaged about 44 sit-ups in 30 seconds. There are no published data on sit-ups for female national or provincial players. However, according to American College of Sport Medicine (1995) for the normal female population (n= 144) (between age 20-29), sit-ups scores in one minute range between 18 and 51. This represented the 1% to 99% respectively. Since Kilinc (2008) measured sit-ups in 30s it is difficult to compare them with the normal female population, according to American College of Sport Medicine (1995).

2.4.4 Agility

Agility can be described as changing direction rapidly (Hoffman, 2006). Agility allows an athlete to react to a stimulus, start quickly and efficiently, move correctly and change direction while maintaining balance (Verstegen & Marcello, 2001). Training for agility may be vital for optimal success in competitions. Agility can be the peak of nearly all the physical abilities that an athlete possesses such as coordination, stabilisation, biomechanics, speed, strength, energy system development, elasticity, power, dynamic balance and mobility (Kraemer & Gomez, 2001; Verstegen &

Marcello, 2001). Young, James and Montgomery (2002: 282) described agility as "muscle power related to running speed with changes of direction."

Basketball is a game of short turns, acceleration and deceleration, changes-in-direction and stops, and therefore players need to be agile. Agility is important on both defence and offence (Verstegen & Marcello, 2001). On defence, agile players make it hard for an offensive player to score as they have the ability to move their feet side-to-side and backwards and forwards quickly. It also allows a defender to stay with an offensive player. Agility allows an offensive player to beat a defender to score, pass or dribble.

Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave (2012) stated that agility should be measured according to basketball-specific movements, such as sprinting, sudden stops, shuffling[7] side-ways, and moving backwards and forwards, like in game situations. Authors reporting basketball data have measured agility in different ways, making comparisons difficult. Delextrat and Cohen (2009) used a 4.5m x 4.5m x 9m agility T-test (Topendsport, 2015) where the subject's average time was 10.45s while Erculj, Bracic and Jakovljevic (2011) used a zig-zag test (BrianMac, 2015). These two tests are very different from each other. Pauole, Madole, Garhammer & Rozenek, (2000) tested recreational university players from different sporting codes whose average time was 12.52s in the T-test.

2.4.5 Speed

Speed is the ability to perform a motion in the fastest time possible (Hoffman, 2006). Erculj, Bracic and Jakovljevic (2011) stated that speed is an ability that significantly influences playing performance. Players need to be fast to be successful in the modern game of basketball. When a player attacks at speed, it makes it hard to defend (Rose, 2013). Speed is largely dependent on muscular power (Rose, 2013). Kraemer and Gomez (2001) mentioned that speed biomechanics have two basic components: stride length and stride frequency; these are also aspects of speed development, which is improved by emphasising the development of an explosive stride (Dintiman, 2001). The key to improved stride length and stride frequency is to

[7] **Shuffling –** also known as defence it is when a player bends his/her knees, by spreading the legs shoulder width or just beyond shoulder width and slide side to side, backwards and forward, while the gluts are 90 to 100 degrees above the ground (Basketball Glossary, 2014).

increase muscular power, improve flexibility in the body joints involved in the movement, and to perfect the mechanics of the movement (Dintiman, 2001).

Speed is a great advantage for any team (Coleman & Ray, 1987; Rose, 2013), as teams with speed have inexhaustible opportunities both on offence and defence (Rose, 2013). A fast, well-conditioned team can put the pressure on opponents by pushing the ball on every possession on offence (Rose, 2013). During dribbling sequences, change of speed may be important because this allows the ball carrier to become free, or free her/himself from a defensive player close by (Coleman & Ray, 1987). On defence, speed allows players to put pressure by forcing turnovers to quick easy baskets (Rose, 2013). The team that has speed may attack while the defence has not yet recovered or organised to defend, and it can mean always staying between an offensive player and the basket while s/he tries to score (Coleman & Ray, 1987).

2.4.5.1 20m sprint

A 20m sprint is one of the ways to measure speed in basketball. This particular test was chosen because a basketball court is 28m long. Many studies measuring speed have therefore used the 20m sprint speed test in their research (Delextrat and Cohen, 2008; Kilinc, 2008; Berdejo-del-Fresno & Gonzalez-Rave, 2010). The average time to complete a 20m sprint of the Australian female national team (which came fourth at the 1994 FIBA World Cup, in Sydney) was 3.3s (Stapff, 2000). In a study by Erculj, Bracic and Jakovljevic (2011) national players in Slovenia (not ranked) and Serbia (ranked 17) averaged 3.6s. Provincial players in the UK averaged 3.5s for the sprint speed test (Delextrat & Cohen, 2009). According to Kilinc (2008) university players in the USA averaged 3.3s. Based on these data there does not appear to be large differences in the speed over 20m, between the different levels of skill.

2.4.5.2 Suicide run

A suicide run tests speed, endurance and agility and measures the capacity of anaerobic power within an athlete (Delextrat & Cohen, 2009). It is an appropriate test for basketball as all these three components play a vital role in players' ability to perform at a high level.

The test is done on a basketball court (Figure 3.2). The player runs from base line to the free-throw line (5.8m) and back, from base line to the half way line (14m) and back, from the base line to the other free-throw line (22.2m) and back and lastly from base line to the other base line and back (28m).

There are few studies (Hoare, 2000) examining the time taken to run suicides by basketball players. There were no published scientific articles found on suicide run results amongst national and university players. Delextrat and Cohen (2008) measured a suicide run of provincial players in the UK; the results showed on average the players completed it in 33.15s.

2.4.6 Aerobic endurance

Endurance refers to the body's ability to bear prolonged exercise (Hoffman, 2006). Paish (1998) stated that endurance training lays the foundation for other training; without endurance, complete fitness can never be attained. Aerobic endurance refers to the ability of the heart and lungs to generate oxygen to muscle tissues to perform for longer periods of time (Daniels, 2001).

Basketball requires players to have aerobic capacity to withstand the high intensity of the game. Aerobic endurance has been positively associated with better mental discipline during the game (Brittenham, 1996; Drinkwater, Payne & McKenna, 2008), because decision-making becomes easy and fatigue will not be a factor during the game (Brittenham, 1996). Endurance in basketball allows players to maintain their, speed or fast movements while executing a skill (Erculj, Bracic & Jakovljevic, 2011).

The multi-stage fitness test (bleep test) is probably the most common test to measure aerobic endurance in basketball (Drinkwater, Payne & McKenna, 2008). This test can be used to estimate an athlete's maximum oxygen uptake, better known as VO_2 max (Léger & Lambert, 1982). VO_2 max it is the maximum amount of energy one uses during vigorous maximal exercise (Quinn, 2014). Pinet, Prud'homme, Gallant and Boulay (2008) indicate that oxygen uptake (VO_2) is the best variable representing metabolic stress when correlated with exercise intensity. Coaches and trainers use this test to determine the aerobic endurance capacity of basketball players as it is easy to administer.

There were only five studies found looking at the VO_2 max of female basketball players at different levels. The two studies used a 20m multi-stage shuttle run to predict the VO_2 max of international and provincial players. The results are as follows; Stapff (2000) measured international players in Australia (average of 51.7 VO_2 max) and Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave (2012) measured provincial players from the UK (average of 45.2 VO_2 max). The other three studies have used a treadmill to predict the VO_2 max of female basketball players. These include the female USA national team (59.0 ± 2.7 VO_2 max) (Hoffman, 2006), the Canadian national team (51.3 ± 4.9 VO_2 max) (Smith & Thomas, 1991) and the Finnish professional team (provincial) (48.0 ± 6.6 VO_2 max) (Hakkinen, 1993).

2.5 Fitness Programmes

In order for players to attain peak fitness for competition, it is important to monitor and correctly manage their fitness training (Drinkwater et al., 2007). Drinkwater, Payne & McKenna (2008) also assert that players require a high level of fitness to compete in the game of basketball and that the reason for sport-specific testing batteries is to enable coaches, players and trainers to monitor and manage training programmes to produce maximum fitness. However, as basketball is highly dependent on skill execution, and there is not necessarily a causal link between the skills of players, size of players and their fitness (Drinkwater, Payne & McKenna, 2008). Therefore, anthropometric and fitness characteristics should not be the only tools used to evaluate players (Drinkwater, Payne & McKenna, 2008).

It is also necessary to develop sports-specific training protocols, in terms of the physical load that are placed on athletes, in any competitive season (Abdelkrim et al., 2010a). Careful selection and execution of testing batteries are very important to enhance performance in basketball players (Drinkwater, Payne & McKenna, 2008). Fitness testing of team sports is an important factor in the evaluation of training programmes and assessment of players (Delextrat & Cohen, 2009).

If an athlete wants to be a high-level performer, s/he needs conscious engagement in practice over a number of years by spending copious amounts of time completing training that continually challenges the athlete to improve performance (Goncalves, Silva, Carvalho & Goncalves, 2011). Training programmes should be of a high quality and systematic according to sport-specific requirements and standards, and must differ during the game season (in-season), after the season (post-season), and before the season (pre-season) to keep athletes in shape, avoid over-training and prevent injuries (Javorkek, 1995). Jovorek (1995) suggested that coaches and trainers should test players according to sport-specific standards to perceive physical progress or deterioration in performance.

Foran and Pound (2007) mentioned that evaluating fitness programmes is very important. In terms of assessment, athletes should be assessed pre-season (start of the season), in-season and off-season (Drinkwater, Payne & McKenna, 2008) and do strength training during the above seasons (Groves & Gayle, 1993).

The S&C coach generally manages the physical fitness of athletes, preparing players to be physically conditioned for the season. Consequently, it is not surprising that the best teams have a comprehensive managing and monitoring system for fitness (NBA, 2015a, b, c, d, e). In the USA, at state (or, in South African terms, provincial) level, the S&C management structures of teams in the NBA and WNBA have at least two athletic trainers and one S&C coach (WNBA 2015a, b, c, d, e, f, g; NBA, 2015 a, b, c, d, e). At any competitive level of play including university level, teams have fitness trainers and conditioning coaches to ensure peak fitness (Drinkwater et al., 2007).

Over a period of eight years, Drinkwater et al. (2007) examined the competitive records of the anthropometric and fitness test scores linked to recruitment age, gender and recruitment year of young athletes (male and female), to determine dissimilarities in newly recruited players. These players had all been regularly tested, approximately five times each over a period of eight months. Records of the progress of basketball players show a pattern of responsibility, reliability and availability. The records also assist in determining the progress or deterioration of players in S&C performance. Regular evaluation helps motivate players to improve by following a S&C programme (Drinkwater et al., 2007).

Dreyer (2005) suggested that an off-season S&C programme could be the difference between a winning and an average basketball team. Strength and conditioning programmes should enhance playing ability. They are important because they help prevent injuries and increase athletic performance (Johnson & Meador, 1989). Strength and conditioning training keeps athletes in shape, mentally fit and continually motivated in their sport. Within S&C programmes, sport-specific training is a key element because it trains athletes in a particular manner to enhance their performance (Brittenham, 1996).

A typical example of time put in for fitness training can be seen by one of the world's best basketball players, Derron Williams, a professional NBA player for the Brooklyn

Nets. He is a three time All-star candidate who does physical and fitness training five to six times a week during the off-season (Stein, 2013).

Training programmes and the management of players are very important in everyday sport as they build a foundation to prowess tactics and technical abilities on the court, while limiting the course of an injury.

As mentioned before, the best players in the world follow a strength and conditioning programme. Management of strength and conditioning programmes are followed from university, (Dreyer, 2005) all the way to professional level (provincial and international level) (Staph, 2010; Stack, 2013; Stein, 2013). These players are most likely to manage training according to sport specifics and train different body parts. Management of strength and conditioning is important and all these three levels of players (university, provincial and national) follow a strength and conditioning programme.

2.6 Summary

It is crucial for basketball players to be physically well conditioned. A well-conditioned player executes skills, makes better decisions on offence and defence and impacts the team dynamics, tactics and technical abilities. As part of this training, it is important to develop all the components of fitness that contribute to performance (Paish, 1991). Javorek (1995) elaborated that S&C coaches and programmes have an important role in helping players become the best possible athlete. A vital part of any S&C programme is an assessment and continued monitoring of the athlete's fitness characteristics.

