THE RELATIONSHIP BETWEEN FITNESS, MORPHOLOGICAL CHARACTERISTICS, SKILLS AND PERFORMANCE IN MEN'S FAST PITCH SOFTBALL

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Dedication

To my mother, Pauline who always believed in me and the importance of continued education. I'm sure she would have been very proud.

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ABSTRACT

An understanding of the structure, function and performance relationships in different sports, including softball, allows for improved coaching approaches, development of sport specific fitness and skills training programmes, team selections and talent identification in young players. Despite the fact that fast pitch softball is an established sport with a long history, it has received little scientific attention. It does for example, not have a specific battery of softball specific fitness tests and relies on the tests and norms of baseball. The specific morphological and fitness demands of the sport are therefore not fully understood. The purpose of this study was to establish whether morphological and fitness characteristics are related to skill and performance measures in men's fast pitch softball players and to determine what the strengths of any such relationships are.

The sample was purposively selected and consisted of 15 Provincial and 15 club male fast pitch softball players. All participants were members of the provincial Softball Federation. Anthropometric, fitness and skills test and measurements were conducted at the training sites over a number of weeks because it coincided with team training. Anthropometric measurements included height, weight, skinfolds, and were done in accordance with ISAK specifications. Derived anthropometric variables included BMI and body fat percentage. The following physical fitness tests were conducted: vertical jump test, standing broad jump and the Illinois agility run while the skills tests conducted were the softball throw for distance, the two base sprint test, the batting tests and the fielding test. Match statistics were easier to obtain since records were available in printed form from the Provincial softball federation for the Provincial players and from the club for its members. The data obtained were analysed and interpreted both collectively as a group of thirty and then separately as provincial and

club teams for the purpose of comparison. Since the data were not normally distributed, the Spearman's rank Correlation was used to test for associations between variables. Comparisons of the squads were done using the nonparametric Wilcoxon Rank Sum test.

The results of the study identified a number of strong significant relationships between the different variables tested. Height and percent body fat, amongst others were found to be the two anthropometric variables which significantly interacted with two key performance areas of fast pitch softball i.e. batting and fielding. Percent body fat also negatively correlated with the vertical jump test which highlights the general negative impact of excess fat on performance.

The relationships established in this research strongly suggest that coaches include fitness, morphological and skills tests in their coaching and fitness programmes and they should further be used in team selections processes as they are strong indicators for success and will make the selection process more objective.

DECLARATION

I declare that *The Relationship between Fitness, Morphological Characteristics, Skills and Match Statistics in Men's Fast pitch Softball* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Melissa Wentzel 2012-11-10

Signed ……

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CHAPTER 1

STATEMENT OF THE PROBLEM

1. Introduction

1.1 A Brief History of the Game

Women's fast pitch softball evolved as the counterpart of baseball for men in 1887 in Chicago and went on to become a popular sport played all over the world. The first softball league was organised in 1900 in Minnesota, USA, and the game was officially named "Softball" in 1926. The uninitiated should however be aware that the present official softball is anything but soft and is in fact quite hard and capable of causing injury to players (www://www.softball.org.an/ast_site/genericpages.asp.?gp=7, Australian Softball Federation, 2003).

Today there are two forms of softball which are played around the world i.e. fast pitch softball and slow pitch softball. Previously only for women, fast pitch softball is now also played by men in over 100 countries (including South Africa) and has been an Olympic medal sport from the 1996 Atlanta Olympic Games until the 2008 Beijing Olympic Games. The International Softball Federation has applied to the International Olympic Committee (IOC) for its reinstatement in 2016 but has been unsuccessful. The IOC has stipulated that softball will only be considered for inclusion in the 2020 Olympic Games if it combines with Major League Baseball (http://espn.go.com/frontpage/?w_cid=ie9pin:frontpage).

Fast pitch softball is quite popular in most of the Provinces in South Africa, with regular inter - provincial tournaments and the South African national team participating in international softball events for men, women and youths. Western Province Softball is a fairly dominant force in South African Softball. A feather in the Softball Federation's cap was the hosting of the Junior Women's Softball World Cup in South Africa in December 2011 in the Western Cape. South Africa as an affiliate of the International Softball Federation participated in this international competition.

1.2 Factors Contributing to Success

Success in softball, like in any other competitive sport, depends on various factors, including fitness, skill and the morphological characteristics of the players. The success of teams in provincial, international or other competitions depends on a suitable combination of these components (Rhea, 2011).

1.2.1 Morphological Characteristics

In terms of morphological characteristics, success in most sports requires a unique combination of height, weight, body type and muscularity to meet the physical demands of a sport (Rhea, 2011). Rhea (2011) further contends that at top Olympic level it is vital to have the optimum physical attributes for medal success. Physical build, in terms of muscle mass and physical body size, are important determinants of success at the higher levels of sports participation. Having a significant amount of body fat will have a negative impact on performance as a result of carrying excess weight. Excessive body fat will negatively affect speed and also increase thermal stress as a result of increased body surface area and

metabolically inactive tissue (Rhea, 2011). Personal experience as fitness trainer and coach reveal that athletes who carry excess weight perform exercises more slowly, do less, and appear to sweat more profusely than their leaner counterparts. According to Healthline (2011) they may be more prone to injury when performing difficult skills than the athlete with a more optimal body composition.

1.2.2 Physical Fitness

Physical fitness is also a key requirement for softball players. In order to be effective in softball, all players must possess:

- the common characteristics of power for batting, throwing and sprinting;
- the ability to jump for height;
- speed and agility (for base running as every player gets the opportunity to become a batter and then a base runner).

These characteristics are in addition to the specific requirements of each individual fielding position (Brown, 2001).

According to Carvajal, et al. (2009) there are differences in the physical build of athletes playing different sports and different positions within the same sport and therefore certain morphological types are better suited to the biomechanical demands of certain sports and playing positions in these sports. These observations are evident in games where in defensive positions players are bigger and more muscular, while in offensive positions they are quicker, more agile, may have to cover greater distances and are consequently lighter.

This also applies to softball. The first baseman for example, must have quick reflexes, good glove work and strong decision - making ability. The throw doesn't have to be strong but it must be accurate, and pure speed is not as important as agility (Stockton, 1984).

1.3 Significance of the Study

Despite the fact that fast pitch softball is an established sport with a long history, it has received little scientific attention. It does for example, not have a specific battery of softball - specific fitness tests and relies on the tests and norms of baseball. The specific morphological and fitness demands of the sport are therefore not fully understood.

An understanding of structure, function and performance relationships in different sports, including softball, allows for improved coaching approaches, development of sport specific fitness and skills training programmes, team selections and talent identification in young players'. This research intends to add to the existing store of scientific knowledge about the game of fast pitch softball.

1.4 Aim of the Study

The aim of this study was to establish whether morphological and fitness characteristics are related to skill and performance measures in men's fast pitch softball players and to determine what the strengths of any such relationships are.

1.5 Objectives of the Study

The objectives were:

i) To assess the morphological and fitness characteristics of men's fast pitch softball players at the club and provincial levels.

ii) To assess the skills characteristics of men's fast pitch softball players.

iii) To assess the performance levels of players.

iv) To ascertain whether there is a relationship between the fitness and morphological characteristics of men's fast pitch softball players on the one hand and their skills and performance levels on the other.

v) To compare Provincial players with club players to establish whether differences in performance are also reflected in their differences in anthropometry and fitness levels.

1.6 Definition of Terms

Physical fitness: The ability to perform daily tasks with vigour and without undue fatigue (de Vries, 2000).

Morphology: Refers to the structure of the human body (Carter & Honeyman Heath 1990).

Anthropometry: The branch of anthropology concerned with comparative measurements of the human body and its parts; the science dealing with measurement of the size, weight, and proportions of the human body (Saunders, 2007).

Match statistics: The play – by - play report of the performance of a player for a certain number of matches (Softball South Africa, 2006).

Sport - specific fitness tests: Fitness tests that are tailored to the specific needs of the sport the athlete is being tested for.

Softball - specific fitness: Fitness attributes specific to the demands of the game of softball and necessary to ensure enhanced performance in the sport.

Agility: The ability to change the direction of the body or body parts rapidly (Baumgartner & Jackson, 1995).

Speed: The rate at which a person can propel the body, or parts of the body between two points (Johnson & Nelson, 1986).

Muscular power: The ability to generate maximum force in the fastest possible time. It is also the ability to release muscular force in an explosive manner (Miller, 1994).

Body composition: The relative percentages of body weight comprised of fat and fat - free body tissue (American College of Sports Medicine, 1995).

Visual acuity: The clearness of vision and the capacity to detect both small stimuli and small details of large visual patterns (Gabbard, 1996). There are two types of visual acuity, namely:

- Dynamic visual acuity which is the ability to focus on and see detail when either you are moving or the object is moving.
- Static visual acuity is the ability to focus on and see detail on a stationary object at varying distances (Planer, 1994).

Reaction time: refers to the interval of time between the onset of a stimulus and the initiation of a response to that stimulus. It is important to note that reaction time includes the physical movement (Gabbard, 1996).

Response time: The movement time combined with reaction time (Gabbard, 1996). It is the time taken to respond to a stimulus. It therefore includes the neural (chemical) as well as physical (movement) reactions to the stimulus.

Performance: The carrying out of specific physical routines or procedures by an athlete or player who is trained or skilled in physical activity and is influenced by a combination of physiological (physical suitability and level of skill), psychological (mental toughness), and socio-cultural factors (http://dictionary.sensagent.com/sports+performance/en-en/).

1.7 Limitations

Time was a limitation in that the duration of the study was limited to the beginning of the season which did not leave much time for testing. Since many players were also involved in another sport during the off - season, scheduling time for the tests was problematic. Absenteeism compounded the problem.

Pre - season training, often not very informed, resulted in over - use injuries which affected the test performance of some players and was a limitation. A positive was the fitness acquired from the pre - season training.

The purpose of the research required that the sample consist of senior Provincial team players and senior players not chosen for Provincial duty. Generally the provincial players were the older more experienced while club teams consisted of many more younger players. This lead to the exclusion of age as research variable. The two groups of participants would be referred to as Provincial and club players respectively. The composition of the sample was in itself a limitation since numbers, especially of the Provincial players, were small and participants could not be easily replaced. Availability of test participants was therefore a limitation.

1.8 Delimitations

The delimitations of the study were divided into two categories, namely, inclusion and exclusion criteria. The former related to factors that determined whether subjects would be included in the study, and the latter to factors that excluded subjects from participating in the study.

1.8.1 Inclusion Criteria:

- The study will be limited to Provincial players (those selected to Provincial teams) and senior team club players of the present season in the Western Cape .
- Only participants with full match statistics were included for analyses.
- Only participants free of injury and willing to complete all tests were included.

1.8.2 Exclusion Criteria:

- Junior or youth players were excluded from the study.

- Provincial or senior club players without full match statistics were excluded from the study.

It should be noted as indicated by research, that the best time for fitness testing would be at the end of the off - season strength and conditioning programme, when strength and fitness was at their highest and in - season overuse injuries at their lowest (Siegler, et al., 2006). According to Vescovi, et al, (2006) this time corresponded to the end of a training cycle, so the players were at their best.

1.9 Thesis Outline

Chapter One commences with a brief history of the game and locates the research within softball in the Western Cape Province. Factors contributing to fast pitch softball success, and central to this research, are introduced. These include morphological, fitness and skill demands. The significance, aims and objectives of the study are elucidated, relevant terms are defined, and the limitations and delimitations of the study conclude the chapter.

