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# ANTHROPOMETRIC VARIABLES AND PHYSICAL FITNESS CHARACTERISTICS OF MALE SOUTH AFRICAN SEMI-PROFESSIONAL FOOTBALLERS

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***ABSTRACT***

*The purpose of this cross-sectional study was to gain an understanding of the anthropometric and physical fitness characteristics of a group of competitive, semi-professional footballers during their pre-season training period. One hundred and twenty-four Division Two footballers from the ABC Motsepe League, Gauteng, South Africa, participated in this study. Body mass index (BMI) and performance data (upper body explosive strength, counter-movement jump, Illinois agility test [with ball], 30m-sprint, and intermittent endurance running were collected. Goalkeepers were heavier ($p<0.001$), had greater BMI ($p<0.05$) and had greater absolute upper body power values ($p<0.001$) than outfield positions. Strikers were shorter than defenders and goalkeepers ($p<0.05$). Additionally, outfield positions ran further than goalkeepers in the intermittent running test ($p<0.001$). Midfielders tended to be slower over the 30m-sprint compared to other positions ($p=0.07$). A few anthropometric and physical fitness characteristics according to playing position varied, some of which are similar to other studies on male football populations. Compared to elite professional footballers from South Africa, semi-professional footballers need to increase their lean muscle mass and the power production of their lower limbs.*

***Keywords*:** Soccer; Physiological performance; Sub-elite; Africa; Fitness.

## INTRODUCTION

Anthropometric factors, physical fitness attributes and skills are central to the game of football (Stølen *et al*., 2005). In the match situation, the ability to use these learned skills dynamically is required for optimal play. Possession of the ball during the game denotes having control of the direction and rhythm of play. The experience of individual athletes can influence the success or failure of the match outcomes. Players in the attacking and midfield positions are particularly important for addressing counter play, ball possession and shots at goal, while defenders and the goalkeepers are predominantly responsible for maintaining and protecting the penalty area (Arnason *et al*., 2004).

Participation in football spans across socio-economic divides across the world, but at the elite level teams perform as business enterprises (Maguire & Pearton, 2000). Individuals in these teams are recruited through a competitive annual ‘buying’ or loan system, and it is not uncommon for players to move to different teams in their professional career. South Africa is not dissimilar, and individual player fitness and physiological credentials may result in athletes securing exorbitant salaries during the competitive season (Cornelissen & Solberg, 2007). However, in the semi-professional football leagues, resources are limited and quality fitness assessment of football players is not prioritised. Consequently, little is known of the anthropometric variables and physical fitness characteristics of footballers participating in these leagues. Sports specific testing is imperative to assess the preseason physical preparedness of players and the creation of normative data for future reference and player development (Datson *et al*., 2014).

## PURPOSE OF RESEARCH

The purpose of this study was to describe the physiological attributes of semi-professional footballers who participate in the ABC Motsepe league, a 3$^{rd}$ tier football league in the Gauteng province. The league acts as a development platform for football players who desire to play in the South African Premier Soccer League (PSL). The authors hypothesised that, due to the competitive nature of the league, the semi-professional footballers involved in this study would have a relatively high standard of fitness during the preseason.

## METHODOLOGY

### Participants

This cross-sectional study included 124 male Division Two footballers from five football teams. All players volunteered to take part in this study and were registered by the South African Football Association (SAFA) to compete in the ABC Motsepe League (Gauteng Stream). They were grouped according to the common playing positions that included outfield positions, namely defenders (n=39), midfielders (n=40) and forwards (n=30) and goalkeepers (n=15) (Clark, 2007; Sporis *et al*., 2009; Haugen *et al*., 2012). Prior to the study, the football teams had already been training over a six-week period, with a frequency of four sessions per week. Due to the semi-professional nature of the league, training is mostly guided by the coach or assistant staff. Few clubs competing in the ABC Motsepe league have access to a gymnasium and their players rarely perform strength training. Training content is mainly limited to tactical based sessions and running with emphasis on endurance qualities.

### Ethical clearance

Approval to conduct the study was given by the Human Research Ethics Committee (Medical), The University of the Witwatersrand (M140419). Prior to testing each participant signed an informed consent form and completed a pre-participation medical questionnaire. Any player self-reporting an injury was excluded from the study.