Studies of female basketball players are not as common as those done on male basketball players (Bayios et al., 2006). In addition, most of the studies do not examine the whole spectrum of morphological characteristics; for example, some studies lack anthropometric data, body composition results or somatotype measurements, while others did not investigate speed (Drinkwater, Payne & McKenna, 2008). Drinkwater, Payne & McKenna (2008) stated that it is difficult to compare studies and results between teams as assessment protocols are often inconsistent among different associations or researchers. For instance, Hoffman et al. (1991) used a no-step vertical jump protocol, 27 m sprint distance, and the sum of eight skinfold sites for body fat percentage, while Drinkwater, Payne & McKenna (2008) used a step protocol, 20m sprint distance and the sum of seven skinfold sites.

Further, coaches are reluctant to share the assessment data of players with their peers or researchers for various reasons, making it difficult to compare or view the results of high profile athletes (Hoffman, 2006). Not only is there limited public data but researchers and coaches also develop their own methods to test players; thus, even if data were publicly available, a comparison of these results across players would be difficult (Hoffman, 2006).

In SA, basketball is considered a recreational and social sport. The South African female national basketball team is ranked 71 out of 73 countries globally (FIBA, 2014a). It is well known that good anthropometric and fitness characteristics and a good S&C managerial structure is vital for the success of elite basketball teams. However, there have been no published research studies investigating the anthropometric and fitness characteristics of female basketball players in SA. Therefore, the fitness status of female basketball players in SA in relation to other players playing at same/different levels globally is uncertain.

The primary aim of this study was therefore to examine the anthropometric and fitness characteristics of SA female basketball players. The secondary aim was to investigate the current structures in place for managing and monitoring of the fitness of these players.

CHAPTER THREE:
METHODOLOGY

This chapter describes the research design and subject selection; outlines the anthropometric and fitness evaluation procedures for specific tests; includes questionnaires that were administrated to players; and provides a description of the data analysis.

3.1 Research Design

A quantitative descriptive design was used in this study. Quantitative descriptive studies initiate relationships between variables and enables comparisons across and/or between groups (Jones, 1997). A cross-sectional study is taking a sample out of a population and measuring subjects once off (Lian, Engebretsen & Bahr, 2005). The current study is a cross-sectional study measuring the anthropometric and fitness characteristics of three groups (SA female basketball players at university, provincial and national level) and then comparing the groups. Furthermore, data from questionnaires relating to the strength and conditioning programmes of the three groups were compared between groups. Finally, anthropometric and fitness data from previously published basketball studies on players in the USA and Europe were also pooled and compared to the results from the three groups. The study was approved by the Cape Peninsula University of Technology (CPUT) Ethics Committee.

3.2 Subject Selection

Invitations to participate in the study and complete assessments were sent to various academic institutions (University of Johannesburg, University of the Witwatersrand, Cape Peninsula University of Technology, University of Cape Town, University of the Western Cape, University of Pretoria and Stellenbosch University), and provincial and national players. Fifty-five (out of the 75 female basketball players who were approached) agreed to participate in the study: 24 university, 17 provincial, and 14 SA national team players. The players resided in the Western Cape, Eastern Cape, KwaZulu-Natal, Free State, Mpumalanga, Limpopo and Gauteng regions. All participants were informed about the nature of the trial and signed a letter of informed consent prior to participation (Appendix A).

All participants were playing members of a university, provincial or national squad and tests were completed in-season. All tests were performed at the following venues: Cape University of Technology, University of Johannesburg, University of Cape Town and the University of the Witwatersrand. The same type of equipment was used at all venues. Exclusion criteria included any history or current signs of injury that would influence their performance or be affected negatively by the assessment.

3.3 Procedure

Prior the assessments, players changed into their sporting apparel (shorts, t-shirt and sneakers). They first had to fill in a consent form, then fill-in the questionnaire. Players did not warm-up (by jogging or stretching before the start of the assessment). The researcher measured the anthropometry first then the fitness assessment were as follows: sit-and-reach, push-ups and sit-ups, bench and leg press, chest pass and countermovement jump, agility, 20m sprint, suicide-run and bleep test. Between tests, all players rested and continued with the rest of the tests when ready.

3.4 Anthropometry

All participants' body mass and height were recorded. Waist and hip circumference, and the sum of seven skinfolds (biceps, triceps, subscapular, suprailiac, abdominal, thigh and calf) were measured. Body fat percentage was estimated using the skinfold measurements (Durnin & Womersley, 1974).

3.5 Fitness Assessment

The fitness assessment included measurements of flexibility (sit and reach), muscular strength (1RM bench press and 1RM leg press), explosive power (CMJ and chest pass), muscular endurance (push-ups and sit-ups), agility (T-test), speed (20m sprint and suicide run) and aerobic endurance (20m multi-stage shuttle run).

3.5.1 Flexibility

Flexibility of the players was measured using the sit and reach test. The test is a reliable (R = 0.97) test in measuring flexibility of the hamstring and lower back muscles (Bozic, Pazin, Berjan, Planic and Cuk, 2010; Mier, 2011). The sit and reach test required subjects to be in a seated position on the floor with legs stretched out straight ahead without bending the knees and no shoes. With the hands on top of one another, the subject had to reach forward toward their toes as far as possible along the top of the box. Subjects were allowed two trial runs attempts and thereafter given three attempts; the best result was recorded.

3.5.2 Muscular strength

3.5.2.1 Upper body strength

Upper body muscular strength was measured using the 1RM bench press according to standard procedure (Hoffman, 2006; Marzilli, 2008). This test is a reliable and valid test measuring upper body strength (Johnson & Nelson, 1979). A Smith machine was used and consists of a barbell that is fixed within steel rails allowing only vertical movement. The subjects were required to lie on a bench and weights were placed on each side of the barbell. A warm up of 6 repetitions at 18kg was performed first, and then weights were added until their 1RM was reached.

3.5.2.2 Lower body strength

Lower body muscular strength was measured using the 1RM leg press. The test is reliable and valid for measuring lower body strength (Johnson & Nelson, 1979). The equipment and materials required for the testing include a leg press machine and weight plates. Subjects were required to lie on an incline leg press machine. Subjects warmed up by completing 6 repetitions at 30kg. Subsequently, weights were added until a 1RM leg press was reached.

3.5.3 Explosive power

3.5.3.1 Basketball chest pass

Upper body explosive power was measured using a chest pass. A women's size 6 leather basketball was used for the chest pass and the distance the ball travelled from the chest to landing was measured (a size 6 ball is 73.66cm in circumference and weighs between 510–567g, Putman, 2015). One of the properties of this ball is that when it is dropped on the basketball court from a height of 180cm it should bounce between 120 and 140cm. The chest pass using this basketball was performed in accordance with previous studies done in basketball (Hoare, 2000; Delextrat & Cohen, 2009). Subjects had to pass the ball while sitting on a chair comfortably (Johnson & Nelson, 1979). Their upper body was tied to the chair so they could only use their upper arms to pass i.e. throw the ball as far as possible. Sand was used to determine where the ball landed. The distance from the centre point of the two feet of the chair to the nearest point where the ball bounced was measured. Subjects were allowed two warm-up trials, and then the best of three attempts was recorded.

3.5.3.2 Countermovement jump

The purpose of this test was to measure the explosive power of the lower limbs. Explosive power was measured using a CMJ, which is both a reliable and valid test for lower body explosive power (Johnson & Nelson, 1979) and performed in accordance with previous studies done in basketball (Kilinc, 2008; Koklu et al., 2011). To perform the CMJ, subjects had to stand sideways flat footed, against a measuring board and reach with one hand as high as possible touching the measuring board with the longest finger. The point where the finger touched the board was used as the baseline value for measuring jump height. 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. A CMJ is a rapid up-down movement with arm swing (Bobbert, Gerristsen, Litjens & Van Soest, 1996). This action achieves more height because of the influence of the stretch-shortening cycle (elastic energy) of the muscle involved, allowing one to produce more power and jump higher (Bobbert et al., 1996). The calculation of jump height equals the height at jump height minus baseline height. The subjects were allowed two trial runs, after which the best of three attempts was recorded.

3.5.4 Muscular endurance

3.5.4.1 Push-ups

Muscle endurance of the upper-limbs was measured using push-ups, which is both a reliable (R = 0.83) and valid test for upper body muscle endurance (Wood & Baumgartner, 2004; Hashim & Madon, 2012) and in accordance with previous studies done in basketball (Hoffman, 2006; Kilinc, 2008). Hoffman (2006) suggested that push-ups can be tested as per the standard push-up, or according to the bent-knee “ladies” push-up. For the current study, ladies push-ups (Hoffman, 2006) also provided data that could be compared to other basketball published studies (Rivera, Rivera-Brown & Frontera, 1998; Hoffman, 2006). Bent knee push-ups are performed with hands shoulder width apart and knees touching the floor, with a straight back. The researcher put a fist under the chest of each player with the thumb and index finger on top. Subjects had to touch the closed hand with their chest and then extend their elbows before returning to the starting position. The total number of push-ups in 30 and 60 seconds was recorded.

3.5.4.2 Sit-ups

Muscle endurance of the mid-body was measured using sit-ups, which is both a reliable and valid test for mid-body muscle endurance (Johnson & Nelson, 1979) and in accordance with previous studies done in basketball (Hoffman, 2006; Kilinc, 2008). Each subject had to lie down on her back with her knees bent. She straightened from this position until her elbows touched her knees and then lowered her torso until her shoulder blades touched the floor. The total number of sit-ups in 30s and 60s was recorded.

3.5.5 Agility

Agility was measured using an agility T-test, which is both a reliable and valid test for agility (Raya et al., 2013), which was performed in accordance with previous studies done in basketball (Abdelkrim, Chaouachi, Chamari & Chtara, 2010b). Timing devices (speed lights) were used for this particular test and placed at the start of the test (cone A). Subjects had to start by sprinting forward for a distance of 10m between the speed lights placed at cone A and cone B, and touch the base of cone B with their right hand. They then had to shuffle, by sliding side-to-side with their knees bent without crossing their feet, for a distance of 5m to their left to cone C, and touch its base with their left hand. This was followed by another shuffle of 10m to their right to cone D, to touch its base with their right hand; then a shuffle of 5m back to cone B, to touch its base with their left hand. Finally, subjects had to back-peddle a distance of 10m to return to cone A, the start of the test (see Appendix D). There were no practice attempts. Subjects had three attempts and the best of the three attempts was recorded.

3.5.6 Speed

3.5.6.1 Sprint

Speed was measured based on time to compete a 20m sprint, which is both a reliable and valid test for speed (Moir, Button, Glaister & Stone, 2004). Brower Timing Systems (BTS) speed lights were placed at the start of the test at zero meters. Players had to stand in a stationary position behind the zero mark and sprint a distance of 20m in between the speed lights. This distance was chosen because it is sport specific, slightly less than a basketball court (28m) and is consistent with previous studies done in basketball (Kilinc, 2008; Delextrat & Cohen, 2008; Koklu et al., 2011). There were no practice attempts. Subjects had three attempts and the best of three attempts was taken.

3.5.6.2 Suicide run

A suicide run is commonly used in basketball to measure the anaerobic capacity of basketball players. The test was performed in accordance with previous studies done in basketball (Hoare, 2000; Delextrat & Cohen, 2009). The BTS were placed on the base line (zero meters). Subjects were asked to sprint continuously for 140m at maximum speed with a number of direction changes. To complete the 140m, players had to sprint as follows:

1. Players started at the base-line then ran a distance of 5.8m to the first free-throw line and sprinted back to the base line;
2. From the base-line to the half-line (14m) and back to the baseline;
3. From the baseline to the far free-throw line (22.2m) and back to the baseline; and
4. From base line (0m) to the far end baseline (28m) and back to the baseline (start of the test).

As the subjects arrived at each line, they had to sprint back to the starting (base) line. Subjects had one attempt and the result was recorded (Figure 3.2).