Chapter Two, via the literature review, provides a brief explanation for the dearth of academic sources with regards to men's fast pitch softball and places the research within the context of the game. It expands on the various characteristics pertinent to successful participation in men's fast pitch softball. Tests for body composition which concern body fat and lean muscle mass measures; for anthropometry relating to body shape and type; and for fitness which involves power, agility and speed and for skill requirements, are discussed. Positional requirements and player selection using match statistics are also mentioned

together with other necessary requirements, some not testable, like vision, work ethic, coachability, attitude and mental toughness.

Chapter Three describes a quantitative study, descriptive in nature and using interval data, in which anthropometric, skills and fitness parameters are assessed and correlated with performance measures (match statistics). A correlational statistical measure is used to determine whether relationships existed between the studied variables, what their magnitudes were and whether such relationships were positive or negative. The similarity of sample and population sizes is explained and data was collected from all the participants using test protocols explained in detail. Match statistics were obtained from provincial scorers' records. Data is analysed using the Spearman Rank Correlation.

Chapter Four deals with research results indicating whether covariance exists between the variables investigated. It provides an indication of the strength of the relationship between such variables, whether these relationships are positive or negative and whether these relationships are statistically significant. These results allow for discussion, the drawing of conclusions and making of recommendations with regard to the characteristics required for success in men's fast pitch softball, possible shortcomings in the research itself and ideas for further research.

Chapter Five indicates a clear relationship between anthropometric characteristics and successful sports participation at the higher levels. The relationships between the variables investigated are discussed, conclusions are drawn and recommendations are made. A comparison is also made of these relationships at a club team and Provincial team level. Recommendations provide guidance to coaches and team managers with regards to team

preparedness and selections based not only on match statistics but on scientific and game - related tests as well.

CHAPTER 2

LITERATURE REVIEW

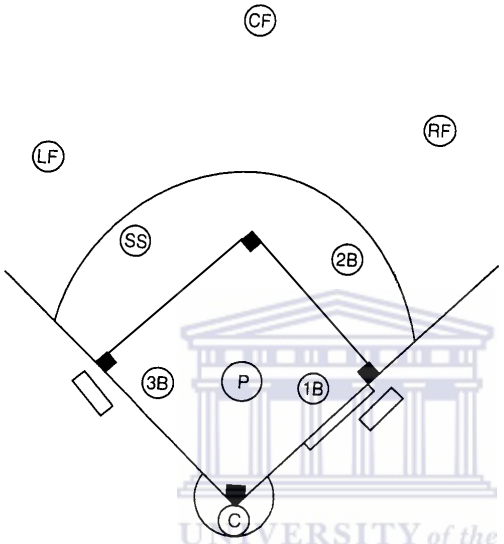
2.1 Introduction

2.1.1 Research Within the Context of the Game

Firstly it is important to note that a survey of academic journals and books, both on the internet and via library searches, including the UWC library, provided no academic resources on men's fast pitch softball. This lack of academic writing and scientific research on men's fast pitch softball is however seen by the researcher as vindication of the importance of this choice of topic for research. However to minimise the effects of what could be considered a research limitation, firstly data resources pertaining to baseball and women's fast pitch softball where rules and morphological characteristics, fitness and skill requirements are very similar to those of men's fast pitch softball, were used. Secondly use was made of fitness tests, some general and others used in other sports, which mimicked the fitness requirements for men's fast pitch softball.

Secondly a description which places the proposed tests and required attributes for the game within a particular context is invaluable, especially to the reader unfamiliar with the game of fast pitch softball. Understanding why certain attributes or skills are required to play the game well or are required for some positions, makes it necessary that some knowledge of the game and how it is played, is provided.

A game is contested by two teams of nine players each taking turns to bat (offence) and field (defence). The team scoring the most runs, or which prevents the other team from scoring more than they do, wins the game. The field diagram which follows allows a clearer understanding of how runs are scored, of the positions occupied by the players on defence, and of the qualities required to play the game well.



P	PITCHER	3B	3rd BASE	RF	RIGHT FIELD
C	CATCHER	SS	SHORTSTOP		
1B	1st BASE	LF	LEFT FIELD	**KEY**	
2B	2nd BASE	CF	CENTRE FIELD		

For example, a run is scored when the batter, after becoming a runner, touches all the bases i.e. 1st base, 2nd base, 3rd base and home plate (where he started from) without being put out, viz. a batter or runner being retired by a defensive player. The necessity of good running speed should therefore be obvious to base runners. The batter requires visual acuity to hit the

moving ball well and thereby start his movement around the bases. Fielders in the infield require strong throwing arms, fast reactions and agility to field batted balls they are quite close to. Similarly outfielders fielding at a distance from home plate require speed to retrieve well - hit balls and good throwing arms to get these balls back into the infield as quickly and accurately as possible. Coaches and players need to know which morphological attributes are advantageous to playing fast pitch softball and what the effects of too much body fat on performance would be.

Evaluative practical assessment (tests) of the various skill requirements, individual match statistics generated by individual players indicating player performance, and determining relationships between the relevant variables (including the role of morphology) – whether such relationships were strong, weak or non - existent – was the focus of this research.

Although fast pitch softball is played at various levels from recreational to international, the demands on players, relatively speaking, remain the same. Paradoxically often less attention is given to the lower levels in that they play on the poorer fields, further away from the grandstand, with the poorer umpires handling their games. Such teams often have the less experienced coaches and are more often than not, subjected to fitness regimes that do not adequately prepare them for the extra bit of effort that competition requires. Carrying excess weight, body fat for example, appears to be the norm among these senior players and is often the cause of avoidable injuries like sprained ankles and wrenched ligaments.

Irrespective of perceived inequalities among the different levels of the game, it remains important that in terms of preparation, training cycles, adequate coaching in terms of techniques, fitness, and such factors that the coach is able to manipulate, must be given the

attention it deserves. Creating an awareness of factors relevant to safe and effective participation in the game is central to this research.

In order to be effective defensively and offensively, all players must possess the common fitness characteristics of power for batting, sprinting speed and agility for base running, for chasing the ball when hit by the opposition, as well as leg power to jump when catching high balls (www.topendsports.com/testing/illinois.htm).

The selection of representative teams at both the national and international level is not only based on playing performance but as is the case with most other sports, also on the performance in sport - specific fitness tests. Softball - specific fitness tests may be beneficial to fast pitch softball players generally as it will emphasise the fitness requirements that are necessary for success in the sport. Individual match statistics together with the results of tests for skills may make the selection of players for elite competition more appropriate. Similarly it may inform local coaches of players free of injuries or fitter than others, and therefore more deserving of selection to their club teams.

2.2 Requirements for Fast pitch Softball

2.2.1 The Importance of Fitness Testing

According to Brooks et al. (2000), exercise testing refers to an activity using a stimulus to bring about a given response. A standard exercise stimulus is introduced and the response is measured against recognised norms and standards that are themselves based on typical

responses to the exercise stress. Results obtained from the tests are much more meaningful when the tests are standardised.

Over and above this, fitness testing means that elite athletic performance can be closely analysed, that results can motivate athletes and make them more competitive, that they become aware of their responsibilities and that it can be a useful tool in the process of team selection (Thomson Learning, 2004).

Morphology or anthropometry and physical fitness testing are important predictors of successful sporting performance. Talent identification is important in ensuring that the best players compete at the highest level of organised sport. It is a well - known fact that in some sports movement performance can be predicted by the athletes' morphological characteristics, specifically stature, limb length, fat - free mass and motor abilities (Di Cagno et al., 2008). Therefore although there are always exceptions, morphology can be a determining factor in success at some sports, as for example in basketball where taller individuals are generally more predominant than shorter ones. Thus height, although not the only criterion, would definitely feature on a list of criteria used by scouts to recruit players to such teams.

Within any team sport where there are different playing positions, these different positions have different anthropometric or morphological and physical fitness requirements. In a study of female soccer players, all of the positions had similar levels of aerobic fitness, even though in a game situation different positions have different physical demands. So for example, a goalie doesn't cover as much distance as a midfielder, yet their level of fitness is similar to that of other players. However when the team trains together, the differences between playing

positions demands may be reduced. Vescovi et al. (2006) discovered that although differences were not statistically significant, results did indicate that defenders are slightly slower than midfielders and that defenders and goalies are not as agile as midfielders and forwards.

2.2.2 Sport - specific Fitness Testing

To be effective predictors of success in a particular sport, tests should be selected on the basis of their applicability to the specific sport or position played. Where possible such tests should reflect as realistically as possible, situations to be encountered in the game. Within the game of softball, different positions have different requirements in terms of fitness, skill and morphology:

- The first baseman must have quick reflexes, good glove - work and strong decision - making ability. The throw doesn't have to be strong but it must be accurate since pure speed is not as important as agility (Stockton, 1984). In addition to good glove work, the first baseman also needs to be agile and able to move quickly, especially laterally away from the baseline, so that he is able to field close enough to the line to field line drives but also quick enough to move away from the baseline in the direction of the second baseman if and when required to do so. Also offensively the first baseman must be a powerful batter (Brown, 2001).
- The second baseman also needs to have good glove work, be quick, be able to make a good throw, know the plays required and have good lateral movement. The second baseman is the mirror image of the shortstop, who fields on the other side of the second base. Also, like the other infielders, the second baseman needs to be effective as a batter (Brown, 2001).

- The third baseman has a strong and accurate throw with quick feet and excellent glove work (Stockton, 1984). Similarly Brown (2001) says that the third baseman must be quick, have good glove work and, like the first baseman be able to move quickly in a lateral direction, and on offense be a powerful batter.
- The shortstop shares all the characteristics of the other infielders with the exception of being the best athlete as a result of their high work rate and having to be a cover fielder for the second and third basemen (Brown, 2001).
- The pitcher must have all the qualities of the other infielders as well as having control over pitches (Brown, 2001).
- Catchers must be exceptionally agile and co - ordinated so that they can be effective fielders (Stockton, 1984). The catcher needs to be quick, and specifically be able to frame pitches and block the ball, must be a leader and have good communication skills and interact well with pitchers (Brown, 2001). Even though these are two important characteristics, they do not form part of this particular test battery, but during testing this player was usually the most vocal, and would encourage (show leadership) to the other players.
- Outfielders must have superior speed and quickness, as well as powerful, accurate throws. The centre outfielder specifically, must be the best outfielder of the three, with good speed and a strong, accurate arm (Stockton, 1984). The outfielders need speed, a strong arm, must be powerful batters or be able to slap hit. Also because of the fielding position being so far from the diamond, and thus the batter and ball, they must be able to read the path of the ball (visual acuity) in order to field it (Brown, 2001).

For a fitness test to be relevant to a particular sport, it needs to provide stresses similar or identical to the fitness and / or skill demands of that sport. When testing team sports, the athletes should be assessed over the specific distances covered in the sport as well as the specific types of movement or movement patterns where applicable (Kent Sports Development Unit, www.kentsport.org). Important test components should include speed, power, strength, agility, body composition and range of motion (Meyers, 2003).

Generally, sport performance testing has been expensive and limited to facilities at the elite levels of sport. So for example, performance testing at the club and Provincial level in the local Province is minimal or non - existent. In spite of these obstacles Meyers (2003), states that such testing has become easier and more accessible to today's progressive coach because of the knowledge available from a greater focus on injury prevention and performance at the younger levels and the combination of sport science technology with the traditional field and court assessment.