### Instruments and procedures

All teams were tested on their home turf (average altitude ranging between 1600-1750m) during the pre-season and within a two-week period. The order of the tests were: (1) body mass and stature measurements; (2) counter-movement jump; (3) overhead medicine ball throw; (4) Illinois agility test (with ball); (5) 30m-sprint; and (6) the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1). Testing was conducted in the latter part of the afternoon for all teams. Anthropometric and countermovement jump tests were performed without shoes on a level, hard surface (smooth concrete floor).

All other tests were performed on the football pitch with participants wearing standard football kit and boots. A standard 15-minute warm-up was implemented and included light jogging and dynamic stretching exercises. Prior to the commencement of each field test, participants were given a practical demonstration and clear instructions. All tests were conducted by an experienced sports scientist and two research assistants. A three-minute rest period was provided between test trials. Rest periods between performance tests approximated five minutes, except prior to the Yo-Yo IR1, where a 10 minute rest was allowed.

***Anthropometry***

The body mass of the participants was recorded in kilograms (kg) to nearest 0.1kg whilst they stood on an electronic scale (Health o meter silver and black weight tracking scale HDM691DQ-95, Sunbeam Products, INC, Boca Raton, FL 33431). Stature was measured with a SECA wall mounted stadiometer (Model number: 240, Hamburg, Germany) in metres (m) (to the nearest 0.01m) with the participants standing in an upright position and their head in the Frankfurt plane (Thompson *et al*., 2010). Body mass index (BMI) was calculated according to Thompson *et al*. (2010).

***Physical performance measurements***

Overhead medicine ball throw

Upper body power is an important attribute for certain skill components in football, such as throw-ins (Reilly *et al*., 2000). Therefore, the overhead medicine ball throw test (with a 3kg medicine ball) was selected as a simple method of determining differences in upper body power of the playing positions. Participants stood behind a clearly defined line with both feet side by side and shoulder width apart and facing the direction to which the ball was to be thrown (Stockbrugger & Haennel, 2001). With the medicine ball grasped in both hands, participants then mimicked a football throw-in by bringing the ball back behind the head before vigorously throwing the medicine ball forward for maximal horizontal displacement.

Participants were instructed to keep both feet in contact with the ground as the ball was released. They were allowed to bend at the knees and hips to maximise throwing distance. Participants received one submaximal (for familiarisation) and two maximal trials. Any participant who had a trial disqualified (foot or feet crossed the line after the throw), were given a further attempt after five minutes of rest. Horizontal distance (m) was calculated from where the ball landed to the starting line. The throw with the greatest distance (m) was recorded.

Countermovement Jump test

To assess lower body explosive power, the Countermovement Jump (CMJ) test was performed on a contact jump mat (Fusion Sport, 2 Henley ST, Coopers Plains, QLD, 4108, Australia) with a PDA unit (HP IPAQ 112, Hewlett Packard Company, Palo Alto, CA 94304) digitally recording the maximal vertical jump displacement reached, to the nearest millimetre. The participants were asked to step onto the centre of the jump mat, pause and then descend (by flexing their knees) to a self-selected depth before taking a jump for maximal vertical height. Participants were allowed to make use of their arms to maximise the vertical jump. Two attempts were performed with a three-minute rest period between each attempt. Participants were not allowed to bend their knees in the air while jumping as this would affect jump height calculation (Markovic *et al*., 2004). The jump height (in centimetres) with the greatest vertical displacement was recorded.