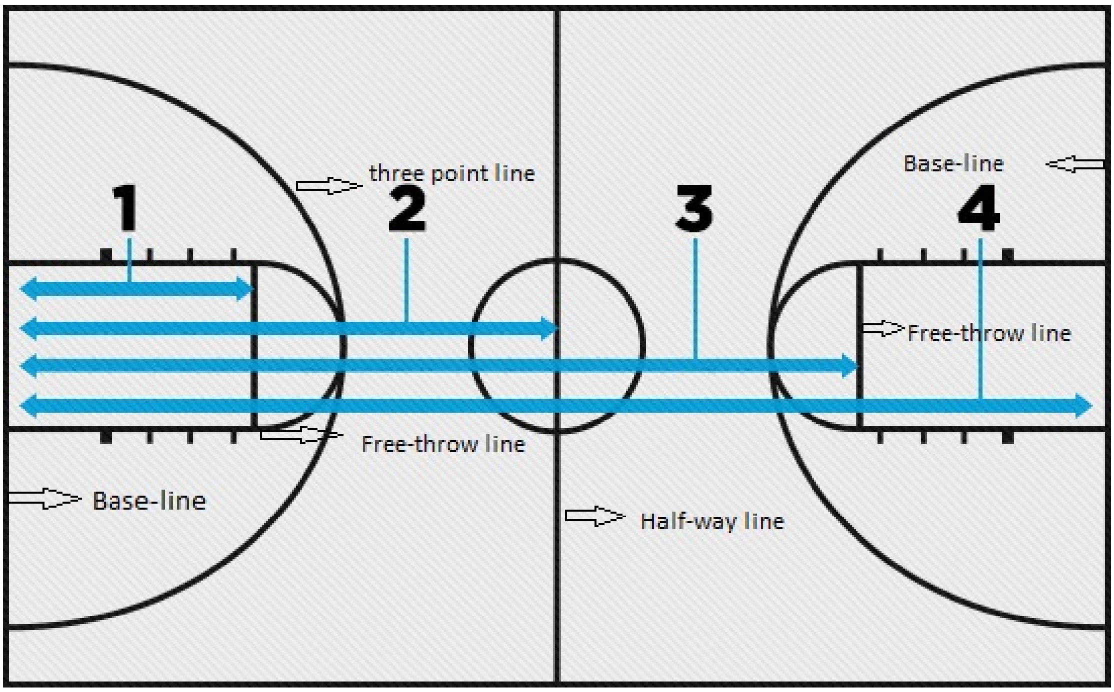

Figure 3.2: Suicide procedures adapted from Bodybuilding (2014)

3.5.7 Aerobic endurance

Aerobic endurance was measured using a 20m multi-stage shuttle run (bleep test), which is both a reliable and valid test for aerobic endurance (Léger & Lambert, 1982; Léger et al., 1988) and performed in accordance with previous studies done in basketball (Hoare, 2000; Drinkwater, Payne & McKenna, 2008; Berdejo-del-Fresno & Gonzalez-Rave, 2010; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012). Two cones were placed 20m apart and subjects had to run in between the cones. One or both feet had to be on the line at the signal of the bleep or before the bleep of an audio-disc player. The audio-disc tape ensured that subjects started running at an initial speed of 8.5km/hour and that the running speed increased by 0.5km/hour each minute (Léger et al., 1988). This increase in running speed is described as a change-in-test level. Test results for each subject were expressed as test level and shuttle. The predicted VO_2 max was obtained by cross-referencing the final level and shuttle number at which the subject voluntary stopped running or if the signal bleeped before the subject could step on the line (Léger et al., 1988).

3.6 Questionnaires for Strength and Conditioning Programmes.

The purpose of the questionnaire was to determine the status of strength and conditioning programmes and fitness management structures of the three groups. All participants answered the same questionnaire. These were the only Strength and Conditioning questions provided to the players to complete. The results were compared between the three groups.

General:

How long have you been playing basketball?	
What is your playing position?	

Questions:

Do you have a strength and conditioning program that you follow for the season?	YES		NO	
If yes – who manages the training programme?	Coach	Trainer	Manager	Other
How many hours/week do you do strength and conditioning?				
How many times a year do you get physically assessed?				
Do you think the strength and condition program is effective?				

On a scale of 1 to 5, 1 being very bad, 2 bad, 3 average, 4 good and 5 very good:

	1	2	3	4	5
How was your physical condition in the last season?					
How physically conditioned were you when the season started?					
How is your S&C in the middle of the season?					
In case of an injury, is there a management procedure to manage injuries?	YES		NO		
If yes, how efficient is this procedure?					

3.7 Statistical Analyses

Mean ± standard deviations of the descriptive data and fitness characteristics were calculated. The descriptive data and fitness characteristics 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.

The results of the three groups were also compared to previously published work. This was done by pooling the data of the relevant publications and comparing it to the study's data. All published studies on female basketball players at university, state and national level in the USA, the UK, Australia, Slovenia and Serbia and Czech Republic were used. The results of the three groups were compared to other players playing at same/different levels globally from 1979–2014. The reason for the long time-span was because there were not enough data posted on female basketball players across the globe or, where data were available, the tests were not similar to those used in the current study and did not allow comparison with one another.

The results of the national players in this study were compared to the players that competed in Slovenia and Serbia's national teams (Erculj, Bracic & Jakovljevic, 2011) and also the players that competed in the 1994 World Championships in Australia (Carter et al., 2005). Provincial players measured in this study were compared to studies of provincial players in the UK (Bayios et al., 2006; Delextrat & Cohen, 2008; Berdejo-del-Fresno & Gonzalez-Rave, 2010; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012). University players measured in the current study were compared to the results found in scientific studies of university players in the USA (Kilinc, 2008 and Marzilli, 2008).

A two-tailed independent t-test was used to compare the fitness characteristics between each group to the anthropometric and fitness characteristics of published data of players playing at a similar level. Meta-analysis is a statistical approach used to combine independent authors who used similar studies to test pooled data for statistical significance (Crombie, 2009). This approach was used to get the mean and standard deviation of pooled data from previous studies, to determine the averages and compare them with the three groups. Significance was considered when $P \leq 0.05$. The Statistical Package for the Social Sciences (SPSS) version 21 statistical software was used for the data analysis. Results of questionnaires for the three groups were calculated using percentages.

CHAPTER FOUR:
RESULTS

4.1 Introduction

This chapter compares the anthropometric and fitness characteristics of university, provincial and national players in SA, and also compares the data to other players playing at same/different levels globally. The questionnaires results were represented as a percentage for each group.

As mentioned in the previous chapter, 55 players were recruited to participate in the study: 24 university, 17 provincial and 14 SA players. All the data were obtained for the anthropometry and questionnaires. However, there were missing data for some of the other tests because the players were, for various reasons, unable to complete them. All the subjects completed anthropometry and the questionnaires. All the players completed a CMJ. Out of the university group, 23 players completed a 1RM bench press and sit and reach test, and 18 players completed the agility T-test, 20m sprint, suicide run and bleep test. The provincial group shows 16 players completed the agility T-test and 14 players completed the 20m sprint and suicide run. Of the SA national team, 12 players completed the agility T-test, 20m sprint and suicide run and 13 players completed the bleep test. Table 4.1 presents a summary of the tests completed.

Table 4.1: Data of the tests completed on university (U), provincial (P) and SA players

Tests conducted and numbers of players completing each test			
	University	**Provincial**	**SA**
Age (yrs)	24	17	14
Height (m)	24	17	14
Mass (kg)	24	17	14
% body fat	24	17	14
Sit and reach (cm)	23	17	14
1 RM bench press (kg)	23	17	14
1 RM leg press (kg)	24	17	14
Chest pass (m)	24	17	14
Countermovement jump (cm)	24	17	14
Push-ups (30s)	24	17	14
Push-ups (60s)	24	17	14
Sit-ups (30s)	24	17	14
Sit-ups (60s)	24	17	14
T-test agility (s)	18	16	13
20 m sprint (s)	18	14	12
Suicide run (s)	18	14	12
Bleep test (level/shuttles)	18	17	13
Predicted VO_2 max	18	17	13

4.2 Playing Positions

Playing positions of university, provincial and SA players are presented in Table 4.3. Of the university players measured, 79% were guards, 13% were forwards and 8% were centres. The provincial group measured showed 94% were guards, 6% were forwards and there were no centres. The SA players consisted of 64% guards, 29% forwards and 7% centres.

Table 4.2: Playing positions for university, provincial and SA players

	% U (n= 24)	**% P (n= 17)**	**% SA (n= 14)**
Guards	79	94	64
Forwards	13	6	29
Centres	8	0	7

4.3 Subject Characteristics

The subject characteristic data for university, provincial and SA female national players are presented in Table 4.3.

A one-way ANOVA was used to test for differences in age among university, provincial and SA female basketball players. Age differed significantly across the three groups: F[8] (2, 52) = 3.7, p[9] = 0.031. Bonferroni (*post hoc*) comparison of the three groups indicates that SA players were older (M[10] = 24 95% CI[11] [22, 26]) than provincial players (M = 21, 95% CI [20, 22]), p = 0.029. There were no significant difference between ages of the provincial players (M = 21, 95% CI [20, 22]) and university players (M = 22, 95% CI [20.47, 23.53]), p = 0.560 or between SA players (M = 24, 95% CI [22, 26]) and university players (M = 22, CI [20, 23]), p = 0.472.

[8] F = F ratio (Stockburger, 1996).

[9] P = P value (Stockburger, 1996).

[10] M = Mean (Stockburger, 1996).

[11] IC = Confidence Interval for Mean (Stockburger, 1996).

Height differed significantly across the three groups, F (2, 52) = 7.4, p = 0.002. Comparison of the three groups indicates that SA players were taller (M = 1.74, SD = 0.1, 95% CI [1.68, 1.79]) than both provincial players (M = 1.63, 95% CI [1.6, 1.66]), p = 0.003 and university players (M = 1.66, 95% CI [1.61, 1.68]), p = 0.005. There was no significant difference between the heights of provincial players and university players.

There were no significant differences in body mass and body fat percentage between the three groups.

Table 4.3: Subject characteristics of university, provincial and SA players

	U (n= 24)	**P (n= 17)**	**SA (n= 14)**	**F**	**P value**
Age (yrs)	22 ± 3.6	21 ± 2.7*	24 ± 3.5*	3.7	0.031*
Height (m)	1.65 ± 0.1*	1.63 ± 0.1*	1.74 ± 0.1‡	3.2	0.002*
Mass (kg)	65.7 ± 11.9	61 ± 7.0	71.1 ± 13.3	3.2	0.051
% body fat	23.89 ± 5.9	19.53 ± 4.8	22.28 ± 5.5	3.1	0.052

All descriptive data are presented as mean ± standard deviation (SD) and F value. The p-value reports differences between the three groups. * denotes that significance was accepted p<0.05. ‡ denotes that the value is significantly higher than the other values.

4.4 Flexibility, Muscular Strength, Explosive Power and Muscular Endurance

Flexibility, muscular strength, explosive power and muscular endurance data for university, provincial and SA female national players are presented in Table 4.4.

Flexibility (sit & reach) differed significantly across the three groups, F (2, 51) = 6.4, p = 0.003. Comparison of the three groups indicates that the provincial players (M = 14.5, 95% CI [11.96, 17.01]) were significantly more flexible compared to university players (*M* = 9.14, 95% CI [6.53, 11.74]), *p* = 0.006. SA players (*M* = 13.857, 95% CI [11.71, 16.00]) were also significantly more flexible than university players, p = 0.029. There was no significant difference between provincial players and SA players.

Upper body muscle strength (1RM bench press test) did not differ significantly between the three groups, F (2, 51) = 0.1, p = 0.896. Lower body muscle strength

(1RM leg press test) did not differ significantly between the three groups, $F(2, 52) = 0.1$, $p = 0.874$.

Explosive power of the upper limbs (chest pass test) indicates that the three groups differed significantly: $F(2, 52) = 7.0$, $p = 0.002$. Post-hoc comparisons of the three groups indicates that SA players (M = 7.82, 95% CI [7.26, 8.38]) threw the basketball ball further than university players (M = 6.77, 95% CI [6.44, 7.11]), $p = 0.001$. However, there was no significant difference between SA players and provincial players (M = 7.23, 95% CI [6.83, 7.62]), $p = 0.159$. There was also no significant difference between provincial and university players. Explosive power (CMJ test) of the lower limbs indicates that there was no significant difference across the three groups, $F(2, 52) = 2.7$, $p = 0.077$.

Upper body muscular endurance (push-ups) did not differ significantly between the three groups both in 30 and 60 seconds push-ups respectively: $F(2, 52) = 0.3$, $p = 0.752$ and $F(2, 52) = 0.4$, $p = 0.656$. Mid-body muscular endurance (sit-ups) did not differ significantly between the three groups for the number of sit-ups in both 30 seconds ($F(2, 52) = 2.0$, $p = 0.141$) and 60 seconds ($F(2, 52) = 2.4$, $p = 0.105$).