The anaerobic or maximal tests are divided into:

- the vertical jump (Elvira, et al., 2001 reported test accuracy for the vertical jump with a $p < 0.05$ and a method error of 0.020(%), as a variation coefficient of 3.76 and a correlation coefficient of 0.76);
- the standing broad jump (Miller 1994, reported face validity and a reliability coefficient ranging from .83 to .93);
- the softball repeated throws for accuracy test (Safrit & Wood 1995 reported face validity and that reliability in the 4^{th} grade girls was .80, in 5^{th} grade girls was .82 and in 6^{th} grade girls was .85)
- and finally, the medicine ball throw (Borrie, et al., 1998, reported that the mean difference in peak values was 0.14 for females, with a 95% CI of 0.25m to -0.17m).

In the test battery used in this research, the medicine ball throw was replaced by the softball throw for distance test (Morrow, et al. 2005), as it more closely mimics the game situation.

Laboratory testing is one form of testing but its applicability and accessibility is limited and specifically the equipment has limited value when testing team and racquet sports.

Field tests are another form of testing and it is more suitable in that the testing conditions are not strictly controlled as in the lab but are very similar to the actual playing or game environment (Kent Sports Development Unit, www.kentsport.org). This means that data is collected within the context of the sport.

The experience of the coach and the objectivity of the analysis of the sport skill activity or requirement, needs to be merged to create a plan for athletic enhancement. With this principle in mind, many sport skills have already been successfully analysed including the soccer kick, softball and baseball hitting, the football pass, the golf swing and the baseball pitch (Meyers, 2003).

Most physical tests require a warm - up which serves to prevent injury and may also enhance performance. It is best to have a standard warm - up which should be appropriate and applicable to the tests to be administered and should not be unduly exhausting (Kent Sports Development Unit, www.kentsport.org).

When administering the fitness tests, it is generally recommended that the morphology tests, i.e. height, weight and skinfolds, be followed by aerobic fitness, muscular strength and endurance, and flexibility tests. Tests need to measure power, speed, skill and agility (the ability to change direction without significant deceleration). It is also important to note that if

an aerobic test is maximal, it may impact negatively on the tests that follow and ideally the tests should be performed on separate days so that the athlete can recover fully after exerting a maximal effort (Kent Sports Development Unit, www.kentsport.org).

Softball, like cricket is an intermittent game of stops and starts which vary in length, and as a result the physiological demands of the game may be underestimated. These demands on the body may therefore not be as intense as in other sports. It is noted however, that individual players perform better when they are fitter (Noakes & Durandt, 2000).

2.2.3 Body Composition Testing and Morphology

2.2.3.1 Body Composition

Body composition is an important health - related component of fitness. To properly identify the health risks associated with a too high or too low body fat percentage (BF%), it is necessary to have an accurate method of body fat assessment (Wagner & Heyward, 1991).

According to Carvajal (2009), some authors suggest that the body composition of many athletes has evolved toward a more compact and competitive build as part of a process known as secular acceleration, which is associated with increases in weight, height, muscle mass and other physical dimensions over time. He therefore suggests that measuring body composition in terms of absolute and relative amounts of fat and fat - free mass is an important part of health, nutritional status and physical fitness assessment. Singh, et al. (2010), states that having a large proportion of muscle tissue compared to a small proportion of fat tissue, makes

an important contribution to physical fitness and performance especially when individuals are required to carry their own body weight.

When the Cuban pitchers in the study (Carvajal, et al., 2009), were divided into two groups, namely lower performance and higher performance, there were significant differences in games won, body weight, bone mass and residual mass between the two groups.

Body composition analysis is commonly used to estimate body fat percentage and fat - free mass. Skinfolds are commonly used for the purpose of body fat estimation and as there is no actual measure of the body fat percentage of a living individual, methods of body composition assessment are merely estimates (Carter, et al., 1999). Skinfolds are more accurate at estimating body density than height, weight or body mass index. The skinfold method accurately measures body density (Wagner, et al., 1999).

Skinfolds are an excellent field method to use on lean subjects, making it the method of choice on athletes. It is difficult to get reliable results on obese individuals as their skinfolds are very large, or on older participants as they have lots of loose connective tissue (Wagner, et al., 1999).

According to Wagner, et al., (1999), skinfold callipers measure the thickness of two layers of skin and the underlying subcutaneous fat which is done by pinching the skin with the thumb and the forefinger, pulling it away from the body slightly and placing the callipers on the fold.

This method of body fat assessment relies on numerous assumptions, namely:

- skinfolds are a good measure of subcutaneous fat (Wagner, et al., 1999);
- there's a good relationship between subcutaneous fat and total body fat (Wagner, et al., 1999);
- the sum of skinfolds is a good measure of subcutaneous fat (Heyward, 1991);
- the total error of estimation (biological plus technical) of fat content from skinfold thickness is 3.3%BF (Wagner, et al., 1999);
- age is an independent predictor of body density for both men and women (Heyward, 1991).

The accuracy and precision of skinfold measurements depend on the type of callipers used, the training and experience of the tester and proper site identification by the tester. Incorrect location and measurement of skinfold sites can be attributed as a large cause of low inter - tester reliability. This could be the result of the lack of standardisation when it comes to site selection and location. This inconsistency has resulted in the development of standardised testing procedures and detailed descriptions for identification and measurement of sites (Heyward, 1991).

Skinfold callipers are relatively inexpensive pieces of equipment and the method of measuring skinfolds is less time - consuming than laboratory methods. This method of measuring skinfolds has brought about the use of prediction formulae that were specifically devised to produce estimates that are fairly accurate and valid (Heyward, 1991). Since skinfolds measure body fat percentage as an estimate, there shouldn't be a single digit value described as acceptable. Body fat percentage should have an approximate range and it should be acceptable for an athlete to fall anywhere within the range (Healthline, 2011).

When using high quality skinfold callipers, similar skinfold measurements are observed because these callipers have a constant pressure of $10gmm^{-2}$ throughout the range of measurement (Heyward, 1991).

Using Nomograms to predict body fat percentage are potentially time - savers but it must be kept in mind that nomograms use either the Siri or Brozek equations when converting body density to body fat percentage. Nomograms should only be used when the subjects are exclusively young adult males (Heyward, 1999).

2.2.3.2 Anthropometry

Anthropometry has been applied to sports because it is a valuable tool in assessing the influence morphology and body type has on sporting performance. The value of assessing body type means that a coach can use an athlete in a position to which he / she is most suited, by playing to their strengths and downplaying their weaknesses. When improving the player's weaknesses means keeping them competitive, these weaknesses can be altered with appropriate training or the player can be moved to a position to which he / she is better suited.

The role of an ideal body shape and body type for a particular sport or a particular playing position has brought about the idea of 'morphological optimisation', meaning that athletes with the ideal body type will perform better at their sport at higher levels of competition. Also the majority of successful athletes will have that specific morphology, and the more ideally suited an athlete is to their sport, the lower their risk for injury (http://www.sportnz.org./Documents/CommunitiesandClubs/CoachingCompetitiveAdultAnthropometryResourceMay07).

A few authors suggest that morpho - functional differences among baseball players correspond to their performance role, since the defensive actions of catching, fielding and throwing need different levels of power, strength, coordination, agility, running speed, balance, etc. than the offensive actions of batting and base running, even though all players have both a defensive and offensive role (Carvajal, et al. 2009).

In the team sport of handball, it was found that in top - level male handball players, their body type corresponded to their playing position and its kinesiological demands. The handball player has an athletic body build with mesomorphy (robustness and muscularity) being dominant with slight ectomorphy (leanness and linearity), but there are differences between positions.

- The back players are taller, have greater body mass and more endurance than wings because they have the most complex function in the game. They have ball possession most of the time and they are decision - makers in the game.
- Wings don't need heavy body mass as they have minimal contact with rival players but they must be fast and agile with and without the ball. Having a heavier body would be a disadvantage.
- The pivot or circle runner has the responsibility of always competing with the opposition for position by pushing, pulling, resisting and turning with the opponent in close quarters, so the morphology most suited here is a low centre of gravity, strong upper body and heavy body mass.
- The goalkeeper is confined to a small space and has the most specific duty. The goalie must be quick and explosive and is tall with an athletic body build (Srhoj, et al., 2002).

Similarly Carvajal, et al. (2009), found that in softball, all playing positions are characterised by specific morphological traits. All had a meso - endomorphic somatotype and were more muscular than lean. In terms of specific reference to ectomorphy, infielders were the leanest, followed by pitchers. Catchers were found to be more endomorphic than infielders and outfielders; catchers and infielders more mesomorphic than pitchers; and infielders and pitchers more ectomorphic than catchers and outfielders.

Anthropometry is thus very important in team selection and also dictates the direction the training process will take. Training must be tailored to suit the players' current anthropometric status, their development needs, the specific demands of the game and desirable results.

2.2.4 Power and Agility Tests

2.2.4.1 Power Tests

Power is the amount of work you can do in a specified time and it is necessary when strength and speed are necessary. In other words, it is a combination of muscular strength and speed of movement. The more power you have the more force you can generate with minimal effort, the greater your power the quicker you can respond and the more force you can generate with less exertion. Also, an explosive first step generates the speed needed to get to balls hit farther away.

Muscular power can be measured as the distance the body or an object can be propelled through space and examples are the vertical jump (lower body power assessment) and the medicine ball put (upper body power assessment) (Miller, 1994).

Jump tests have always been considered the best lower extremity power assessment method. This can be attributed to the simplicity of the test apparatus (tape measure) used, as well as the ease of test administration. Jump tests are common in most tests of physical conditioning (Elvira, et al., 2001).

There are numerous field tests to assess lower body power and performance, such as the standing vertical jump, the standing broad jump and different sprint tests. There is no equivalent field assessment for upper body power (Borrie, et al., 1998).

- The vertical jump or Sargent jump test is the method used for directly measuring the vertical jump height jumped. It can be measured using chalk and a measuring tape. There are also timing systems that measure the time of the jump and from that calculate the vertical jump height (www.topendsports.com).
- The standing long jump or broad jump which measures distance jumped, is the easiest and most commonly used test of explosive leg power. It is one of the fitness tests in the American NFL Combine fitness battery, an event in Sports Hall competitions in the UK, and was once an event at the Olympic Games (www.topendsports.com).

2.2.4.2 Agility Tests

Agility is the ability to move quickly into different positions at speed and with little or no loss of momentum. Agility is essential to overall performance in softball. On the offensive it is a

requirement for quick and efficient base running while defensively it allows the fielder to get into the correct position to field the ball cleanly and have a solid platform from which to make a play or throw. Speed is also important for getting to the ball and even though some people have natural speed, others can improve their speed with training (Roetert & Ellenbecker, 1998).

Although agility is an important component of many team sports, it is not always tested since it is often difficult to interpret the results due to the test's inability to discern between left and right turning ability. According to Getchell (1979), the Illinois Agility Test is a commonly used test of agility in sports, which has many norms.

2.2.5 Skills Tests

2.2.5.1 Throwing

Throwing (referred to as pegging in softball) is the act of propelling a ball from one spot to another. Over - arm throwing which propels a ball, whether small and round (softball) or bigger and oblong (rugby ball), over longer distances, is an important skill in numerous sports. When a player throws a ball from any area of the field, the fielder must be able to throw the ball with speed and accuracy. In sport a maximal throw (being able to throw hard and easily reach the target) does not always guarantee success or put - outs. In many cases the accuracy of the throw, resulting from good technique, is more important (Cooke & Strike, 2000).