Illinois Agility test

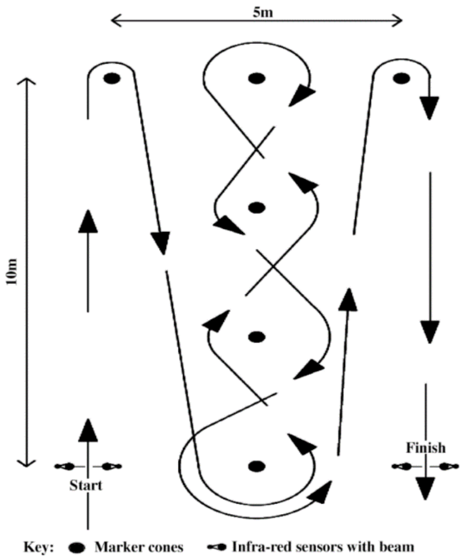


***Figure 1*. ILLINOIS AGILITY TEST**

The Illinois agility test was adapted to determine football-specific agility (Lockie *et al*., 2013) (Figure 1). The agility course was clearly marked in an area that was 10m long by 5m wide. Another four cones were placed along the centre of the rectangular area at an equal distance of 3.3m distance apart (Lockie *et al*., 2013). Two infrared timing gates (Fusion Sport Smart Speed System, Fusion Sport, 2 Henley ST, Coopers Plains, QLD, 4108, Australia) were positioned at both the start and finish lines. The time taken to complete the course was captured on the handheld PDA unit (see manufacturer details above) to the nearest millisecond. Participants began with their lead foot 15cm behind the start line and timing commenced once the participant intercepted the starting gate. The participant then followed a predetermined course through the cones running maximally, while maintaining control of the ball. Each participant had one submaximal practice trial before receiving a maximal attempt. Participants were not allowed to rock back and forth prior to starting the test. Player who knocked over a cone/s or did not run the course in the correct sequence had to repeat the test. Time taken to complete the course was recorded in seconds (to the nearest 0.01s).

30m-sprint test
A maximal 30m linear sprint test was used to measure the sprinting abilities of the footballers. Infrared timing gates (Fusion Sport Smart Speed System, Fusion Sport, 2 Henley ST, Coopers Plains, QLD, 4108, Australia) were placed at the starting line (0m), 10m, and 30m marks, on the football pitch. Participants were asked to place their lead foot 15cm behind the starting line and sprint maximally through all three timing gates. No rocking back and forth prior to the

commencement of the sprint was allowed. Timing commenced when the first timing gate was intercepted. The participants were given one submaximal attempt and one maximal attempt. The time taken to sprint 30m was recorded in seconds (to the nearest 0.01s) by a handheld PDA unit (HP IPAQ 112, Hewlett Packard Company, Palo Alto, CA 94304).

Intermittent running endurance

The Yo-Yo Intermittent Recovery Test (Level 1) (Yo-Yo IR1) is a valid and reliable method of assessing intermittent running endurance in football players (Krustrup *et al*., 2003; Bangsbo *et al*., 2008; Rampinini *et al*., 2010). Furthermore, research has shown that high intensity running, a vital factor contributing to match success in football, is positively correlated with distance run in the Yo-Yo IR1 (Mohr *et al*., 2003; Krustrup *et al*., 2005; Castagna *et al*., 2009; Rebelo *et al*., 2014). Participants performed a 40m-shuttle by running from a standing start, 20m out and back to the sound of an audible beep played over a loudspeaker (Bitworks Design, Cheltenham, UK, Team Beep Test 20metres, Version 4:0). The time given for each shuttle was progressively shortened at the start of each stage, forcing the participants to increase their running speed. On completion of the shuttle, participants had a 10-second rest in which they jogged five metres out and back in a designated recovery area. A participant's test was terminated if they failed twice to complete the 40m-shuttle in the designated time period analysis. Performance was recorded as the maximal distance achieved in metres (m).

### Statistical analysis

Statistical analysis was performed on the results of those participants that completed all tests (n=104). Twenty participants did not have complete data sets due either to technical errors (n=12) or arriving late (n=8). All statistical analyses were performed using Statistica version 13 (StatSoft, Tulsa, OK). The Kolmogorov-Smirnov test was used to test the normality of the distribution of the data. The distribution was determined to be normally distributed (all d statistics were $p>0.05$). Descriptive data were therefore presented as mean (±SD), and comparisons were made between playing positions using analysis of variance (ANOVA). Tukey honest significance difference (HSD) was used as a post-hoc analysis. The correlation between variables was determined using a Pearson correlation matrix. The correlation coefficients were considered as small (less than 0.30); as moderate (between 0.31-0.49); large (between 0.50 and 0.69); and very large (0.7 and greater) (Hopkins, 2002). Statistical significance was set at $p<0.05$.