Table 4.4: Flexibility, muscular strength, explosive power and muscular endurance of university, provincial and SA players

	U	P (n= 17)	SA (n= 14)	F	P value
Sit and reach (cm)	9.14 ± 6.0* (n= 23)	14.48 ± 5.0*	13.86 ± 3.7*	6.4	0.003*
1 RM bench press (kg)	31.09 ± 9.4 (n= 23)	31.52 ± 6.8	32.47 ± 9.7	0.1	0.896
1 RM leg press (kg)	163.33 ± 45.7 (n= 24)	156.47 ± 47.0	162.86 ± 37.3	0.1	0.874
Chest pass (m)	6.77 ± 0.8* (n= 24)	7.22 ± 0.8	7.82 ± 1.0*	7.0	0.002*
Countermovement jump (cm)	33.34 ± 6.8 (n= 24)	37.77 ± 5.0	35.76 ± 5.8	2.7	0.077
Push-ups (30s)	19.67 ± 6.9 (n= 24)	20.59 ± 5.7	21.36 ± 7.7	0.3	0.752
Push-ups (60s)	29.91 ±11.5 (n= 24)	33.00 ± 9.5	33.00 ± 13.6	0.4	0.656
Sit-ups (30s)	19.33 ± 4.3 (n= 24)	18.53 ± 3.1	21.29 ± 4.1	2.0	0.141
Sit-ups (60s)	35.08 ± 9.1 (n= 24)	36.06 ± 6.3	40.71 ± 7.4	2.4	0.105

All descriptive data are presented as mean ± SD and F value. The p-value reports differences between the three groups. * denotes that significance was accepted p<0.05.

4.5 Agility, Speed and Endurance Capacity

Agility, speed, and endurance data for university, provincial and SA female national players are presented in Table 4.5.

Agility (T-test) differed significantly across the three groups: F (2, 44) = 6.6, p = 0.003. Comparison of the three groups indicates that SA players (M = 11.6, 95% CI [10.97, 12.26]) were significantly more agile than university players (M = 13.0, 95% CI [12.26, 13.74]), p = 0.012. There was no significant difference between provincial (M = 11.7, 95% CI [10.22, 13.45]) and SA players. The provincial players were significantly more agile than university players, p = 0.012.

Speed (20 m sprint) differed significantly across the three groups: F (2, 41) = 5.8, p = 0.006. Comparison between the three groups indicates that provincial players (M = 3.51, 95% CI [3.39, 3.63]) were significantly faster than university players (M = 3.8, 95% CI [3.68, 3.92]), p = 0.007. There was no significant difference between SA players (M = 3.59, 95% CI [3.39, 3.79]) and provincial players, nor between university players and SA players.

Speed and agility (suicide run test) did not differ significantly between the three groups: F (2, 41) = 1.6, p = 0.220.

Predicted VO_2 max differed significantly across the three groups. The results indicate that the provincial players (M = 37.8, 95% CI [34.68, 53.39]) had higher predicted levels of VO_2 max than SA players (M = 32.35 95% CI [29.33, 35.35]), p = 0.031. There was no significant difference between provincial players and university players and there was also no significant difference between SA players and university players.

Table 4.5: Speed, agility and predicted VO_2 max of university, provincial and SA players

	U (n= 18)	P	SA	F	P value
T-test agility (s)	13 ± 1.5*	11.72 ± 1‡ (n= 16)	11.59 ± 1.2‡ (n= 13)	6.6	0.003*
20 m sprint (s)	3.81 ± .2*	3.51 ± .2‡ (n= 14)	3.59 ± .3 (n= 12)	5.8	0.006*
Suicide run (s)	34.99 ± 3.1	33.29 ± 1.5 (n= 14)	34.39 ± 3.4 (n= 12)	1.6	0.220
Predicted VO_2 max (mL/(kg'min)	35.44 ± 6.4	37.80 ± 18.2‡ (n= 17)	32.35 ± 4.9* (n= 13)	3.5	0.039*

All descriptive data are presented as mean ± SD and F value. The p-value reports differences between the three groups. * denotes that significance was accepted p<0.05. ‡ denotes that the value is significantly higher than the other values.

4.6 Comparison of Anthropometric and Fitness Data of Players in SA and Other Countries

In this section the data obtained from the university, provincial and SA players were compared to other players playing at same/different levels globally. .

4.6.1 Subject characteristics of university players in SA and the USA

Table 4.6 compares the subject characteristics of university players in SA with pooled data on university players in the USA (Kilinc, 2008; Marzilli, 2008).

The SA university players were significantly older, shorter and carried more body fat than the pooled data for university players in the USA. There was no significant difference in the body mass between SA university and the university players in the USA.

Table 4.6: Subject characteristics of university players in SA vs. the USA

	Kilinc (2008) (n= 12)	Marzilli (2008) (n= 14)	Pooled data (n= 26)	U (n= 24)	P-value
Age (y)	20 ± 0.7	19 ± 1.2	19 ± 1*	22.00 ± 3.6*	0.001*
Height (m)	1.73 ± 0.1	1.67 ± 0.05	1.70 ± 0.1*	1.65 ± 0.1*	0.023*
Mass (kg)	59.2 ± 4.4	67.6 ± 8.2	63.7 ± 6.7	65.7 ± 12	0.462
% Body fat	11.20 ± 1.2	24.20 ± 3.8	18.20 ± 2.9	23.89± 5.9	0.000*

All descriptive data are presented as mean ± SD. * denotes that significance was accepted p<0.05.

4.6.2 Physical fitness data of university players in SA and the USA

Table 4.7 compares the data of flexibility, strength, muscular endurance, explosive power and speed of university players in SA and university players in the USA (Kilinc, 2008; Marzilli, 2008). University players in the USA are significantly better at sit and reach, 1RM bench press, 30s push-ups and sit-ups, CMJ and 20m sprint compared to university players in SA, but there was no significant difference in the 1RM bench press.

Table 4.7: Flexibility, muscular strength, muscular endurance, explosive power and speed of university players in SA vs. in the USA

	Kilinc (2008) (n= 12)	Marzilli (2008) (n= 14)	Pooled data (n= 26)	U	P-value
Sit and reach (cm)	26.40 ± 5.0*	-		9.14 ± 6.0 * (n= 23)	0.000*
Bench press (kg)	31.40 ± 3.4	52.80 ± 9.2	42.92 ± 7.2*	31.09 ± 9.4* (n= 23)	0.000*
30s push-ups (s)	30.4 ± 4.9*	-		19.66 ± 6.9* (n= 24)	0.000*
30s sit-ups (s)	39.90 ± 3.7*	-		19.33 ± 4.3* (n= 24)	0.000*
CMJ (cm)	52.70 ± 5.3*	-		33.34 ± 6.8* (n= 24)	0.000*
20 m sprint (s)	3.30 ± 0.1*	-		3.81 ± 0.2* (n= 24)	0.000*

All descriptive data are presented as mean ± SD. * denotes that significance was accepted p<0.05. - indicates that the authors did not report the variable.

4.6.3 Subject characteristics of provincial players in SA and the UK

Table 4.8 compares the subject characteristics of provincial players in SA with pooled data on provincial players in the UK (Bayios et al., 2006; Delextrat & Cohen, 2009; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012).

There was no significant difference in age of the SA provincial players and provincial players in the UK. However, provincial players in the UK were significantly taller, heavier and had a higher body fat percentage than the SA provincial players.

Table 4.8: Subject characteristics of provincial players in SA vs. in the UK

	Berdejo-del-Fresno, Lara-Sanchez and Gonzalez-Rave (2012) (n= 14)	Bayios et al. (2006) (n= 133)	Delextrat and Cohen (2009) (n= 30)	Pooled data	P (n= 17)	P-value
Age (y)	21 ± 2.3	22 ± 3.8	25 ± 3.00	23 ± 3.6 (n= 177)	21 ± 2.7	0.048
Height (m)	1.74 ± 4.2	1.75 ± 7.8	1.75 ± 5.4	1.75 ± 6.5* (n= 177)	1.63 ± 0.1*	0.000*
Mass (kg)	75.20 ± 15.4	71.50 ± 10.1	68.20 ± 9	71.20 ± 10.4* (n= 177)	61.05 ± 6.9*	0.000*
% Body fat	24.67 ± 4.2	24.30 ± 3.6	21.30 ± 4.4	23.80 ± 3.8* (n= 177)	19.53 ± 4.8*	0.000*

All descriptive data are presented as mean ± SD. * denotes that significance was accepted p<0.05.

4.6.4 Flexibility, explosive power, speed and endurance tests of provincial players in SA and the UK

Table 4.9 compares the data on flexibility, explosive power, speed and endurance tests of provincial players in SA and pooled data on provincial players in the UK (Bayios et al., 2006; Delextrat & Cohen, 2009; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012).

The provincial players in the UK were significantly less flexible in the hamstrings than provincial players in SA (p = 0.000) but had significantly faster times in the suicide run (p = 0.002) and better VO_2 max (p = 0.000) compared to the provincial players in SA. There was no significant difference in explosive power of the upper limbs (chest pass), speed (20 m sprint) between the provincial players in the UK and the provincial players in SA.

Table 4.9: Flexibility, explosive power, speed and endurance of provincial players in SA and the UK

	Berdejo-del-Fresno, Lara-Sanchez and Gonzalez-Rave (2012) (n= 14)	Berdejo-del-Fresno and Gonzalez-Rave, (2010) (n= 19)	Delextrat and Cohen (2009) (n= 30)	Pooled data (n= 74)	P	P-value
Sit and reach (cm)	5.95 ± 7.36	8.00 ± 8.0	-	7.13 ±7.6*	14.48 ± 4.9* (n= 17)	0.000*
Chest pass (m)	-	-	6.93 ± 0.67		7.22 ± 0.8 (n= 17)	0.213
20 m sprint (s)	-	-	3.50 ± 0.23		3.51 ± 0.3 (n= 14)	1.000
Suicide run (s)	-	-	31.14 ± 2.15*		33.29 ± 1.5* (n= 14)	0.002*
VO_2 max (ml/(kg'min)	45.18 ± 4.17	43.18 ± 4.17	-		.37.8 ± 6.3‡ (n= 17)	0.000

All descriptive data are presented as mean ± SD. * denotes that significance was accepted p<0.05. - indicates that the authors did not report the variable.

4.6.5 Subject characteristics of national players in SA, World Cup 1994 data, Slovenia and Serbia and Czech Republic

Table 4.10 compares the subject characteristics of national players in SA, with pooled data of international players (national players in World Cup Australia [1994], Slovenia and Serbia, and Czech Republic).

There were no significant differences in age and body mass between the national players in SA versus international players. There was no significant difference in % body fat in national players in SA compare to national players from other countries. However, national players globally were taller than the national players in SA (p = 0.000).

Table 4.10: Subject characteristics of national players in SA vs. national players in other countries

	Carter et al. (2005) (n= 168)	Erculj, Bracic, and Jakovljevic (2011) (n= 26)	Mala et al. (2015) (n= 14)	Pooled data (n= 208)	SA (n= 17)	P-value
Age (y)	25 ± 3.3	25 ± 3.6	26 ± 4.2	25 ± 3.5	24 ± 3.5	0.351
Height (m)	1.80 ± 1.0	1.81 ± 9.1	1.85 ± 9.0	1.81 ± 5.0*	1.74 ± 0.1*	0.000*
Mass (kg)	73.2 ± 9.3	74.2 ± 12.7	76.6 ± 7.8	73.7 ± 11.0	71.1 ± 13.3	0.365
% body fat	-	-	21.22 ± 1.7		22.28 ± 5.5	0.497

All descriptive data are presented as mean ± SD. * denotes that significance was accepted p<0.05. - indicates that the authors did not report the variable.

4.6.6 Speed of national players in SA vs. national players in Slovenia and Serbia

Table 4.11 compares the data on the 20 m sprint speed of national players in SA verses national players in Slovenia and Serbia.

There was no significant difference in speed for national players in SA and national players in Slovenia and Serbia.

Table 4.11: Speed capacity of national players in SA vs. in Slovenia and Serbia

	Erculj, Bracic and Jakovljevic (2011) (n=30)	SA (n= 17)	P-value
20 m sprint (s)	3.59 ± 0.1	3.59 ± 0.3	0.885

All descriptive data are presented as mean ± SD. * denotes that significance was accepted p<0.05.

4.6.7 Flexibility, muscular strength, muscular endurance, explosive power and speed of national players in SA vs. university players in the USA

Table 4.12 compares the flexibility, strength, muscular endurance, explosive power and speed of national players in SA with the pooled university players in the USA.