Throwing is however very important and a strong throw can be measured using the softball throw for distance test (Johnson & Nelson, 1986), where a good result in this test can be used as a predictor of offensive performance. However before a ball can be thrown it needs to be fielded, and therefore the ability to throw goes hand in hand with the ability to field a ball. Fielding could be the act of catching a fly ball (a batted ball before it makes contact with the ground) or cleanly fielding a ground ball and making a play.

2.2.5.2 Fielding

There is a fielding test known as the Elrod Throwing and Fielding Test (Softball and Baseball: Elrod, 1969) which tests both the ability to field a ball as well as the throw with accuracy. This test can measure the abilities separately or give a combined score (Johnson & Nelson, 1986).

2.2.5.3 Base Running

Base running speed is the speed at which players run between bases and it is generally measured by means of the base running test. Research results include:

- Safrit, et al. (1995) who reported logical validity and validity coefficients ranging from .89 to .95 for females in the 5^{th} through 8^{th} grades for the base running test.
- The baseball speed test (Bloomfield,et al., 1994) where comparative data was used to show the mean ranges, and totals of distances and calculated them in seconds.
- With the baseball and softball agility tests Bloomfield et al. (1994) used normative data and found the mean and range scores at 6.13s and 5.76 - 6.55s.

2.2.5.4 Batting

The batting test measures power and placement in batting. Safrit, et al. (1995) reported that logical validity and the validity coefficients ranged from .54 to .85 for females in the 5th through 8th grades, high school and college and the reliability coefficients ranged from .69 to .91 for females in the 5th through 8th grades, high school and college.

2.2.6 Positional Player Characteristics

In order to be effective in softball, apart from being able to play a particular defensive position well, all players must possess the common characteristics of power for batting (Batting test); running with speed; the ability to jump for height and distance (the vertical or Sargent's jump test or the standing broad jump tests); speed and agility for base running (the base running test as well as the agility T - test, Johnson and Nelson (1986) and the Illinois Agility Test – Getchell, (1979).

Amber and Kavekar (2005), mention the following comments from 85% of the coaches interviewed with regards to the recruitment of players:

- They preferred multi - position players saying that "the addition of depth, versatility and flexibility are invaluable since many infielders become outfielders."
- The top three positions recruiters are on the lookout for are pitchers, shortstops and catchers for the following reasons: "Pitchers are the most important aspect of our game"; A pitcher "keeps the team in the game"; "There is necessity of one (a good pitcher) to be successful"; "The game starts in the circle"; "They are the cornerstone of a team"; Without great pitching, a team will not go anywhere".

- With reference to shortstops coaches said that they “can be placed anywhere on the field”, “are often the best athletes” while catchers “are leaders of the team and necessary to help the pitcher” (Amber & Kavekar, 2005).

Winning pitchers are strong, fit, have good coordination and are always thinking. Significant correlations have been found between throwing (pitching) speed and height, body weight, mesomorphy and muscle mass, suggesting a strong relationship between pitching speed and the above - mentioned variables (Carvajal, et al., 2009).

In a study of Cuban baseball players it was found that first basemen were the tallest and heaviest players with the highest batting efficiency (number of bases run per hit divided by the times at bat). The second baseman, shortstop and third baseman (infielders) were lighter and leaner than other players and had the lowest batting efficiency. They had a slightly larger muscle mass than pitchers, while catchers and outfielders had the highest mean fat mass (Carvajal, et al. 2009).

First basemen and outfielders are frequently strong offensively and as batters had a higher batting efficiency (number of bases run per hit divided by the times at bat). Their morphology, larger muscle mass and greater mesomorphy, also consistent with offensive power, was not significantly higher than that of other players. Infielders and catchers, as the most defensive positions, had the lowest batting efficiency, and while their mean muscle mass did not differ significantly, the mean value for catchers was slightly higher. In a study by Carvajal, et al. (2009), catchers were found to be tall and muscular, and had the highest values for mesomorphy, but their height was not significantly different from the first baseman

who were the tallest. The infielders weighed the least and had the lowest levels of body fat, which corresponded with the values of agile, speedy, quick players.

2.2.7 Player Selection and Technological Advances

When selecting players, especially for higher competition, body composition, skill, match statistics and fitness are important. However some recruiters who are unable to observe the player in an actual real game situation, make use of a skill video or dvd, which could spark coach / recruiter interest and provide an opportunity of seeing the player "live". This allows the coach / recruiter to see how the player performs in various game situations and within the team set - up but it is a "point of reference or starting point only." Live practices also make it possible to observe the recruit's athletic ability, attitude and "hustle" as well as hitting, speed, clutch performance under pressure, passion, intensity and aggressive style (Amber & Kavekar, 2005). The top three characteristics recruiters look for are "power and strength, basic skills or athleticism and speed". Others aspects include "bat speed, hand - eye coordination, skills, programme need - based athlete" (Amber & Kavekar, 2005).

The pitcher seen as "the cornerstone" of the team and who's main function is to prevent the opposition from scoring runs, presently has this pivotal function made more difficult by technological advances resulting in the introduction of composite softball bats. These new bats, because of their composition and length - to - weight ratios, allow for greater bat speeds which result in balls being hit at greater speeds. Balls now travel further and faster and give, especially the pitcher, and the other defensive players, less time to react to batted balls (McDowell, et al., 2005). This resulted in poorer defensive plays, negatively affecting match statistics, and an increased risk of injury (McDowell, et al., 2005).

In a study by McDowell, et al., (2005), the main finding was that composite softball bats translate into balls batted at unsafe velocities, which can pose a significant risk for injury. The United States Softball Sports Association (USSSA) and the Amateur Softball Association (ASA) of America declared that a bat which achieves an "initial batted - ball velocity (BBV) of 137.2 km/h (85.2mph) translating into available pitcher reaction time (APRT) of 0.420 seconds (USSSA, 2003), (ASA 2003) be considered unsafe" (Amber & Kavekar, 2005).

According to Mcdowell, et al. (2005), batted balls exceeding the recommended safe speeds pose a real risk for defensive players, most notably pitchers. During 2002 until 2004 there have been a number of devastating and fatal injuries to pitchers when balls were batted directly back at them, striking specifically the head and neck region. What is alarming to note is that these injuries and deaths occurred in slow pitch softball, a game that is slower and played more recreationally than fast pitch softball. This makes softball a more dangerous game than is commonly thought by coaches, players and parents.

This increased ball speed poses greater risk to older players who have a slower reaction time and who make up the majority of recreational or lower league softball players. These bats have been used since the late 1990's by everyone who plays softball, from primary school all the way up to the Olympics, and have proven a significant factor having an impact on fielder statistics (McDowell, et al., 2005).

2.2.8 Match Statistics

Statistics are used in many sports as a way of evaluating performance, both of individuals as well as teams. Statistics can be generated with data obtained from the individual's performance during a game or event or may provide an overview of an individual's performance for a season or an entire career.

Even though softball is a team sport, the outcome of a game can depend heavily on individual performances, specifically the pitcher. This dependence on the pitcher is reflected earlier on in comments made by coaches / recruiters when referring to pitchers as the "cornerstone of the team"; that "everything starts in the middle" and that "a team will not go very far without a good pitcher".

As it is the pitcher's job to limit runs by the opposing team, the statistics will reflect how many runs the opposition got as a result of hits. Statistics which reflect badly on the pitcher are indicated when batters advance to a base(s) because of a batted ball; when they are awarded a base - on - balls; or when runners advanced on a passed ball, viz. balls pitched that were not in the strike zone and passed the catcher.

The pitcher's statistics give a clear indication of his performance in the game and show how many batters he faced, how many balls he pitched, how many walks he gave, etc. and his contribution in the form of strike - outs, put - outs and batting. Statistics show specifically how many games he started, how many he finished and how many games he's appeared in (http://www.livestrong.com/article/94032-softball-pitching-statistics-mean/).

Currently statistics and performance at trials are used when it comes to athlete selection to the local softball federation Provincial squad. An investigation of the recruiting criteria of NCAA (National Collegiate Athletic Association) Division I softball coaches revealed that in a sample of the top 50 coaches with over 475 combined years of coaching, statistics formed a part of the recruitment criteria (Amber & Kavekar, 2005). It is important to note however, that 11% of the respondents admitted to not using statistics.

When making use of statistics in talent identification, players are divided into pitchers and non - pitchers, with specific statistics required in these positions. These statistics can further be divided into offensive statistics, non - pitchers, and defensive statistics, pitchers. The top 3 statistics most sought after in a non - pitching player are on - base percentage (OB%), runs batted in (RBI) and batting average (BA). Other responses included walk - to - strike ratio (BB:K), extra base hits, homeruns (HR), batting average with runners in scoring position (BA w/RISP), number of strikes (K), power stats, stolen bases and hitting. The top three statistics for a pitcher are “earned run average (ERA)”, “walk - to - strike ratio (BB:K)” and number of strikes (K) (Amber & Kavekar, 2005).

As stated when selecting pitchers, defensive statistics are more important than offensive ones as their main function is to keep the run rate down. However, with the advances in modern technology, specifically the use of composite materials in bat construction, it is making it harder for pitchers and other defensive players to react to the batted ball. Less time to react means that decision - making and fielding are affected, meaning a negative impact on statistics, as well as posing an injury risk to defensive players, particularly the pitcher as the pitching circle is closest to the batter in the batter’s box (McDowell, et al., 2011).

2.2.9. Other Necessary Characteristics

The sense of vision allows objects to be identified in space and also to determine their movement. Vision also gives information about the environment as well as our own bodies (Shumway - Cook & Woollacott, 1995). This visual proprioception gives us information about our bodies and is a key factor in the control of posture, movement and manipulating function.

Vision is considered the most important means of gathering external or environmental information and experts have estimated it as accounting for 80% of information gathered and interpreted (Gabbard, 2000).

When an object is moving in a predictable manner, as in a straight line or has a predictable flight path, it is easier to make an accurate movement to catch or strike at it (Gabbard, 2000). This makes it easier to divide attention between the movement towards the object and then what to do after the object has been acted on, struck or caught.

Accurate responses to slow moving objects are more difficult than to faster moving ones. An example would be slow pitch softball, where the ball is thrown up to arc high above the ground, the batters are more successful at hitting balls that have a bit more pace and have a flatter flight path than those that move slower and have more height (Gabbard, 2000).

Accuracy of response seems to improve with an increase in the object's speed, but only to a point. However, in fast pitch softball the batter's response may reach a point where the

pitcher's fast ball is simply too fast to be hit as a result of a too slow batting speed which leads to decreased performance accuracy (Gabbard, 2000).

Characteristics of recruits that are important but cannot be tested are mental toughness and being able to perform at your best consistently regardless of the competitive circumstances. Also important were a strong work ethic; coachability and attitude. These three characteristics make it possible for recruits to excel throughout their athletic career. When observing games and practices, coaches noted that middle infielders and catchers set the tone, fulfilled a leadership role and are key motivators to pitchers (Amber & Kavekar, 2005).

Similarly Amber and Kavekar (2005), state that the most sought after characteristics were "power and strength, basic skills or athleticism and speed". It is important to note that these three elements are all accounted for in this study using the tests selected to form the test battery.