## RESULTS

The mean age of the sample was 22.4±2.75 years with a mean BMI of 22.0±2.13kg.m$^{-2}$. Goalkeepers were significantly heavier ($p<0.001$), had a greater BMI ($p<0.05$) and demonstrated poorer intermittent running performance ($p<0.001$) than outfield playing positions.

BMI had a positive correlation with the medicine ball throw ($r=44$; $p<0.001$) and a negative correlation with intermittent running endurance ($r= -0.36$; $p<0.001$) (Table 2). CMJ height correlated negatively with speed (10m: $r= -0.36$; $p<0.001$; 30m: $r= -0.56$; $p<0.001$; flying 20m: $r= -0.53$; $p<0.001$). Additionally, there was a moderate correlation between the 10m and flying

20m sprint (r=0.31, p<0.005). No physical fitness variables correlated with the Illinois agility test (data not shown).

***Table 1***. **PARTICIPANT ANTHROPOMETRIC VARIABLES AND PHYSICAL FITNESS CHARACTERISTICS ACCORDING TO PLAYING POSITIONS**

| **Variables** | **Forwards** (n=23) M±SD | **Midfielders** (n=37) M±SD | **Defenders** (n=35) M±SD | **Goalkeepers** (n=9) M±SD | **p-Value** for model |
|---|---|---|---|---|---|
| Age (years) | 21.9±2.14 | 22.2±2.49 | 22.8±3.21 | 22.8±3.42 | 0.64 |
| Mass (kg) | 61.7±7.09 | 63.1±7.41 | 66.2±7.68 | 75.1±12.9* | 0.00026 |
| Height (m) | 1.69±0.06** | 1.7±0.06 | 1.73±0.06 | 1.76±0.07 | 0.005 |
| BMI (kg.m$^{-2}$) | 21.7±1.91 | 21.8±1.98 | 22.0±1.83 | 24.1±3.23* | 0.015 |
| MB throw (m) | 8.02±0.88** | 8.21±1.05 | 8.73±0.93 | 9.67±1.11 | 0.000095 |
| CMJ (cm) | 47.0±5.77 | 44.3±4.87 | 46.5±6.28 | 45.9±3.64 | 0.21 |
| 10m (s) | 1.78±0.10 | 1.82±0.08 | 1.82±0.06 | 1.81±0.06 | 0.22 |
| 30m (s) | 4.24±0.10 | 4.34±0.16† | 4.3±0.12 | 4.28±0.11 | 0.07 |
| Flying 20m (s) | 2.46±0.07 | 2.52±0.12 | 2.48±0.08 | 2.47±0.07 | 0.09 |
| YoYoIR1 (m) | 2406±595 | 2106±513 | 2071±428 | 1293±527* | 0.000005 |
| Illinois agility (s) | 22.0±1.48 | 21.6±1.41 | 21.7±1.28 | 22.7±1.78 | 0.24 |

* Significantly different from outfielders ** Significantly less than goalkeepers and defenders;
† Significantly slower than forwards.
BMI=Body Mass Index MB throw=Medicine Ball throw CMJ=Counter Movement Jump
YoYoIR1=Yo-Yo Intermittent Recovery test Level One

***Table 2***. **CORRELATION MATRIX BETWEEN PERFORMANCE VARIABLES, INCLUDING ANTHROPOMETRY**

| **Variables** | **BMI** | **MB throw** | **CMJ** | **10m** | **30m** | **Flying 20m** | **YoYoIR Level 1** |
|---|---|---|---|---|---|---|---|
| MB throw | 0.44*** | | | | | | |
| CMJ | 0.03 | 0.18 | | | | | |
| 10m | -0.10 | -0.09 | -0.36*** | | | | |
| 30m | -0.23* | -0.21* | -0.56*** | 0.74*** | | | |
| Flying 20m | -0.26* | -0.22* | -0.53*** | 0.31** | 0.87*** | | |
| YoYoIR1 | -0.36*** | -0.33*** | 0.04 | -0.03 | -0.03 | -0.03 | |