University players in the USA were significantly more flexible and stronger in the upper body, had better muscular endurance of both upper limbs and mid-body section, better lower limb explosive power and were faster than the national players in SA.

Table 4.12 Flexibility, muscular strength, muscular endurance, explosive power and speed of SA national players vs. university players in other countries

	Kilinc (2008) (n= 12)	Marzilli (2008) (n= 14)	Pooled data (n=26)	SA	P-value
Sit and reach (cm)	26.4 ± 5*	-	-	13.85 ± 3.7* (n= 14)	0.000*
Bench press (kg)	31.4 ± 3.4	52.80 ± 9.2	42.92 ± 7.1*	32.47 ± 10* (n= 14)	0.000*
30s push-ups (s)	30.4 ± 4.9*	-	-	21.35 ± 7.7* (n= 14)	0.000*
30s sit-ups (s)	39.9 ± 3.7*	-	-	21.29 ± 4.1* (n= 14)	0.000*
CMJ (cm)	52.7 ± 5.3*	-	-	35.76 ± 5.8* (n= 14)	0.000*
20 m sprint (s)	3.3 ± 0.1*	-	-	3.6 ± 0.3* (n= 12)	0.003*

All descriptive data are presented as mean ± SD. * denotes that significance was accepted $p<0.05$. - indicates that the authors did not report the variable.

4.7 Players perception on their strength and conditioning status

4.7.1 Strength and Conditioning Programmes of Players

The answers from the questionnaires on the S&C programmes of players were used to determine how many players follow a S&C programme, who manages the S&C programme, weekly training hours, the number of players that were assessed annually and the effectiveness of the programme.

4.7.1.1 Availability and Management of S&C programmes

Players were asked: Do you have a S&C programme that you follow for the season and 21% of university, 47% of provincial and 29% of SA players, said yes (Table 4.13). If players answered “yes” to the previous question, then they were asked who manages the programme (Table 4.13). 13% of university players were managed by coach and 8% by trainer; 41% of provincial players by coach and 6% by trainer; and 7% of SA players by coach, 7% by trainer and 15% by other.

Table 4.13: Management of S&C training programmes

	% U (n= 24)	% P (n= 17)	% SA (n= 14)
Players that have a S&C programme	21	47	29
If yes - who manages the training programme?			
Coach	13	41	7
Trainer	8	6	7
Manager	0	0	0
Other	0	0	15

4.7.1.2 Fitness and weekly training hours

Players were asked: how many hours per week do you do strength and conditioning: 58% of university players, 53% of provincial and 71% of SA players did not do any fitness training weekly. Of the players that did fitness training, 4% of university players train 1 hour per week (none of provincial and SA players train an hour per week); 13% of university and 47% of provincial players train between 1 to 2 hours per week (none of SA players train for two hours per week); 8% of university players train 2 hours per week (none of provincial or SA players train 2 hours per week) and 17% of university, none of the provincial, and 29% of SA players train for three or more hours weekly (Table 4.14).

Table 4.14: Weekly fitness and training hours

	% U (n= 24)	% P (n= 17)	% SA (n= 14)
How many hours/week do you do strength and conditioning?			
0 hour	58	53	71
about 1 hour	4	0	0
1-2 hours	13	47	0
2 hours	8	0	0
3 hours and more	17	0	29

4.7.1.3 Assessments to monitor physical fitness

Players were asked; how many times a year do you get physically assessed: 21% of university, 12% of provincial and 36% of SA players get assessed at least once annually, with a large majority of players at all levels not being assessed at all (Table 4.15).

Table 4.15: Frequency of physical assessments

	% U (n= 24)	% P (n= 17)	% SA (n= 14)
Players that get physically assessed annually	21	12	36
How many times a year do you get physically assessed?			
Zero assessment	79	88	64
Once annually	4	0	36
Twice annually	8	6	0
Thrice annually	8	6	0

Due to rounding the values may not equal 100%.

4.7.1.4 Effectiveness of S&C programmes

Those players that had a S&C programme were asked: Do you think the strength and condition programme is effective and 80% of university, 75% of provincial and 100% of SA players believed that it was effective.

4.7.1.5 S&C status during the previous playing season

Data relating to players' S&C status during their last season are presented in Table 4.16. When players were asked to rate their S&C status in the last season, 5% of university, 6% of provincial and 21% of SA players rated their S&C status as very bad; 18% of university, none of the provincial and 14% of SA players rated their S&C status as bad; 32% of university, 59% of provincial and 37% of SA players rated their S&C status as average and 36% of university, 35% of provincial and 14% of SA players rated their S&C status as good. Lastly, 9% of university, none of the provincial and 14% of SA players rated their S&C status during the previous playing season as excellent.

Table 4.16: S&C status during previous playing season

	% U (n= 22)	% P (n= 17)	% SA (n= 14)
Very bad	5	6	21
Bad	18	0	14
Average	32	59	37
Good	35	36	14
Excellent	9	0	14

4.7.1.6 S&C status at the start of the playing season

Players' ratings of their S&C status at the start of the playing season are presented in Table 4.17. Nine per cent of university players rated themselves as very bad, while none of the provincial or SA players did; 42% of university, 6% of provincial and 14% of SA players rated their S&C status as bad: 26% of university, 47% of provincial and 57% of SA players rated their S&C as average; 23% of university, 35% of provincial and 36% of SA players rated their S&C status as good. Lastly, only none of the university, 12% of provincial and none of the SA players rated their S&C status at the start of the playing season as excellent.

Table 4.17: S&C status of the start of the playing season

	% U (n= 23)	% P (n= 17)	% SA (n= 14)
Very bad	9	0	0
Bad	42	6	7
Average	26	47	57
Good	23	35	36
Excellent	0	12	0

4.7.1.7 S&C status in the middle of the playing season

Data relating to players' rating of their S&C status in the middle of the season is presented in Table 4.18. None of the university, provincial or SA players rated their status as being very bad. Only 14% of university, none or the provincial or SA players rated their S&C status as bad; while 59% of university, 24% of provincial and 7% of SA players rated their S&C as average; and 27% of university, 41% of provincial and 65% of SA players rated their S&C status as good. Lastly, none of the university, 35% of provincial and 21% of SA players rated their S&C status at the middle of the playing season as excellent.

Table 4.18: S&C status in the middle of the playing season

	% U (n= 22)	% P (n=17)	% SA (n=14)
Very bad	0	0	0
Bad	14	0	7
Average	59	24	7
Good	27	41	65
Excellent	0	35	21

4.7.1.8 Management procedures in case of an injury

Questionnaire data by university, provincial and SA players related to management procedures in case of an injury is presented in Table 4.19. Players were asked: in case of an injury, is there a management procedure to manage injuries and 42% of university, 35% of provincial and 71% of SA responded there was a management procedure.

Table 4.19: Management procedures in case of an injury

	% U (n= 23)	% P (n= 17)	% SA (n= 14)
Do you have a management procedure in case of an injury?	42	35	71

4.7.1.9 Effectiveness of management procedures in case of an injury

Data relating to players' rating of the effectiveness of the management procedures in case of an injury is presented in Table 4.20. Players were asked: how efficient are procedures: none of the university or provincial players rated the management procedure as very bad, but 10% of SA players rated the management procedures as very bad; 20% of university, and none of provincial or SA players rated the management procedures as bad; while 50% of university, 17% of provincial and 37% of SA players rated the management procedures as average and 30% of university, 50% of provincial and 45% of SA players rated them as good. Lastly, none of university, 33% of provincial and none of SA players rated the management procedures as excellent.

Table 4.20: Effectiveness of management procedures in case of an injury

	% U (n= 23)	% P (n= 17)	% SA (n= 14)
Very bad	0	0	10
Bad	20	0	0
Average	50	17	40
Good	30	50	50
Excellent	0	33	0

CHAPTER FIVE:
DISCUSSION

5.1 Introduction

This research study is the first to examine and compare anthropometric and fitness characteristics of female basketball players at different playing levels in SA. These players were also compared to similar levels globally. It is also the first study to investigate the management of the strength and conditioning programmes of these players.

5.2 Playing Position

In a traditional team set-up there are 12 players consisting of 6 guards, 4 forwards and 2 centres (FIBA.com, 2014c, d, e, f, g, h, i, j, k, l), with a maximum of 5 players on the court. In the three groups studied, there were a higher percentage of guards than forwards and centres (Table 4.3) compared to a traditional team set-up. The most probable reason for this is that team coaches do not always employ a typical team structure, as players can play multiple positions in the modern game of basketball (Medcalf, 2013). This is not uncommon as many team structures and playing positions do not conform to tradition and are reliant on the strength of the team (Coleman & Ray, 1987). Mr Kimati Toboti, (2014) SA female national coach, agreed that basketball coaches play a different structure or strategy to suit the overall strength of the team. He further elaborated that if teams have shorter players, a different strategy and team structure will be played (often including more guards) compared to a traditional basketball set-up (Toboti, 2014).

5.3 Descriptive Data

5.3.1 Age

SA national players were significantly older than the provincial players, but there was no significant difference between SA and university players or between the university and provincial players. Several authors have measured age in basketball but have not discussed the significance of it (Hakkinen, 1993; Ackland, Schreiner & Kerr 1997; Carter et al. 2005; Bayios et al., 2006; Drinkwater et al., 2007; Kilinc, 2008; Delextrat

& Cohen, 2008, 2009; Berdejo-del-Fresno & Gonzalez-Rave, 2010; Erculj, Bracic & Jakovljevic, 2011). The ages of national and provincial players in SA were similar to those of their competitor's age abroad (Ackland, Schreiner & Kerr, 1997; Carter et al. 2005; Erculj, Bracic & Jakovljevic, 2011). The university players measured in this study were significantly older than those in other countries (Kilinc, 2008; Marzilli, 2008). Perhaps the reason why the university players in SA were older could be related to the time it took them to complete their diplomas/degrees. However, this is speculative and requires further investigation. The effect of age on performance is also uncertain. Generally, more experienced players tend to perform better in basketball (USA Basketball, 2014a) and playing experience can be related to age. However, we did not measure playing experience making further discussion on the effect of age, playing experience and performance difficult.

5.3.2 Height

SA national players were significantly taller than both provincial and university players. This was somewhat expected as taller players often dominate in basketball (Drinkwater, Payne & McKenna, 2008; Martin, 2014). Being tall provides advantages both in offence and defence (Emma, 2014; Kurtus, 2014; Martin, 2014). Most often, taller players have longer arm spans which also gives them an advantage in offense and defence, (Levin, 2014; Pomero, 2014). In offence they have better chances of scoring close to the basket and making high percentage shots; they are able to take offensive rebounds and score them quickly; they can shoot over defenders; and they are able to make overhead passes and receive better passes to and from teammates. With their arm span and tall frame they are able to beat opponents with one explosive dribble to separate themselves from a defender and shoot the ball. It is hard to block tall players as they have a higher reach. In defence: their capabilities are valued as they are able to block shots easier; cover more ground more quickly; and make it harder for an attacking player to pass the ball over and around them because of their tall frames (Emma, 2014; Kurtus, 2014; Levin, 2014). Therefore, as SA national players they would have a height advantage over the provincial and universities players. This is possibly also a reason for their inclusion in the SA national team.

The SA university, provincial and national players were significantly shorter than their counterparts globally (Tables 4.6, 4.8 and 4.10) and are therefore disadvantaged in basketball as they lack the height advantages as cited above. The national players in SA are amongst the shortest basketball players in the world (Federacion Espanola

De Baloncesto, 2015; FIBA Archive, 2009) which could negatively impact their performances. Interestingly, SA is also listed as one of the countries with the shortest populations globally, with an average height of 1.59 m for females (*Disabled World*, 2008). However, this is not the case in China whereby the Chinese female population average height is 1.58 m (*Disabled World*, 2008), and the Chinese National Female Basketball team height average was 1.87 m (FIBA.com, 2014e) compared to the height of SA players (1.74 m).

The Parliamentary Monitoring Group (PMG) (2013) mentioned that BSA has minimal resources to operate the sporting code and there are no systems for talent identification and scouting players. In addition, tall girls are often lost to other sporting codes such as netball. One of the many reasons why there is lack of height in basketball players is that basketball is mostly played by black females (PMG, 2013) who are usually short compared to white girls who are much taller (Ngema, 2014). In a personal interview, BNL coach Ngema pointed out another issue: SA basketball is competitive at university level for females, but after players leave or graduate from universities, they enter the work place and only play basketball socially or stop the game all together. Only about 500 female basketball players play at a senior level in SA (Ngema, 2014), making the pool of players extremely small.