2.3 Conclusion

Due to the dearth of literature sources with regards to men's fast pitch softball, the literature review relied heavily on resources from baseball, women's fast pitch softball and other sports with similar demands in terms of morphology, fitness and skills. At least in terms of match statistics, these were derived from men's fast pitch softball results at both the club and Provincial levels. It is hoped that the findings of this research will inform the decisions made by coaches and managers of men's fast pitch softball with regards to training and selection of players in a more scientific and informed manner via improved coaching methods and sport - specific training programmes. This research also seeks to address the lack of information and

research about men's fast pitch softball by investigating relationships between the research variables chosen for this study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this study, the tests were administered over a number of days (weeks) while the athletes were at Provincial squad training which included game drills and lengthy batting practice sessions in the nets. It was therefore not possible to do all of the testing in any one of such practice days as a result of the number of players that were to be tested and not wanting to upset the coaches by using their player training time. Fatigue was also a factor that was considered.

This is a quantitative study in which anthropometric, skills and fitness parameters were assessed and correlated with performance measures (match statistics). Since this study gathers and records data from observation of particular events in the real world using a scientific methodology, empirical knowledge is generated. None of the variables examined by the researcher were manipulated since the aim was not to discover cause and effect relationships between variables but whether relationships between the variables existed. Such relationships are useful for the purposes of prediction or making an 'educated guess' of a possible outcome.

Since this study will examine covariance between two or more variables, correlational research was conducted on the collected empirical data. Correlation provides a statistical measure of the relationship between variables and also gives an indication of the strength of the relationship as well as whether it is positive or negative in nature. It is therefore descriptive in nature using interval data.

3.2 Sample Size

Prior to the selection of the research samples, permission was obtained from the relevant Provincial Softball Federation to conduct this research. Thereafter the relevant coaches of the teams were approached for their cooperation.

The sample was purposively selected and consisted of 15 Provincial and 15 club male fast pitch softball players. All participants were members of the Provincial Softball Federation. The size of the sample was influenced by Provincial team squad members totals which is normally eighteen. Sample and populations sizes are therefore the same for the Provincial team. However three were not available and the number was thus fifteen which amounted to a significant percentage of the total Provincial squad population. Although the population is fixed at eighteen, squad individuals may change as a result of selections each year, and this may influence future comparative studies. The club team members were easier to get access to, but a decision was made to select a number of participants equal to that of the Provincial team. Choosing a club as a sample constituted a percentage of the total population of clubs which numbered thirteen in total and consisted of eighteen teams. It was decided to choose a single club for this study to facilitate and make easier the collection of club player data.

3.3 Ethical and Legal Considerations

The players and coaches were informed as to what the study would entail and they all signed informed consent forms. Since players had already started their preparation for the forthcoming season, which included exercises both aerobic and anaerobic in nature, they were considered fit enough to complete the tests without fear of injury. The tests were all of

short duration and the warm - ups prior to testing minimised all risks of possible injury. Treatment and medical advice was provided on the odd occasion where it was necessary. It must be noted that such incidents or episodes resulted not from the administration of the tests but was rather the treatment of existing injuries, which in most cases were overuse injuries.

The players were also informed that all information would be kept strictly confidential. They were made aware of the benefits of the tests, that they would be informed of how they rated on these tests, and what their strengths and weaknesses were. The players were also informed that their participation was voluntary and that that they could withdraw from the study at any time.

The players were also told that their participation would contribute to the advancement of the game of fast pitch softball and results would be used to attain such progress.

3.4 Data Collection

Anthropometric, fitness and skills test and measurements were conducted at the two training sites over a number of weeks because it coincided with team training. Coaches although cooperative, gave up a maximum of thirty to forty - five minutes for such tests to be conducted. Match statistics were easier to obtain since records were available in printed form from the relevant Provincial Softball Federation for the Provincial players and from the sample club for its members. The data obtained were analysed and interpreted both collectively as a group of thirty and then separately as Provincial and club teams for the purpose of comparison.

3.5 Measurement

3.5.1 Anthropometric Measurements

3.5.1.1 Weight

Body mass is the quantity of matter in the body and is indicated by weight which is the force the matter exerts in a standard gravitational field (ISAK, 2006). Subjects stepped onto a Seca digital scale, wearing minimal clothing, which amounted to a vest and shorts and without shoes. The individual's weight was recorded to the nearest 100g. Measurements were all recorded after 6pm before they started with their training.

3.5.1.2 Height

Height was measured with a non - stretchable tape measure taped to a flat vertical surface (a wall without a skirting board was used). The players stood on a hard solid surface with bare feet, heels together, legs straight, arms relaxed at the sides and with the shoulders relaxed. A right - angled board was used to position the head in the Frankfort Horizontal plane. The Frankfort horizontal plane is achieved when the Orbitale (r) (lower edge of the eye socket) is in line with the Tragion (r) (the notch superior to the tragus of the ear) and the Vertex (r) is the highest position on the skull.

This was achieved by placing the tips of the thumbs on each Orbitale (r), the index fingers on each Tragion (r) and aligning them horizontally. The measurer then moved her thumbs toward the subject's ears along the jawline so that upward pressure was applied along the

mastoid processes. The subject was instructed to inhale and the measurer placed the board on the subject's head and compressed the hair as much as possible.

Heels, buttocks and scapulae were in contact with the wall. Just before measurement the player was instructed to inhale deeply. This should have brought elevation of the shoulders and straightened the posture but in the cases where it made no visible difference and the player just expanded his chest area, light vertical traction was applied at the jaw bone. This traction was just enough to increase the height, but not lift the heels. The measurement was taken before the subject could exhale, without the subject raising the heels.

The measurement was recorded to the nearest 0.1cm and the tester's eye had to be level with the headboard to avoid errors of parallax. As the tester / measurer was a short female she had to stand on a chair to take the measurements accurately (ISAK, 2006).

3.5.1.3 Skinfold Measurement

To counteract the effects of exercise, skinfold measurements were taken before the start of their training sessions. According to ISAK (2006) factors like exercise, warm water and heat can lead to dehydration and / or hyperaemia (increased blood flow) which can affect body mass, skinfold and girth measurements. Since training generates heat which will cause the effects mentioned by ISAK (2006), tests were done before training to ensure reliable measurements.

The accuracy of the measurements taken depends on the accuracy of the equipment and the experience of the tester. A tape measure helped to locate the correct site. A properly

calibrated skinfold calliper, with a constant spring pressure of 10g/mm2 throughout its range was used. The Harpenden calliper, which is properly calibrated before leaving the factory, was used. An experienced tester selected and located the proper sites and measured correctly. The proper measurement technique is essential to getting accurate, repeatable results. Measurements were only taken on dry, undamaged healthy skin. The subjects were instructed to relax their muscles during the test and the measurements were taken on the right sides for consistency. Water soluble ink was used when marking the skinfold sites and the tape measure was used to accurately find the midpoints.

The skinfold was grasped with the tips of the thumb and index finger and then pulled away from the body. The calliper was put perpendicular to the fold on the marked site about 1cm below the finger and thumb. While holding the skinfold, the reading was taken to the nearest 0.50mm, within 1 to 2 seconds after the grip had been released, to avoid too much compression of the skin.

At least two measurements were taken at each site, and if repeated measures varied by more than 1mm the measurement was repeated. If the measurements became smaller with each measurement it meant that the fat was being compressed. When that happened, measurement was done at another site and the problem site was rechecked a little later. The skinfold recorded was the average of the two measures taken (www.harpendencalipers.co.uk/skinfold - measurement - process.html).

Site selection is very important and can be the greatest source of error in skinfold testing. The sites selected must suit the protocol being used. The sites are the same on both males and females. According to ISAK, 2006, the appropriate sites include:

- Biceps – measurement is taken on a vertical fold on the anterior surface (front) of the biceps (upper arm) midway between the anterior fold (front of elbow) and the antecubital fossa. The arm should hang relaxed at the athletes' side for this measurement.
- Triceps – this measurement is taken on a vertical fold on the back and middle of the upper arm, between the acromion process of the scapula and the olecranon process of the ulna (bony process on elbow). The arm must be relaxed and extended at the side.
- Subscapular – this measurement is taken on the upper back, as a diagonal fold on a line coming from the vertebral border to between 1 and 2cm from the inferior angle of the scapula. (The fold is 1 - 2cm below the point of the shoulder blade and 1 - 2cm toward the arm).
- Suprailiac – located on the lower abdomen on the diagonal fold above the crest of the ilium, just above the hipbone and 2 - 3cm forward.
- Abdominal – a vertical fold taken 2cm from and to the side of the umbilicus (bellybutton).
- Thigh – a vertical fold on the front of the thigh between the hip and knee joints, while standing with the leg relaxed and the weight on the other leg.
- Calf - A vertical fold on the middle of the calf at its greatest diameter. The subject should be seated upright, with the arms hanging at the sides and the hip and knee flexed to 90degrees (www.harpendencalipers.co.uk/site - selection.html).

3.6 Fitness Tests

To ensure reliability of measurement in the fitness tests that follow, the participants had to perform all of these tests correctly in the prescribed manner – deviations were not allowed

3.6.1 Vertical Jump

This test measured the explosive power in the legs by measuring the vertical height jumped. There are also timing systems that measure the time spent in the air and then calculate the jump height from that.

The athlete stood, flat footed, side on to a wall and reached up with the hand closest to the wall. The standing reach height or stretched height, with the fingertips as the highest point, was then marked on the wall and recorded.

The player then stepped away from the wall, remaining side - on. He used both arms to start the movement by swinging them down and up while bending the knees followed by using both legs to project the body upward. It is important that the player jumps up and not forward. The player may or may not have used a countermovement and attempted to touch the wall at the highest point of the jump. The vertical jump height was taken as the difference between the standing reach height or stretched height and the height jumped. The score was taken as the best of the jump trials as a distance score in centimetres as per the test protocol (http://www.topendsports.com/testing/tests/vertjump.htm).

3.6.2 Standing Broad Jump

This is another explosive leg power test which measured the distance jumped forward and not straight up. The take - off line was clearly marked. The player stood behind the line marked on the ground with feet slightly apart. They used a two footed take - off and landing with an arm swing and bent knees to drive forward. The player jumped as far forward as possible, as

the forward distance was measured, not the vertical height. Three trials were allowed and the best score recorded. The measurement, in centimetres, was taken as the distance from the take - off line to the nearest point of contact on landing (viz. the back of the heels) as per the test protocol (http://www.topendsports.com/testing/tests/longjump.htm)

3.6.3 Illinois Agility Run

Agility or the ability to run at speed and change direction without decelerating, is important in many sports. The Illinois Agility Test (Getchell, 1979) was used in this study to measure agility.

The test course measured 10 metres long by 5 metres wide with a cone at each corner. The start and finish are the two cones on a short side with the turning points being the cones on the other short side. Another four cones were placed down the centre of the court at 3.3 metres apart. The players lie face down with the head at the start on the outside of the start cone with hands at their shoulders. On the command 'Go', the stopwatch is started and the players get up as quickly as possible and run to complete the course in the shortest time possible in the direction indicated, without knocking the cones over, to the finish line, at which the timing is stopped (See Appendix E for this test diagramme).

The advantage of this test was that it was easy to administer and it didn't require much equipment. It tested the players' ability to turn in different directions and at different angles. The choice of footwear and the type of floor surface can affect the time it takes to complete the course. The accuracy of the time keeper can also affect the results. To ensure a reasonable degree of accuracy in measurements, the same stopwatch and time keeper was used for all

participants. Access to timing gates may increase the accuracy of measurement but will increase costs. This test cannot distinguish between left and right turning ability (www.topendsports.com/testing/illinois.htm).