* p<0.05; ** p<0.005; *** p<0.001 BMI=Body Mass Index MB throw=Medicine Ball throw;
CMJ=Counter Movement Jump YoYoIR1=Yo-Yo Intermittent Recovery test level one

**DISCUSSION**

There is little evidence surrounding the anthropometric variables and physical fitness characteristics of African football players, particularly in low resource settings, such as in South Africa. The aim of this cross-sectional study was to determine the anthropometric and physical fitness characteristics of a cohort of semi-professional football players in Gauteng, South Africa. The findings demonstrate that the sample had similar performances for agility and CMJ performances. However, the goalkeepers had greater upper body power and poorer endurance performance, whilst the midfielders tended to be the slowest sprinters over 30m.

The results show that goalkeepers were heavier and had a greater BMI compared to all outfield positions, while defenders and goalkeepers were taller than forwards. Similar *anthropometric* differences between playing positions have been reported in Croatian First Division footballers (Sporis *et al*., 2009). The physiological stress on the aerobic energy system of goalkeepers is less demanding than outfield positions during match-play (Arnason *et al*., 2004), which partly may explain the body mass differences. Additionally, tall players have an advantage when fulfilling their defensive roles and may be selected into these positions (Reilly *et al*., 2000). Compared to a similar competitive division from France and Premier Soccer League footballers from South Africa, the participants in the current study appear to be lighter and shorter in stature (Cometti *et al*., 2001; Clark, 2007). Possible explanations for the lower body mass of the participants in this study could be that many are from lower socio-economic communities in Gauteng, where poor nutrition practices and limited access to resistance training equipment is common (Gradidge & Constantinou, 2018).

The results confirm that the *CMJ* heights were similar across all playing positions, which confirms the findings of others (Arnason *et al*., 2004, Clark, 2007, Sporis *et al*., 2009). In contrast, the CMJ performances of elite Norwegian forwards and defenders are higher compared to midfielders (Wisløff *et al*., 1998). The CMJ performances observed in the current study are higher compared to French Division Two players (CMJ: height=39.7±5.17cm) (Cometti *et al*., 2001), but lower compared to elite South African footballers competing in the PSL (CMJ: height=53.8±7.9cm) (Clark, 2007) and compared to those reported in a review (CMJ: heights ranged from 47.8-60.1cm for male professional footballers) (Stølen *et al*., 2005). Semi-professional footballers appear to have poorer power outputs compared to more elite footballers. Vertical jump ability is related to team success in football and would therefore be an important physical attribute to develop (Arnason *et al*., 2004). However, the results of the study may suggest that plyometric sessions are not incorporated in their preseason training schedule. Football matches and regular training alone do not provide sufficient overload to develop the jumping abilities of forwards and defenders (Cometti *et al*., 2001). Therefore, it is suggested that these positions, which should also include goalkeepers, receive additional power training, such as plyometrics, to complement their football specific workouts (Chelly *et al*., 2010).

Both defenders and goalkeepers demonstrated greater absolute upper body power in the *Medicine Ball Throw* compared to forwards. The positive moderate correlation between mass and medicine ball throw distance ($r=0.53$; $p<0.05$) can only partially account for the greater throwing distance. Another possible reason could be that defensive positions often use their upper body to distribute the ball when either making a throw-in (defenders) or after a save (goalkeeper). Therefore, coaches should keep in mind that upper body power is an important attribute for certain skill components of the game and should develop this ability, especially in the key defensive positions (Reilly *et al*., 2000).

The results show that there were no differences in the *Illinois Agility Test* (with ball) between outfield positions. This lack of variability in football specific agility tests is possibly due to this skill being of equal importance for all outfield positions. However, anecdotal evidence from a South African PSL club shows that professional footballers perform the same test in ±18.5s (approximately 2.5 seconds faster) than the participants in the current study (Milner, 2017). The ability to change direction and manoeuvre around opponents whilst dribbling is an important skill in football. The difference in agility times between the two leagues could possibly demonstrate the use of the Illinois agility test (with ball) as a useful test to differentiate between levels of playing ability in football. However, this would need to be substantiated with further scientific studies.