Height of players affects the selection process into the national teams and therefore affects playing strategies (Emma, 2014). This may ultimately have a negative impact on performance when competing internationally as coaches have to adjust the way teams execute strategies, tactics and technical abilities on offence and defence. This type of playing might hinder the performance of SA female basketball players because they sometimes have to copy a style of play that is played in that particular position (as a result of a height disadvantage). Furthermore, players then often do not play to their own strengths because of this height disadvantage.

It is most likely that a team with many short players, like the SA national team, will not win playing close to the hoop; but if their speed and agility is at a high level, then they can compete and play a fast and agile game. This means that team strategies will have to change to address the height of the players and focus more on the strong points of shorter players. In the modern game of basketball, tall players can play multiple positions; therefore basketball tends to favour tall players while shorter players have to excel in many of the other basketball skills in order to make a team successful (Medcalf, 2013).

Although height is an important attribute, it is not the only factor that contributes to the success of the player or team. For example, India is ranked 40^{th} internationally and the average height is 1.74 m, the same as the SA players, but SA ranks in 70^{th} position (FIBA, 2014a). Therefore, factors such as fitness characteristics, strategy and skill of players, play an important role.

5.3.3 Percentage body fat

There was no significant difference in body fat% of university, provincial and SA players. These results appear in the normal range for female basketball players and therefore might not negatively affect performance. There was no significant difference in body fat% of national basketball players in SA compare to international players (Czech Republic). However, players at a university level in the USA had significantly less body fat than the SA national players. Both these teams (Czech Republic and the University team who won the US championship) are professional players, however they have large differences in their percentage body fat. The body fat percentage can vary from player to player as a result of age, gender, height, playing position, muscle mass, and bone mass (Erculj & Bracic, 2010) and within a normal range, might not have any effect on performance. Generally, increased body fat could negatively affect performance in basketball as it is not related to an increase in force applied by the muscles (Withers et al., 1987) and will negatively affect acceleration and speed. However, this would refer to excessive fat (over 30%). The reported percentage fat of the SA national team is similar to other international players and within the normal value for skilled female athletes. Similarly the results of the provincial and university players (also within the normal range for female basketball players) although significantly different to their counterparts in other countries might not have any effect on playing performance.

5.4 Fitness Characteristics

A superior level of fitness is beneficial for players to compete at a high level in basketball (Drinkwater, Payne & McKenna, 2008). The best players in the world have exceptional skills but they are also well conditioned in relation to flexibility, strength, muscular endurance, explosive power, speed and aerobic endurance (Delextrat & Cohen, 2009).

5.4.1 Flexibility

SA national and provincial players had significantly better hamstring flexibility than university players, but there were no significant differences between provincial and national players. This provides a possible reason for the higher playing status of the national and provincial players in SA. Good flexibility of the hamstring muscles is beneficial for basketball players and has been shown to enhance performance on the court (Henkin, 2002). In basketball terms, this means when jumping to block a short, on rebounds, sprints, runs, turns and moving sideways in a defensive stance (Rose, 2013). These contractions happen with ease when there is a high level of flexibility within a player, making movement easier (Harvey & Mansfield, 2000). Hamstring flexibility is also important as it lessens muscle stiffness, strains and injuries (Hartig & Henderson, 1999) and has been suggested as assisting in injury prevention in basketball (Hartig & Henderson, 1999; Askling, Saartok & Thorstensson, 2006). The literature review showed that university players in USA (Kilinc, 2008) were more flexible than the provincial players in England (Berdejo-del-Fresno and Gonzalez-Rave (2010); Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012). It was therefore hypothesised that university players would have better hamstring flexibility than provincial players. This hypothesis is now rejected and it is uncertain why so low flexibility results were reported for provincial players in England. Further, there are limited data on female hamstring flexibility making further comparison difficult.

There were no studies found on evaluated hamstring flexibility (sit and reach) of national players. Berdejo-del-Fresno and Gonzalez-Rave (2010) and Berdejo-del-Fresno, Lara-Sanchez and Gonzalez-Rave (2012) measured flexibility in provincial players in England; the averages of these two studies was pooled and compared to the provincial players in SA, who proved to be significantly more flexible than the English provincial players studied. Once again these results are hard to reconcile as the hamstring flexibility reported by some English provincial teams were poor for elite athletes (between 6-8cm). Kilinc (2008) is one of the few scientific studies that has measured sit and reach hamstring flexibility of university players, who went on to win the university championship in the USA. University players in the USA were more flexible than SA national and university players (Tables 4.7 and 4.12). These average values of the USA university players (average of 26.4cm) appear more in line with general athletes. For example, female university volleyball players average hamstring flexibility of ± 22 cm (Fry et al., 1991).

5.4.2 Muscular strength and explosive power

Development of strength has been an important element to enhance athleticism (Marzilli, 2008) and sport performance (Paish, 1998). Strength is also a fundamental component of power (Foran & Pound, 2007; Brittenham & Taylor, 2014). In basketball strength of the upper body is an important offensive element, in setting solid screens (Rose, 2013), rebounding, and also in offence for shooting long-range shots and passing the ball from one side of the court (Haefner, 2014).

5.4.2.1 Upper body muscular strength

There were no significant differences in the upper body muscular strength between the SA, provincial and university players in SA. This suggests that either the upper body muscle strength is not an important factor in determining performance in basketball in SA or that the upper body muscle strength of the national team is poor as they are on par with university players. It was hypothesised that the SA national players would be stronger than both provincial and university players.

In order to better understand this, a comparison should be made with other players in the world. However, the published data of national players from Stapff (2000) did not have a standard deviation making it difficult to compare with the SA national players. There were also no data for female provincial players in other countries for the 1RM bench press to compare the results. A comparison was then made between the pooled data for university players reported by Kilinc (2008) and Marzilli (2008). The national players in SA had significantly worse upper body muscle strength than the university players measured abroad. This now suggests that the upper body muscle strength, as measured by 1RM bench press, in the SA national team is poor, and this could negatively affect their playing performance. The fact that it is on par with the university players in SA is therefore a concern.

5.4.2.2 Upper body explosive power

The national players in SA had better explosive power (chest pass) than university players, however there was no significant difference between the national players and provincial players. 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). It can also mean blocking a defender, as well as assisting in deflecting or intercepting the ball on defence (Rose, 2013). Rose explains how explosive power of the upper body can also mean that players can throw balls further, which could be effective after catching the rebound from the defence-end of the court and passing the ball to a teammate running to score a quick basket on the other side. On defence it could be intercepting, blocking and rebounding the ball, all of which require positioning and timing. SA national team players therefore have the upper body power advantage over SA university players, providing a possible reason for their status in SA basketball.

No published scientific studies were found that evaluated national and university players in other countries making comparison between the performance of SA players and players in other countries difficult. However, chest pass distance was reported for provincial players in the UK (Delextrat & Cohen, 2009). There were no significant differences in chest pass distance between SA provincial players and the provincial players in the UK. This tends to suggest that the explosive power of the upper body of SA provincial players is similar to their competitors in other countries.

5.4.2.3 Lower body muscular strength

When comparing the three groups there was no significant difference in lower body muscular strength (1RM leg press). This suggests that lower body muscle strength is not an important aspect that separates skill in SA female basketball. As mentioned in chapter two, no other study has investigated leg-strength in female basketball using the leg-press. Therefore, leg press was used to get the base of the lower body strength of players because most of the participants were not familiar with power clean and squat exercises which other authors measured (Kilinc, 2008; Marzilli, 2008; Chaouachi et al., 2009).

5.4.2.4 Lower body explosive power

Countermovement jump between the three groups showed no significant difference. It was hypothesised that the SA national players would jump higher than both provincial and university players. A component of power is strength (Paish, 1998). There were no significant differences in the strength of the groups and therefore it is not surprising that there were no significant differences in the lower body explosive power. This once again suggests that the lower body explosive power of SA national players is similar to the lower ranked university players.

Explosive power gives a basketball player the ability to jump for rebounds on defence and offence (Ziv & Lidor, 2010; Rose, 2013). Players can jump high in basketball but the important elements are positioning, anticipating, timing, jumping quicker and mostly jumping higher to get the rebound, blocking a shot (Ziv & Lidor) or intercepting the ball (Rose). Explosive power of the lower limbs is meant to be quick: to explode with a dribble, or beat defenders with the first step to explode to the basket. For example, if an attacking player is ready to shoot the ball behind the three-point line and a defender runs to towards her/him to block the shot. The attacking player can explode with a dribble or two and pass the defender with a quick first step to shoot the ball.

Numerous scientific studies have investigated explosive power in basketball, from junior basketball players all the way to professional male basketball players, illustrating that explosive power is one of the priority skills a basketball player can possess (Hoare, 2000; Drinkwater et al. 2007; Delextrat & Cohen, 2008, 2009; Castagna et al. 2009; Chaouachi et al., 2009; Schiltz et al., 2009; Koklu et al., 2011; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012; Gaida et al., 2012). The CMJ of national and university players in SA was compared with the university players in the USA as reported by Kilinc (2008). The US university players jumped significantly higher than both national and university players in SA, suggesting that the jumping height of SA players is below the level of university players in other countries. This is a significant result as SA players were also significantly shorter than their counterparts in other countries. SA players are therefore handicapped by their naturally low height and further disadvantaged because of their low jumping height (as measured by the CMJ). This will result in SA players being extremely disadvantaged and this is probably one of the most concerning aspects that the coaches, managers and trainers need to address.

5.4.3 Muscular endurance

Muscular endurance is the ability of the muscle to perform a circuit or exercise repeatedly over a long period of time (Hoffman, 2006). This thesis looked at push-ups and sit-ups under the heading of muscular endurance.

5.4.3.1 Muscular endurance of the upper limbs

The comparison of muscular endurance of the upper limbs (as measured through push-ups) of the three groups showed no significant difference. This result indicates that an aspect of physical fitness of the SA national team is on par with recreational university players in SA. Once again, it was hard to compare these results to other players in the world, as very little scientific published data are available. However, as stated in chapter two, according to American College of Sport Medicine (1995) for the normal female population (n= 579) (between age 20-29), push-ups scores in one minute range between 9 and 70. This represented the 5% to 99% rank respectively. When comparing both SA national and provincial players to the normal female population (American College of Sport Medicine, 1995), the SA national and provincial players fall between 70%-75% rank (excellent). However, we would have expected that the SA national players fall in the superior rank (99%) as they should be the elite athletes in the country. When comparing university players to the normal female population (American College of Sport Medicine, 1995), the university players fall on 55% (good). However, a comparison of upper body muscle endurance between basketball players in other countries would provide a better indication of the fitness status of the players as compared to fitness tests of a normal female population.

One of the only studies that the researcher could compare her results to was with to university players in the USA (Kilinc, 2008). Kilinc (2008) measured push-ups performed in a traditional way (prone position), while in the current study modified push-ups were performed (ladies push-up), as most of the players could not perform a traditional push-up. Thus, the results were compared between the modified push-up test (ladies-push-ups) and the more difficult conventional test (prone position). It was found that the university players reported in Kilinc’s study (using the traditional test) were significantly better than both the national and university players in SA. This indicates very poor upper body endurance of SA players in general. This is significant as muscular endurance of the upper limbs helps on offence with dribbling for longer periods of time and shooting, and on defence helps players to ‘stand wide’ for longer, making themselves bigger by opening their arms without tiring, so making it harder for players to pass the ball (Haefner, 2014).

Once again the SA players would be disadvantaged in all these aspects of the game because of their poor muscular endurance.

5.4.3.2 Muscular endurance of the mid-body

Muscular endurance of the three groups showed no significant difference in sit-ups. As seen in previous physical fitness tests, the same trend was shown where SA national players’ performance was similar to university players’. Muscular endurance of the mid-body is important as most of the control in basketball comes from the mid-body, such as jumping, changing direction and sprinting (Brittenham & Taylor, 2014). Muscular endurance of the mid-body also enhances equilibrium of the body (Brittenham & Taylor, 2014). However, according to American College of Sport

Medicine (1995) for the normal female population (n= 144) (between age 20-29), sit-ups scores in one minute ranged between 18 and 51. This represented the 1% to 99% rank respectively. When comparing both SA national and provincial players to the normal female population, the SA national and provincial players fall between 60%-75% (good) rank. This is still less than the preferred 99% rank for elite athletes. When comparing university players to the normal female population (American College of Sport Medicine, 1995), the university players fall on 55% rank (poor), which tend to indicate that the muscular endurance of these players are below standards for basketball.