3.7 Skills Tests

3.7.1 Softball Throw for Distance

This test measured skill and coordination because a good throw involves the whole body, starting with the transfer of weight in the lower body and the final application of force by the upper body.

Several softballs, a tape measure, marking cones and a field measured in 5 yard intervals, and a six foot restraining area parallel to the 5 yard field markers, was required. Testing was done in small groups as that was best.

To start the player stood within the 6 foot restraining area, and threw the ball as hard and as far as he could. A judge in the landing area marked the first contact of the ball with the ground with a marker. The ball's point of contact was marked and if the second or third throws were further, the distance marker was moved. Three trials were allowed. For ease of recording (and reducing the possibility of recording the wrong score) and to encourage friendly competition, the player would stand at the marker of his furthest throw.

The score was given as the distance to the nearest foot of the best throw and the measurement was made at right angles from the point of landing to the restraining area, which meant that

the tape was always straight and not swung in an arc to measure each throw according to the test protocol of Morrow, et al., (2005) (A sketch of this test is provided in Appendix F.).

3.7.2 Two Base Sprint Test

This test measured the speed and skill involved in running two bases. For safety, the player had to run through second base. The testing area was the softball diamond and the test started with the player in the batter's box, swinging as if at a pitched ball and releasing the bat under control, and then running. The timer started when the bat was released and stopped when the player crossed second base. There was one practice trial and then two timed trials, with the better of the two being recorded. The time was recorded to the nearest tenth of a second The test protocol of Morrow, et al., (2011) was followed (This test is clarified in Appendix G.).

3.7.3 The Batting Test

This test measured the players batting power and ability to place the ball following the test protocol of Morrow, et al., (2011). The test was administered on the softball diamond and the ball was set on a tee, the player then tried to hit the ball as far as possible, in either left, right or centre out field. There were two practice test trials and six test trials. The field was marked at 18.3m, 45.7m and 73.2m, in all three zones. Left and right field had a score of 1 in the first zone, 2 in the second zone and 3 beyond the third zone while the centre field's zones were scored 2, 4 and 6 respectively. If the player hit the tee, no points were awarded and there was no re - trial (For more clarity on this test, see Appendix H).

3.7.4 The Fielding Test

The fielding test was one of the AAHPERD Softball Skills Tests which tested the player's ability to cleanly field a ground ball and keep it under control, before tossing it aside. A rectangular area, 17 by 60 feet was marked off, and two lines were drawn across the area 25 and 50 feet from the front or throwing line, resulting in three areas being marked or drawn.

The player stood in the 17 by 10 foot area at the end of the rectangle and the thrower stood behind the throwing line with a bucket containing 10 balls. On the signal to begin, the thrower started throwing ground balls at exactly one every 5 seconds into the first 17 by 25 foot zone. The throw was made in an overhand manner at a good speed. Each throw hit the ground inside the first area and bounced at least once. The directions of the throws change but the thrower did not deliberately try to make the player miss. A throw that did not bounce in the specified area had to be thrown again. The player had to field every ball cleanly, hold onto it under control and then toss it outside of the marked area. He started at the back of the 50 foot line, but then he could field the ball anywhere in the back of the 25 foot line. There was first a practice trial and then 20 trials.

The score was on a pass or fail basis, each throw scored 1 point, the maximum score was twenty (Johnson & Nelson, 1986).

3.8 Validity and Generalisability of Collected Data

The testing started off with anthropometric measurements, weight, height and skinfolds (Wagner, et al., reported SEEs from skinfold measurements to be 2.6kg and 3.5% for fat -

free mass and percentage body fat respectively). Skinfolds were measured first before fitness tests because exercise causes a shift in body fluid to the skin, increasing the size of the skinfold (Heyward, 1991).

Johnson and Nelson (1986) found that when testing reaction timing, the validity of the timing device is inherent because the earth's gravitational pull is consistent and the timer will always fall at the same speed. A reliability coefficient of .89 was reached using average scores when taken on two separate test administrations.

The anaerobic or maximal tests were divided into:

- The vertical jump (Elvira, et al., reported test accuracy when $p < 0.05$ with a method error of 0.020(%) a variation coefficient of 3.76 and a correlation coefficient of 0.76).
- The standing broad jump (Miller reported face validity and a reliability coefficient ranging from .83 to .93).
- The softball repeated throws for accuracy test (Safrit and Wood reported face validity and that reliability in the 4^{th} grade girls was .80, 5^{th} grade girls was .82 and the 6^{th} grade girls was .85).
- The medicine ball throw (Borrie, et al., the mean difference in peak values 0.14 for females, with a 95% CI of 0.25m to - 0.17m).

The batting test (Safrit, et al., reported that logical validity and the validity coefficients ranged from .54 to .85 for females in the 5^{th} through 8^{th} grades, high school and college and the reliability coefficients ranged from .69 to .91 for females in the 5^{th} through 8^{th} grades, high school and college). Concurrent validity coefficients using judges rating of skill as the criterion measure ranged from .54 to .85 for males and females in grades 5 through 8, high

school and college. Intra - class test - retest coefficients ranged from .69 to .91 for males and females in grades 5 through 8, high school and college.

The base running test (Safrit, et al., reported logical validity and the validity coefficients ranged from .89 to .95 for females in the 5th through 8th grades) concurrent validity coefficients used judges rating of skill as the criterion measure ranged from .79 to .92 for males and females in grades 5 through 8, high school and college. Intra - class test - retest coefficients ranged from .89 to .95 for males and females in grades 5 through 8, high school and college (Morrow, et al., 2011). The baseball speed test (Bloomfield, et al., used comparative data and found the means, ranges and totals of the distances and calculated them in seconds). With the baseball and softball agility test (Bloomfield et al., used normative data and found the mean and range scores at 6.13s and 5.76 - 6.55s) as the final test (www.topendsports.com/testing/tests/vertjump.htm).

3.9 Match Statistics

Match statistics are the numerical representation of team and individual playing performance. It is derived from the score sheet and gives a more detailed description of individual performance. It is divided into offensive statistics which is the player or teams' ability to bat, get on base and score runs, and the defensive statistics, which is the ability to suppress the opponents' ability to score runs and is recorded as the fielding, pitching and catching statistics.

3.9.1 Offensive Statistics

Offensive statistics are the batting statistics, which are how many times the player got a safe hit, whether it was a one base (1B), two base (2B), three base (3B) or home run (HR) hit. It includes how many times the batter steps into the batter's box (a plate appearance (PA), how many times the batter gets to bat (known as an at bat (AB), but excludes base on balls (BB), hit by pitch (HP) and when he sacrifices himself (SAC) to score a run, meaning that he is put out but the base runner on third base scores. However, getting to bat doesn't always result in a safe hit, so when looking at PA's and AB's it is possible to find the former statistics to be high and the total number of safe hits (TH) to be very low. When a batter faces a pitcher and the pitcher is able to throw three strikes without the batter being able to bat, it is known as a strike - out (K) This is a very good defensive statistic for the pitcher and a poor offensive statistic for the batter, especially if the batter has a few K's in any particular number of games. The reverse is true for the pitcher.

The statistics also show when the batter is unsuccessful and when the hit results in two outs, namely that of the batter - runner and the runner already on base and is indicated as a ground into double play (GDP), which means that the batter has hit a ground ball and the defensive team can make a double play, meaning, get two outs. Sacrifice fly (SF) and sacrifice bunts (SB) are also indicated, as are the successful stealing of bases, so every time a runner steals a base successfully it is shown as an (S). The last two statistics shown are runs that score (R) and runs that are as a result of the batter (RBI). Even though the RBI stands for runs batted in, it also means that when any runner scores as a result of the batter, whether the batter got a walk, there was a wild pitch or was hit by a pitched ball, the batter is credited with the RBI.

Statistics also indicate how often, and seldom, the player gets to a base safely, whether it is as a result of the pitcher being 'unable to find the plate" or when the batter gets walked, which occurs when four balls are pitched before three strikes (a base on balls (BB). A batter can also get on base if the pitcher pitches a bad ball which cannot be stopped by the catcher, because it is a wild pitch (WP) and it then becomes a passed ball (PB). If the pitcher manages to hit a batter (HP) with a pitched ball, the batter is allowed to get to first base without batting. TH is also a statistic shared by the batter, as an offensive statistic, meaning how many safe hits the batter gets and is a defensive statistic for the pitcher, as it shows how many hits the pitcher allows in the game (SSA, Scorers manual, 2006).

The BB and HP are offensive statistics for the batter, because it means that the batter is awarded a base and it is a defensive statistic for a pitcher, as it demonstrates the pitching consistency and accuracy, or lack thereof. WP is a purely defensive statistic, but it can also mean unearned runs for runners on bases. The PB is the catcher's defensive statistic and indicates how many pitches the catcher has missed.

3.9.2 Defensive Statistics

There are three kinds of defensive statistics, namely, pitching, catching and fielding statistics.

3.9.2.1 Pitching Statistics

The pitching statistics has mostly been explained above as it is the same for the batting statistics, except that the pitching statistic is defensive and the batting statistic is offensive and every time a batter is successful, it means that the pitcher has failed in his number one

goal of keeping hits and runs to a minimum. In the pitching analysis it will show the total number of pitches thrown by the pitcher in the game (TP) as well as the total number of balls (B) and strikes (S). Pitching statistics will also show the number of batters the pitcher pitched to or how many batters faced (BF), the number of frames or innings he pitched (IPT), the number of wild pitches (WP) he threw, as well as the number of illegal pitches (IP) in the game. A very important indicator of the pitcher's performance are the number of earned runs (ER) the opposition got, which indicate the runs scored as a result of safe batting and not walks, wild pitches or being hit by pitched balls.

3.9.2.2 Catching Statistics

The analysis of catching is the simplest as the catcher doesn't really field batted balls except on occasions when a batter hits a foul tip or bats badly and the ball goes straight up in the air and sometimes backward into foul territory. The catcher must catch pitched balls with the batter in the box, so the number of batters the catcher catches for, is the same as the batters the pitcher pitches to and is indicated as the batters faced (BF). When the catcher misses pitched balls or plays to home plate, it is recorded as a passed ball (PB) and runners on base advance. The final statistic for the catcher is an obstruction (OBS) which occurs when a batter gets to first base as a result of taking a swing at a pitched ball and during the swing his bat makes contact with the catcher's mitt.

3.9.2.3 Fielding Statistics

The analysis of the fielding statistics will show the position (POS) played, e.g. POS1 would be the pitcher; the number of innings played in a particular position (IPL); whenever the

fielder gets the batter or base runner put out (PO); whenever the fielder assists (A) with a PO; any error (E) the fielder may make and errors are always indicated in red.

Statistics also show when the player makes a double or triple play (DP / TP) when 2 or more players are put out in a single play and is recorded with the fielding players involved. When the fielder assists with a PO, e.g. by throwing the ball to another base to retire a runner the fielder is credited with an assist. In the case of a hotbox, which is where the base runner is between two bases and the fielding side has the ball, one of the fielding players needs to tag the runner before he gets to a base for a PO to be credited. All players in the hotbox situation are credited with one assist (A) irrespective of how many times they touch the ball.

3.10 Data Analyses

As the data does not have a normal distribution, the analysis will make use of the Spearman's Rank Correlation and what is important to note is that the Spearman's Rank Correlation does not provide any information regarding the strength of a relationship. It only wants to establish whether the null hypothesis can be accepted or rejected. Even when the correlation coefficient is statistically significant it does not mean that cause can be inferred, but rather that a strong association may be inferred. Correlation is a special form of descriptive statistics which determines the presence of a relationship as well as its nature (Estep, 2013).