The *sprinting abilities* of the participants in the current study compare favourably to those of Cometti *et al*. (2001), who observed 10m- and 30m-sprint times in French Division Two footballers of 1.82±0.06s and 4.25±0.15s, respectively. However, the slower 30m-sprint times of midfielders compared to forwards may highlight differences in sprinting profiles between these two positions. Time motion analysis of football matches has shown that forwards cover a greater distance sprinting compared to midfielder positions (Mohr *et al*., 2003). Sprinting contributes directly to securing ball possession while a lack of speed may compromise the scoring or conceding of goals especially in the forward and defensive positions (Reilly *et al*., 2000; Faude *et al*., 2012). Therefore, it would be beneficial for forwards and defenders to receive additional sprint training prior to and during the competitive season. A large, negative correlation was found between CMJ height and the 30m-sprint, which is similar to the finding of Wisløff *et al*. (2004). This confirms the contribution of the lower limb muscle power and stretch shortening abilities to force generation during sprinting activities. In contrast, a moderate correlation was observed between the 10m- and flying 20m-sprint tests suggesting that acceleration and maximal speed are two distinct qualities in footballers (Wisløff *et al*., 2004; Little & Williams, 2005). Fitness coaches should therefore train each sprint quality with specific drills to maximise linear acceleration and speed (Wisløff *et al*., 2004; Little & Williams, 2005).

As expected, the intermittent running performances of goalkeepers are poorer than outfielder positions and are confirmed by others (Arnason *et al*., 2004, Clark, 2007). The volume of running that goalkeepers perform over the course of a match and during practices is lower than outfield positions (Di Salvo *et al*., 2008), hence their poor aerobic conditioning. However, no differences in intermittent running performances were observed between the outfield positions, confirming the findings of Clark (2007). In contrast, others have observed that the intermittent running distances (Mohr *et al*., 2003) and aerobic capacities (Sporis *et al*., 2009; Boone *et al*., 2012) are greater in elite midfielders compared to forwards and defenders. This may be a consequence of the greater distances covered by midfielders in games compared to forwards and defenders as has been observed in elite European football (Di Salvo *et al*., 2008). The Yo-Yo IR1 performances of the South African Division Two players are greater than European semi-professional players (1838±362m) (Mohr & Krustrup, 2014) and comparable to professional European footballers, 2231±294m (Rampinini *et al*., 2010) and 2260±80m (Mohr *et al*., 2003). This suggests that the Division Two players maintain high aerobic conditioning levels during their off-season break. However, the addition of small-sided games in the pre-season can offer a more sports-specific training stimulus compared with traditional forms of training, without sacrificing aerobic fitness (Owen *et al*., 2012).

## LIMITATIONS

The athletes in this study were not followed throughout the entire season, suggesting that our understanding of performance is limited. However, our findings according to position are similar to those of Clark (2007), who collected data during the competitive season. Body mass indices were used as an indicator of body composition due to time constraints with each football team. Future studies could employ additional measures of simple, validated anthropometry, such as waist circumference (Peer *et al*., 2015). Furthermore, the inclusion of an anaerobic test would have yielded informative data as there are a number of repetitive sprints with minimal rest in football matches (Bangsbo, 1994). Nevertheless, including an anaerobic test in the current study may have negatively impacted on the aerobic performance in the Yo-Yo IR1 test and would have extended a limited testing time.

## PRACTICAL APPLICATION

The performance characteristics of semi-professional footballers, as described in this study, suggest that position specific attributes be strengthened in some instances to ensure the movement of players in the development leagues into the PSL in South Africa. In addition, strength and conditioning professionals should focus on building lean muscle mass and improve the force production of the legs during the offseason with supervised resistance training and plyometric sessions.

## CONCLUSIONS

The semi-professional footballers from South Africa demonstrate good speed and aerobic fitness abilities at preseason testing. However, they are shorter, lighter in body mass and less powerful than elite South African footballers. The aerobic conditioning of the participants is comparable to that of professional teams in Europe. Further investigation is recommended to understand how these anthropometric and physical fitness variables change over time and determine, whether external stressors, such as player nutrition and the potential for overtraining, influence the performance outcomes.

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