Most scientific basketball studies which have measured fitness characteristics have not measured sit-ups, even though sit-ups are one of the ways to measure muscular endurance of the mid-body. Kilinc (2008), one of the few authors to have assessed sit-ups, shows a significant difference in sit-ups between the university players in the USA and the university and national players in SA. The difference is considerable with university players in the USA doing ± 20 more sit-ups per minute than the university players in SA, and ± 18 more sit-ups per minute than national players in SA. As we have seen, SA players performed poorly in their sit-ups and push-up scores leading to poor muscle endurance of the upper body. This would negatively affect their ability to jump, quickly turn, accelerate and balance (Brittenham & Taylor, 2014).

5.4.4 Agility

There was a significant difference in agility, where SA and provincial players were more agile than university players; but there was no significant difference between the national and provincial players. This may be due to the higher competition national and provincial players are exposed to. SA and provincial players were also more flexible in the hamstrings compared to the university players (see Section 5.4.2 above) suggesting that the increase in hamstring flexibility could contribute to their better agility performance as compared to university players (Kraemer & Gomez, 2001; Verstegen & Marcello, 2001).

In basketball fast movements, such as moving from side to side and changes of direction, are encouraged. Agility is one of the essential characteristics of basketball players, especially guards. Agility has been measured in scientific studies (Marzilli, 2008; Delextrat & Cohen, 2008, 2009; Erculj, Bracic & Jakovljevic, 2011) but authors have measured agility in different ways, making it hard to compare studies. There was no data that compared the agility T-test (5 m by 5 m and 10 m) used by the researcher. Delextrat and Cohen (2008, 2009) measured agility according to playing position but used different measurements (4.5 m by 4.5 and 9 m) compared to the current study.

Basketball movements combine speed and agility and are needed when using the ball and without using the ball (Erculj, Bracic & Jakovljevic, 2011). Movements based on agility in offence include dribbling from one end of the court to the other, penetrating and manoeuvring between defenders when creating a shot, short turns, and full on acceleration with and without the ball. In defence agility is required when anticipating opponents' movement and always being between them and the basket. All these movements are done at a high intensity (Erculj, Bracic & Jakovljevic). Young, James and Montgomery (2002) propose that the quality of strength of the lower limb muscles may influences agility performance, along with several other factors. The study looked into muscle power related to running speed with change-of-direction, and measured male athletes who were involved in sports that required sprinting and change-of-direction. It was concluded that reactive strength of the leg extensor muscles had some importance in change-of-direction performance but technical factors that influence agility should also be conceded. As Verstegen and Marcello (2001) elaborated, agility is not easily defined as it consists of dynamic power, quick movements, coordination, control, balance and speed. These elements make a difference in elite and exceptional athletes. Athletes with these attributes and skills make it hard for even good defenders to anticipate and defend against players that can move with and without the ball; these high-calibre athletes determine the rate or capacity of intensity in the game. It is even harder defending against a team that thrives on speed and agility.

5.4.5 Speed

5.4.5.1 20 m sprint

The SA national team players were not significantly faster over 20m than the provincial or universities in SA. However, the provincial players were faster than the university players.

SA players are shorter compared to their counterparts in other countries. These players could therefore use their speed in order to compensate for their lack of height, in order to be competitive. When the speed of university players in the USA

(Kilinc, 2008), and national and university players in SA were compared, it revealed a significant difference: university players in the USA were faster than both national and university players in SA. Once again it is noteworthy that university players in the USA have better fitness characteristics than national players in SA. Basketball is predominantly an anaerobic sport (Delextrat & Cohen, 2009). Anaerobic capacity in basketball is one of the main factors that separate average players from good players (Twist, 2001:100).

Several authors have measured speed in basketball (Drinkwater, Payne & McKenna, 2008; Kilinc, 2008; Delextrat & Cohen, 2008, 2009; Berdejo-del-Fresno and Gonzalez-Rave 2010; Erculj, Bracic & Jakovljevic, 2011; Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave, 2012). A fast team can execute a strategy quicker on offence putting pressure on the opponent's defence to organise quickly, making it hard to keep up with such a team (Rose, 2013). Rose (2013) explains that good defenders are athletic, quick, can intercept the ball and force turnovers, as on defence a fast team can overplay because they can recover quickly, and in such situations turnovers occur, making it an instant offence (easy basket). Also, as Coleman and Ray (1987) note, their speed causes opponents to make errors on defence, by putting pressure on the person that has the ball, by marking passing lanes and potential pass receivers. The lack of sprinting speed amongst the SA national team players will make it hard for them to compete successfully internationally.

When provincial players were compared, there was no significant difference in the sprint time of provincial players in the UK and provincial players in SA, once again suggesting that test scores of these players appear to be on par with those in other countries.

5.4.5.2 Suicide run

There were no significant differences in the time to complete the suicide run between the SA national, provincial and university players. Suicide run is a measure of speed, agility and measures the capacity of endurance and anaerobic power within an athlete (Delextrat & Cohen, 2009). Once again results indicate no significant difference particularly between the national and the university players. Based on the results previously presented, it becomes clear that the national team fitness measures based on these aspects are as weak as the university players in SA. Furthermore, the provincial players in the UK were faster than the provincial players in SA in completing the suicide run (Delextrat & Cohen, 2009). Poor performance in these tests would lessen the players' ability to move quickly across the court, to quickly turn and sustain their physical capacity to endure the high intensity of the game.

5.5 Discussion of Questionnaires

5.5.1 Aerobic endurance

A multi-stage fitness test (bleep test) was used to measure the aerobic endurance of the three groups. The SA provincial players had significantly higher endurance capacity than the SA national players. There were no significant differences between provincial players and university players, or between SA national and university players. The SA national team's poor performance in a fitness test is once again noted. In this case their performance was worse than the provincial players, which is a concern.

Drinkwater, Payne and McKenna (2008) compared studies that measured multi-stage 'shuttle runs' but their data could not be compared to the current study because they did not include standard deviations. The researcher found a general lack of standard deviations in other scientific basketball books and reference works (Stapff, 2000), making it difficult to compare the SA national team players and with other national teams. However, Stapff (2000) reported multi-stage average values of level 11 shuttle 5. The SA national players obtained average values of level 5 shuttle 7 with a 1.5 standard deviation. A shuttle stage of level 5 is very low for an international player (Stapff, 2000) and therefore suggests that the aerobic endurance of the SA national team is extremely poor. Aerobic capacity is the foundation for determining the efficiency and time spent on a particular exercise (Paish, 1998). As it was stated in the literature review, endurance refers to the body's ability to bear high-intensity exercise (Hoffman, 2006). Paish also stated that endurance training lays the foundation for other training; without endurance, complete fitness can never be attained.

When comparing the study by Berdejo-del-Fresno, Lara-Sanchez & Gonzalez-Rave (2012) to provincial players in SA there was a significant difference, which indicates that the endurance performance of provincial players in the current study is not on par with others in the world.

5.5.2 Strength and conditioning assessment

A S&C programme needs to be followed for players to reach peak fitness (Brittenham & Taylor, 2014), and assessed in order to see progress or deterioration in players (Drinkwater, Payne & McKenna, 2008). Thus, university, provincial and SA national players were asked to complete a questionnaire on fitness characteristics (Appendix B), to assess whether they had a S&C programme to follow; whether it was effective; and whether they were assessed annually.

When looking at the three groups; it was noted that only 29% of SA national players had a S&C programme. This means that 71% of the SA national team players do not have a S&C programme. Globally, elite players follow periodization programmes to keep athletes in shape, avoid over-training and prevent injuries (Javorkek, 1995; Staph, 2010; Stein, 2013). These training programmes are generally of a high quality and systematic, according to the sport-specific requirements and standards of the sport (Drinkwater et al., 2007). The majority of the SA national team members not having a S&C programme is a major concern and could be the main reason for their poor fitness characteristics as revealed in this thesis. In turn, these poor fitness characteristics could be a large contributing factor to their poor playing performance at an international level. It is promising however that all the SA national players that had a S&C programme, reported that it was effective.

Physical fitness testing of players is an important factor in evaluating the condition of the athlete and is generally the norm in elite sports (Drinkwater et al., 2007; Delextrat & Cohen, 2009). Only 36% of the SA national players were assessed annually which means the large majority of the SA national team do not know their fitness status on an annual basis. The players that were assessed however only got assessed once throughout the year. This indicates that the SA national team do not have a co-ordinated physical fitness assessment for their players. It also appears that the players who did have S&C programmes and that were assessed annually did so outside of the national team management structure. The players were either training or being tested privately or through their provinces and/or universities.

Interestingly, 47% of provincial players reported to have a S&C programme compared to only 29% of SA national team players. It is important to note that the fitness results of the provincial players are on par and at times even better than the SA national players. A possible reason for this is that close to 50% of the players have planned fitness programmes and 75% of these players found the programme effective. However, there is still room for improvement at a provincial level as only 12% of these players were assessed annually (Table 4.15). This is problematic, as players would not know if they are improving or not.

Most university players participate for recreational purposes, and therefore it was understandable that only 21% of the university players had a S&C programme (Table 4.14) and 80% of these players found the programme to be effective. It is alarming to note that the university players have a similar percentage of players on a S&C programme compared to the SA national team. 21% of the university players got assessed annually, with the majority of those players reporting that they were assessed twice or thrice annually.

In the USA and other countries, it is common for university teams and professional teams to have a comprehensive S&C managing structure (WNBA 2015a, b, c, d, e, f, g; NBA, 2015 a, b, c, d, e). These teams generally have fitness trainers and conditioning coaches to ensure peak fitness (Drinkwater et al., 2007). However, in SA S&C programmes, screening and assessments is uncommon in basketball, as most of the players do not have access to a trainer or sports scientists who examine their fitness characteristics (PMG, 2013). This may be due to a lack of staff and funds (Radovic, 2010). Nonetheless, BSA needs to invest in S&C trainers that work with the national players throughout the year.

5.6 Rating Strength and Conditioning

5.6.1 Fitness and weekly training hours

Seventy one percent of SA national team players do not do any S&C training weekly. This lack of S&C training (worse than university (58%) and provincial players (53%)) may explain why the provincial players performed better than or equal to the SA national players on a number of the test batteries measured in this thesis. More than a third of the SA national team relies only on basketball team training for them to improve or maintain their physical fitness. However, it is promising to note that all of the SA national team that do S&C training on a weekly basis do more than 3 hours per week. This training is still low in comparison to other international players who train S&C for five hours or more per week (Staph, 2010; Stein, 2013).

When doing S&C training, there are many factors to consider, such as which days to train upper or lower body, plyometric exercises, speed, endurance and at which point in the basketball season one should train these different aspects, and how often. Therefore, training one to three hours a week, or not training at all, is not sufficient at a national level. The players may not be physically fit to compete at the highest level. This in turn could also increase the chances of injury. These results indicate that there is a lack of fitness management from BSA.

5.6.2 Players perception of their S&C status during the previous playing season

It was interesting to note that 21% of SA players (as opposed to 6% of provincial and 5% of university players) rated their conditioning as being very bad, and a further 14% rated it as bad, which was the worst of the three groups. A total of 35% of the national team rated their S&C status in the previous season as being either very bad or bad, just less than the 37% who rated it as average. At the other levels, only 18% of university players and none of the provincial players rated their conditioning as bad. Furthermore, more provincial and university players (36% and 35% respectively) rated their conditioning as good, compared to only 14 % of SA national players. Lastly, only 14% of SA players, and 9% of university players and none of the provincial players, rated their conditioning as excellent (see Table 4.17).

It is possible that the level at which subjects played, influenced their self-rating, so the SA national team players were less satisfied with their training because they were possibly aware, and dissatisfied with their ranking and performance internationally. University and provincial players may feel more satisfied because they are competing locally against opposition who have similar fitness levels.