Scatter plots of some pairs of variables are provided to give a visual idea about the strength of the correlation. Descriptive statistics (mean, median, standard deviation) are also given.

The Provincial and club squads were compared on 24 measures. Since the distributions of the response variables may not be normal, the comparisons of the squads were done using the nonparametric Wilcoxon Rank Sum test. A more stringent level of 0.01 was set as so many tests are being done. An alternative approach is to control the 'false discovery rate' at 0.05 (Benjami & Hochberg, 1995). The false discovery rate controls for multiple testing that is not as conservative as using a Bonferroni adjustment which is the commonly used method of adjustment.

CHAPTER 4

RESULTS

4.1 Introduction

This study set out to assess the morphological, fitness, skill and performance characteristics of men's fast pitch softball players and to investigate possible associations between fitness, morphological and skills characteristics on the one hand and performance levels on the other. It further set out to compare Provincial players with club players to establish whether differences in performance were also reflected in their differences in anthropometry, fitness and skill levels.

Different positions vary with regard to demands on the above characteristics. However, the sample did not warrant for an investigation of positional variances and only "body fat percentage" and BMI were analysed by position. The descriptive statistics for morphology, fitness, skills and performance are illustrated in Tables 1 - 3.

4.2 Descriptive Statistics

Table 1 Descriptive statistics of the morphological characteristics of men's fast pitch softball players

	N	Minimum	Maximum	Mean	Standard Deviation
Height (cm)	30	156,0	183,0	169,0	0.07383
Weight (kg)	30	41.90	98.00	65.3667	14.82738
Body fat %	30	12.36	27.93	19.7220	4.67569

Although the mean weight was found to be 65.3 kg, the weight range was 57.9 kg. This brought about a very high standard deviation.

Table 2 Descriptive statistics of the morphological and fitness characteristics of men's fast pitch softball players

	N	Minimum	Maximum	Mean	Standard Deviation
Vertical jump	30	39.00	68.00	52.07	7.02965
Standing broad jump	30	206.00	286.00	242.03	16.56469
Agility test	30	10.52	17.92	13.53	2.14427
Base running test	30	5.27	6.77	6.03	.32625
Throw for distance test	30	40.55	58.43	50.87	5.30471
Batting test	30	6.00	32.00	20.33	8.32666
Fielding test	30	10.00	24.00	17.33	3.63255

Table 3 Descriptive statistics of the performance characteristics of men's fast pitch softball players

	N	Minimum	Maximum	Mean	Standard Deviation
Fielding average	30	.84	.98	.9218	.03793
Batting average	30	.00	.67	.2414	.12826
Total hits	28	.00	12.00	3.3929	2.77672
Stolen bases	8	1.00	2.00	1.2500	.46291
Home runs	4	1.00	2.00	1.2500	.50000

Table 4 and Figures1 – 16, illustrate the relationships between morphological, fitness, skill and performance characteristics.

4.3 Correlations

Correlations between all variables are depicted in Table 4 and all significant correlations are illustrated in Figures 1 – 32.

Table 4 Correlations between morphological, fitness, skill and performance characteristics in men's fast pitch softball players

Variable		Height	Weight	Bodyfat	BMI
Height	Correlation Coefficient	1.000	.763**	.594**	.584**
	Sig. (2 tailed)	.	.000	.001	.001
	N	30	30	30	30
Weight	Correlation Coefficient	.763**	1.000	.775**	.950**
	Sig. (2 tailed)	.000	.	.000	.000
	N	30	30	30	30
Body fat %	Correlation Coefficient	.594**	.775*	1.000	.787**
	Sig. (2 tailed)	.001	.000	.	.000
	N	30	30	30	30
BMI	Correlation Coefficient	.584**	.950**	.787**	1.000
	Sig. (2 tailed)	.001	.000	.000	.
	N	30	30	30	30
Vertical jump	Correlation Coefficient	-.428*	-.283	-.427*	-.201
	Sig. (2 tailed)	.018	.129	.019	.286
	N	30	30	30	30
St broad jump	Correlation Coefficient	-.040	-.024	-.264	-.041
	Sig. (2 tailed)	.835	.898	.159	.828
	N	30	30	30	30
Agility	Correlation Coefficient	-.610**	-.534**	-.356	-.454
	Sig. (2 tailed)	.000	.002	.054	.012
	N	30	30	30	30
Baseruns	Correlation Coefficient	.229	.188	.402*	.143
	Sig. (2 tailed)	.223	.320	.028	.449
	N	30	30	30	30
Throw4Distance	Correlation Coefficient	.335	.244	-.012	.187
	Sig. (2 tailed)	.070	.194	.949	.324
	N	30	30	30	30
Batting test	Correlation Coefficient	.618**	.560**	.481**	.404*
	Sig. (2 tailed)	.000	.001	.007	.027
	N	30	30	30	30
Fielding test	Correlation Coefficient	.008	.329	.292	.406*
	Sig. (2 tailed)	.968	.076	.117	.026
	N	30	30	30	30
Fielding average	Correlation Coefficient	.159	.324	.436*	.389*
	Sig. (2 tailed)	.401	.081	.016	.034
	N	30	30	30	30

Table 4 Continue

Spearman's rho		Vertical jump	St broad jump	Agility	Base Runs	Throw4 Distance	Batting test	Fielding test
Height	Correlation Coefficient	-.428*	-.040	-.610**	.229	.335	.618**	.008
	Sig. (2 tailed)	.018	.835	.000	.223	.070	.000	.968
	N	30	30	30	30	30	30	30
Weight	Correlation Coefficient	-.283	-.024	-.534**	.188	.244	.560**	.329
	Sig. (2 tailed)	.129	.898	.002	.320	.194	.001	.076
	N	30	30	30	30	30	30	30
Body fat %	Correlation Coefficient	-.427*	-.264	-.356	.402*	-.012	.481**	.292
	Sig. (2 tailed)	.019	.159	.054	.028	.949	.007	.117
	N	30	30	30	30	30	30	30
BMI	Correlation Coefficient	-.201	-.041	-.454	.143	.187	.404*	.406*
	Sig. (2 tailed)	.286	.828	.012	.449	.324	.027	.026
	N	30	30	30	30	30	30	30
Vertical jump	Correlation Coefficient	1.000	.414*	.394*	-.681**	-.279	-.279	.201
	Sig. (2 tailed)	.	.023	.031	.000	.136	.136	.287
	N	30	30	30	30	30	30	30
St broad jump	Correlation Coefficient	.414*	1.000	.071	-.256	.004	.004	.000
	Sig. (2 tailed)	.023	.	.710	.172	.982	.982	.999
	N	30	30	30	30	30	30	30
Agility	Correlation Coefficient	.394*	.071	1.000	-.208	-.269	-.269	-.098
	Sig. (2 tailed)	.031	.710	.	.269	.150	.150	.606
	N	30	30	30	30	30	30	30
Baseruns	Correlation Coefficient	-.681	-.256	-.208	1.000	-.023	-.023	-.214
	Sig. (2 tailed)	.000	.172	.269	.	.903	.903	.256
	N	30	30	30	30	30	30	30
Throw4Distance	Correlation Coefficient	-.279	.004	-.269	-.023	1.000	1.000	-.094
	Sig. (2 tailed)	.136	.982	.150	.903	.	.	.623
	N	30	30	30	30	30	30	30
Batting test	Correlation Coefficient	-.320	-.022	-.536**	.326	-.022	-.022	.055
	Sig. (2 tailed)	.085	.908	.002	.079	.907	.907	.771
	N	30	30	30	30	30	30	30
Fielding test	Correlation Coefficient	.201	.000	-.098	-.214	-.904	-.094	1.000
	Sig. (2 tailed)	.287	.999	.606	.256	.623	.623	.
	N	30	30	30	30	30	30	30
Fielding average Coefficient	Correlation	-.225	-.106	-.153	.245	-.222	.273	-.030
	Sig. (2 tailed)	.231	.576	.419	.192	.239	.144	.875
	N	30	30	30	30	30	30	30

Table 4 Continue

Spearman's rho		Fielding average	Batting average	Total hits	Stolen bases	Home runs
Height	Correlation Coefficient	.159	.439*	.335	.191	.775
	Sig. (2 tailed)	.401	.015	.081	.650	.225
	N	30	30	28	8	4
Weight	Correlation Coefficient	.324	.330	.197	.000	.775
	Sig. (2 tailed)	.081	.075	.315	1.000	.225
	N	30	30	28	8	4
Body fat %	Correlation Coefficient	.436*	.140	-.029	-.252	.258
	Sig. (2 tailed)	.016	.459	.884	.547	.742
	N	30	30	28	8	4
BMI	Correlation Coefficient	.389*	.217	.135	-.126	.755
	Sig. (2 tailed)	.034	.250	.493	.766	.225
	N	30	30	28	8	4
Vertical jump	Correlation Coefficient	-.225	.161	-.120	.063	-.544
	Sig. (2 tailed)	.231	.396	.543	.881	.456
	N	30	30	28	8	4
St broad jump	Correlation Coefficient	-.106	.158	.121	.504	-.775
	Sig. (2 tailed)	.576	.403	.540	.203	.225
	N	30	30	28	8	4
Agility	Correlation Coefficient	-.153	-.459*	-.293	-.630	-.775
	Sig. (2 tailed)	.419	.011	.131	.094	.225
	N	30	30	28	8	4
Baseruns	Correlation Coefficient	.245	-.130	-.045	-.063	-.258
	Sig. (2 tailed)	.192	.495	.818	.881	.742
	N	30	30	28	8	4
Throw4Distance	Correlation Coefficient	-.222	-.054	.313	.446	.258
	Sig. (2 tailed)	.239	.775	.105	.268	.742
	N	30	30	28	8	4
Batting test	Correlation Coefficient	.273	.541**	.021	.253	.258
	Sig. (2 tailed)	.144	.002	.917	.545	.742
	N	30	30	28	8	4
Fielding test	Correlation Coefficient	-.030	.386*	.005	-.191	.816
	Sig. (2 tailed)	.875	.035	.979	.650	.184
	N	30	30	28	8	4
Fielding average	Correlation Coefficient	1.000	-.041	-.166	.000	-.258
	Sig. (2 tailed)	.	.828	.399	1.000	.742
	N	30	30	28	8	4

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

4.4 Interaction between Morphology, Fitness, Skill and Softball Performance

4.4.1 Morphology

Body fat exhibited a strong positive relationship with weight (r = .775) and height (r = .775) (Figures 1 & 2). Height and vertical jump have a moderate negative relationship, r = - .428. Weight also negatively correlated with jumping ability. However, this relationship was not found to be significant.

The relationship between body fat percentage and vertical jump (Figure 10) was also found to be moderately negative (r = - .427). Body fat appears to have a negative impact on vertical jump height performance. The relationship between the distance achieved in the batting test and the height (Figure 5) was high with a correlation coefficient of .618.