5.6.3 Players perception of their S&C status at the start and in the middle of their playing season

Players were asked to rate their S&C status at the start of the season and their current status in the middle of the season. What is evident from the data (Table 4.17-4.18), is that the large majority of the SA national, provincial and university players rated their S&C status between average and good. These players therefore believe that they are adequately physically prepared to participate in matches. This may be due to overall poor fitness levels amongst their competitors within SA. Players might feel complacent at the level of performance because their opposition is also of a poor standard. This argument does not hold for the SA national team players as they do compete against international opposition. A probable reason for their overestimation of their S&C status is because the majority of them do not get physically assessed and therefore do not know their fitness levels.

5.6.4 Management procedures and efficiency of management strategy

It is important to note that 71% SA national team players have management procedures in case of an injury and there is a process in place to get the player back injury free. Furthermore, it appears that the injury management is fairly effective as 90% of the SA national players rated it between average and good. Similarly, the large majority of players at a provincial and university level rated their injury management procedures between average and good, with 33% of provincial players rating it as excellent. The researcher believes that the procedure for managing injuries in university/provincial/national team go hand-in-hand with the level at which the sport is played.

As part of the normal structure of basketball teams in leagues such as the WNBA, NBA, Euroleague and NCAA, there are management protocols for training and injury management to rehabilitate athletes and get them back injury free. In terms of the management of athletes, it is noted that in the USA, high profile college players purchase insurance to cover career-ending injuries (Fixler, 2013; Legwold, 2013). Most of the players in NCAA Division I, II and III are covered medically in case of an injury while they are still part of the NCAA. These management interventions help to make the procedures reasonably efficient and effective as players are needed back on the basketball court fit and healthy in as short a time as possible.

In SA, the management procedures in case of an injury appear to be reasonable according to the players' perceptions and considering the level at which basketball is viewed.

The results of this thesis indicate that the anthropometric (height) and physical fitness characteristics of female basketball players in SA is significantly below standard. This could be one of many contributing factors to the poor performance at an international level. The players clearly do not have the appropriate support and managing structures in place from BSA. Perhaps the reason for this is the minimal funding available to BSA as basketball.

However, a promising start to rectifying and increasing the profile of basketball in SA was the Four Nations Challenge (March 2015) and the NBA Africa Game (August 2015) that took place in SA this year. The Minister of Sport and Recreation, Fikile Mbalula, has also showed interest in reviving basketball in SA where he stated in his Budget Vote Speech in 2013 "that it was the intention of his department to revive Basketball in the country as a sport of choice amongst young people". He also stipulated at his address of the Four Nations Challenge in March 2015 that basketball will be in amongst the best playing sporting codes in SA by 2030 (Sport and Recreation South Africa, 2015).

5.7 Limitation of the study

There are a number of limitations that the researcher considered and will be discussed:

1) Ideally, the fitness comparison should be performed according to playing position. However, in this study, the participants did not represent the normal percentage of guards, forwards and centres as in a traditional team. Dividing the participants into various playing positions would therefore be difficult to make any real comparisons as the number of centres and forwards measured were minimal.
2) The sample number of the national and provincial players is low, as the researcher was limited by the number and access to players at this level.
3) There are not many scientific studies on the anthropometric and fitness characteristics of female basketball players especially at an international level. Comparison between the SA teams and other teams therefore was often limited to one or two studies. Furthermore, the majority of these studies were more than 7 years old and testing protocols often varied, further reducing the amount of tests the researcher could make comparisons. Despite this limitation, the significant differences were still obtained with the SA teams generally performing weaker than their international counterparts.
4) As stated above there were few scientific studies investigating anthropometry and fitness characteristics of female basketball players globally. Therefore, making comparison difficult as some scientific studies evaluated international players over 7 to 30 years. Over the number of years, the modern day athletes' have become better physically and perform better than athletes tested over 10 to 30 years (Lombard, Durandt, Masimla, Green & Lambert, 2015). For with the latest technology advancing, lifestyles of athletes

elevating, in eating habits, training, training equipment and apparel. This makes today's athletes better. But it is not the case with the SA players. Their counterparts playing at same/different levels are far better than them despite the fact that those studies were reported many years ago.

5) The studies that measured lower body strength (Kilinc, 2008; Marzilli, 2008) used squats (hack). However, this study used a leg press machine as a precaution against injury to the unfamiliar and more demanding squat (hack) exercise.
6) The agility T-test measurement of the international studies differed from the one performed in this study. A comparison could therefore not be made between the results obtained in this study to those obtained in others abroad.

CHAPTER SIX:
CONCLUSION AND RECOMMENDATIONS

6.1 Overview

The primary objective of this thesis was to investigate the anthropometric and fitness characteristics of SA female basketball players. In addition, these results were compared to other international players playing at same/different levels. .

There were many similarities between the SA national, provincial and university players regarding their anthropometry and fitness characteristics and very few significant differences. This is unexpected as we hypothesised that the SA national players would be significantly better than the provincial and university players in the majority of the fitness tests. The SA national players were significantly taller than both the provincial and university players. Of the 11 physical fitness tests administered, the SA national players were only significantly better than the university players in three of the tests (sit and reach, chest pass and the T-test). Surprisingly, the SA national players were not significantly better than the provincial players at any of the physical fitness tests, and actually fared significantly worse in the bleep test compared to the provincial players.

Limited data exists on international female basketball players preventing a comprehensive comparison between the SA national players and their counterparts.
The SA national players were significantly shorter than their international counterparts, with similar results in % body fat and 20 m sprint times. The data were then compared to university players in other countries, and it was found that they were significantly worse in all the fitness tests that were compared. Similarly, the university players in SA performed equally bad in the physical fitness tests compared to their counterparts abroad.

The secondary aim was to examine the current structures in place for managing and monitoring the strength and conditioning of these players.

Relatively few university, provincial and SA national team players had S&C programmes, as well as someone managing their S&C programme. Most of the players who had a S&C programme found it effective. The majority of players did not get tested annually, and the few players that did have S&C programmes did not spend more than three hours a week doing S&C. Finally, most players reported there are effective management procedures in case of an injury.

In light of these results, the following conclusions can be drawn:

Hypothesis One (a): A tentative rejection of the null hypothesis ($p<0.05$).
The findings from this study lead one to tentatively accept the alternative hypothesis as follows: that there is a significant difference between national, provincial and university basketball players with regard to: <u>selected anthropometric measures:</u>
- Where SA national players were significantly *taller* than both provincial and university players.

Hypothesis One (b): A partial acceptance of the null hypothesis.
The findings from this study lead one to tentatively accept the null hypothesis as follows: that there is a no significant difference between national, provincial and university basketball players with regard to: <u>selected anthropometric measures:</u>
- Where provincial players were similar in *height* to university players,
- Where *percentage body fat* was similar between national, provincial and university players.

Hypothesis Two (a): A tentative rejection of the null hypothesis ($p<0.05$).
The findings from this study lead one to tentatively accept the alternative hypothesis as follows: that there is a significant difference between national, provincial and university basketball players with regard to: <u>selected fitness characteristics:</u>
- Where national and provincial players were significantly more *flexible* than university players,
- Where national players had significantly better *upper body explosive power* than university players,
- Where national and provincial players were significantly more *agile* than university players,
- Where provincial players were significantly faster in *sprint speed* than university players,
- Where national players' *aerobic endurance capacity* was significantly worse than provincial players.

Hypothesis Two (b): A partial acceptance of the null hypothesis.

The findings from this study lead one to tentatively accept the null hypothesis as follows: that there is a no significant difference between national, provincial and university basketball players with regard to: selected fitness characteristics:

- Where *flexibility* was similar between national and provincial players,
- Where *upper body strength* was similar between national, provincial and university players,
- Where *upper body explosive strength* was similar between national and provincial players,
- Where *upper body explosive strength* was similar between provincial and university players,
- Where *lower body strength* was similar between national, provincial and university players,
- Where *lower body explosive strength* was similar between national, provincial and university players,
- Where *push up scores* were similar between national, provincial and university players,
- Where *sit up scores* were similar between national, provincial and university players,

;- Where *agility* was similar between national and provincial players,

- Where *sprint speed* was similar between national, provincial and university players,
- Where *time to complete the suicide run* was similar between national, provincial and university players,
- Where *aerobic endurance* was similar between national and university players,
- Where *aerobic endurance* was similar between provincial and university players.

6.2 Recommendations

The fitness status of female basketball players in SA need to improve which could enhance their playing performance. Appropriate monitoring and managing of all players' fitness and their programmes is recommended. This should be a high priority in the development of female basketball in SA.

Importantly, at a provincial and national level, an annual periodisation programme should be in place for every player. This would improve the quality of the training and reduce the risk of injuries. Regular physical fitness assessments and player monitoring would be essential in managing the fitness status of these players. Furthermore, this will allow players to better understand the physical requirements necessary to perform at a higher level. Managing data base of the players' physical fitness results could also aid in team selection.

BSA needs to try and expand the game of basketball in SA. A larger playing population will also attract taller players. Nurturing younger players will develop and enhance skill. There needs to be an initiative between the SA Government (Department of Sport and Recreation) and BSA to ignite basketball in SA.

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APPENDIX A: INFORMED CONSENT

The anthropometric and fitness characteristics of South African female basketball players

Informed Consent Form

I,_____________________________________ have been fully informed about the nature of this research and hereby give consent to act as a participant for the research. I also give consent for all data collected to be made available for research purposes at the Sport Management Department, CPUT. The study was granted Ethics Approval from the Faculty of Business Ethics Committee, CPUT.

Purpose and Benefits

Basketball in South Africa is viewed as a social and secondary sport. According to the International Basketball Federation (FIBA), SA men's basketball is ranked 68 and women's basketball 71 globally. This study aims at investigating the anthropometric and physical characteristics of university, provincial and national players, as well as their strength and conditioning. Furthermore, the study aims to compare the participants with some of the elite basketball athletes around the globe. This will allow us to see the current status of South African Women's Basketball.

Testing Procedure

The testing consists of:

- Body composition measurements
- Physical assessment (flexibility, muscle strength, explosive power, muscular endurance, agility, speed and aerobic endurance)
- Questionnaire

Risks

- There are no inherent risks to this trial. The test protocol will be done according to standard procedure.

Benefits to participant

- The participants will not be paid for their participation in the tests. The tests will help a participant evaluate her fitness level. All results will be distributed in a simple written report and participants will be allowed to ask questions.

The information provided can help athletes with regard to their fitness level and also how to improve or maintain it.

Privacy

- All data collected from the participant will be stored in a computer database and kept safe, with the password known to the investigator, and in a manner that maintains my confidentiality. My anonymity and confidentiality of my participation will further be ensured in any publication of the data. I understand that I am free to withdraw from this study at any time without prejudice.

Participant:	Signature:	Date:
Researcher:	Signature:	Date:
Witness:	Signature:	Date:

APPENDIX B: PLAYERS QUESTIONNAIRE

Physical status of basketball players

General:

How long have you been playing basketball?	
What is your playing position?	

Questions:

Do you have a strength and conditioning program you follow for the season?	YES		NO	
If yes – who manages the training program?	Coach	Trainer	Manager	Other
How many hour/week do you do strength and conditioning?				
How many times a year do you get physically assessed?				
Do you think the strength and condition program is effective?				

On a scale of 1 to 5, 1 being very bad, 2 bad, 3 average, 4 good and 5 very good

	1	2	3	4	5
How was your physical condition in the last season?					
How physically conditioned were you when the season started?					
How is your S&C in the middle of the season?					
In case of an injury, is there a management procedure to manage injuries?	YES			NO	
If yes, how efficient is this procedure?					

APPENDIX C: PHYSICAL ASSESSMENT

An evaluation of the anthropometric and fitness characteristics of female South African basketball players

Name:	Date:
Position:	Age:
Team:	Level:

PHYSICAL ASSESSMENT

Weight (kg)		EXPLOSIVE POWER			
Height (m)		Chest pass (m)			
BMI		Vertical jump (cm)			
Biceps skinfold (mm)		AGILITY, SPEED AND ENDURANCE			
Triceps skinfold (mm)		Agility T-test (s)			
Subscapular skinfold (mm)		20m sprint (s)			
Suprailiac skinfold (mm)		Suicide run (s)			
Abdominal skinfold (mm)		Bleep (levels/shuttles)			
Thigh skinfold (mm)		COMMENTS			
Calf skinfold (mm)					
BODY FAT %					
MUSCULAR STRENGTH					
Bench press (1RM)					
Leg press (1RM)					
FLEXIBILITY					
Sit and reach (cm)					
MUSCULAR ENDURANCE					
Push-ups (min)					
Sit-ups (min)					

APPENDIX D: AGILITY T-TEST PROTOCOL