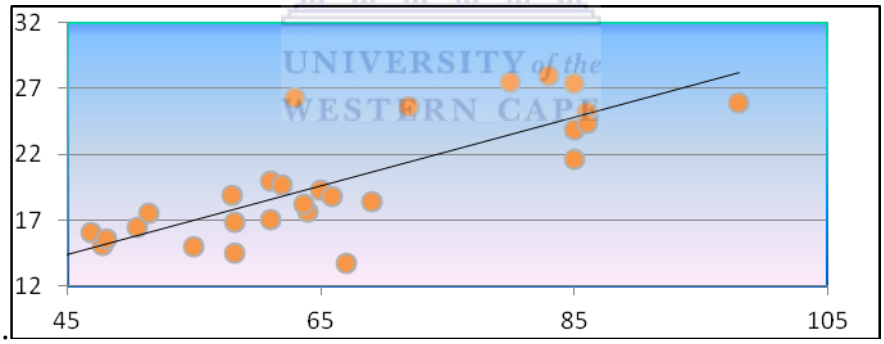


Figure 1 Relationship between weight and body fat percentage

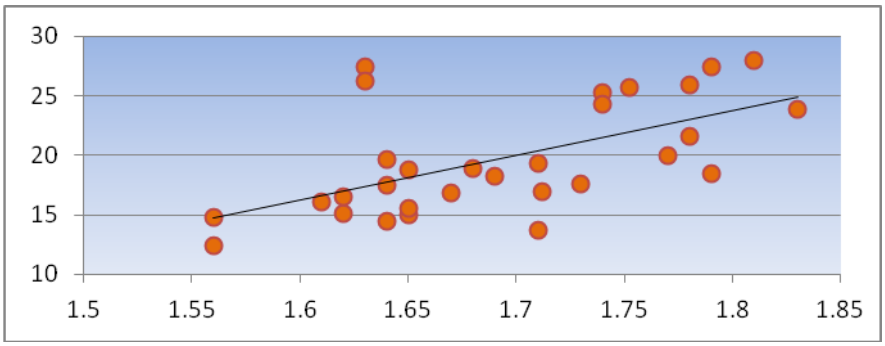


Figure 2 Relationship between height and body fat percentage

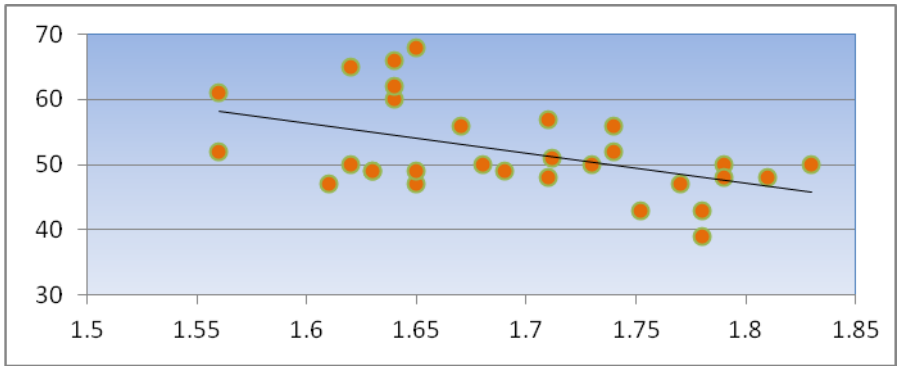


Figure 3 Relationship between height and the vertical jump test

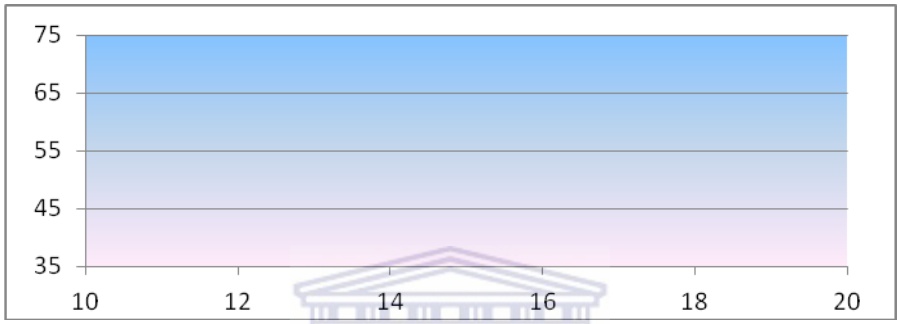


Figure 4 Relationship between body fat percentage and the vertical jump test

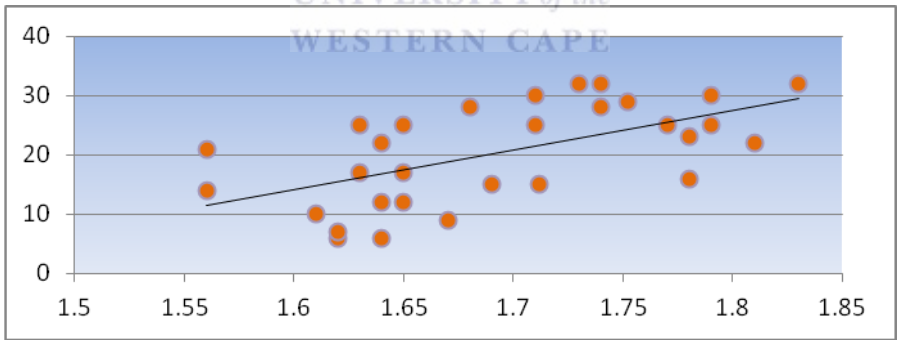


Figure 5 Relationship between height and batting test

4.4.2 Fitness

Figure 6 illustrates the strong negative relationship between base running and vertical jumping (r = - .681). The relationship between the standing broad jump and base running test was found to be small and negative but not significant. (Whenever a test has time as a

variable and speed is being measured, the lower the time, the better the result and this results in graphs that are negative but are positive in terms of results). A negative moderate relationship was found between body weight and agility (r = -.534) (Figure 7).

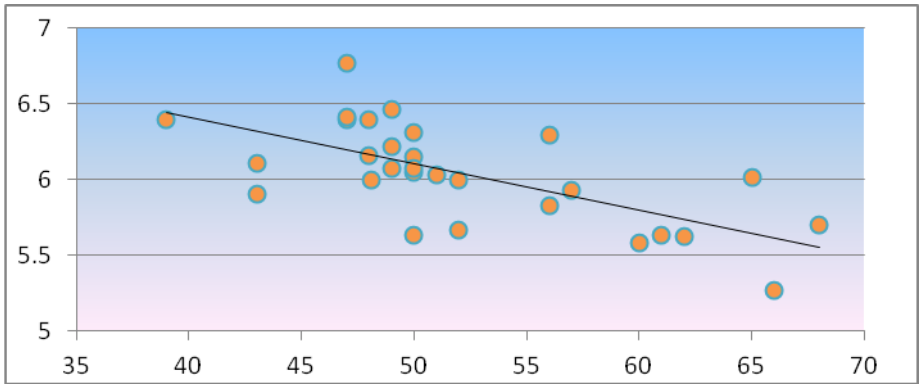


Figure 6 Relationship between the base running test and vertical jump test

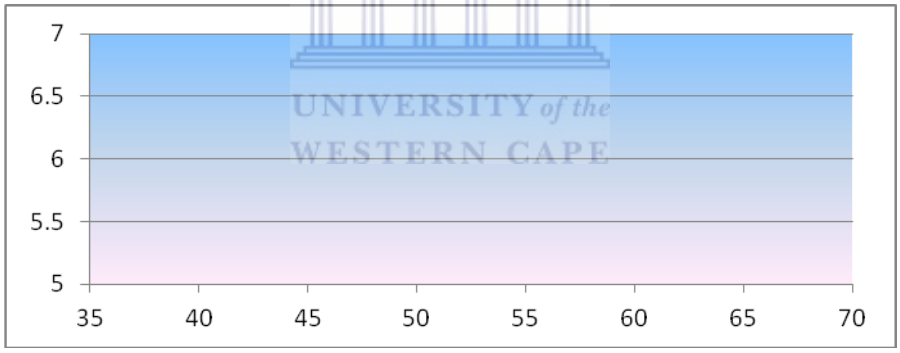


Figure 7 Relationship between weight and agility

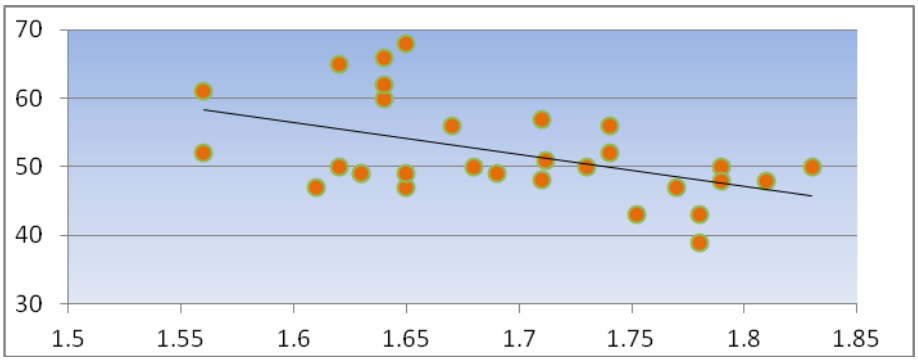


Figure 8 Relationship between height and vertical jump

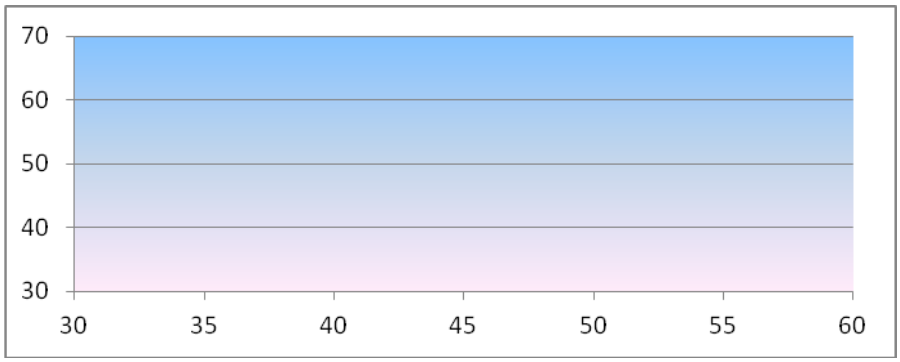


Figure 9 The relationship between weight and the vertical jump

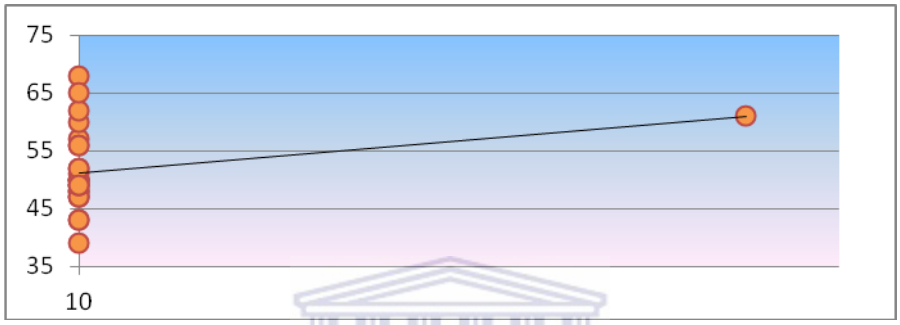


Figure 10 Relationship between body fat percentage and vertical jump test

4.5 Comparison of Body Fat Percentage and BMI of Players in Different Positions

Table 5 Body Fat Percentage and BMI by Position

Observation	Position	Mean_bf	Median_bf	Mean_BMI	Median_BMI
1	Infield	17.08	15.55	20.84	21.38
2	Outfield	19.74	19.21	22.82	21.17
3	First base	20.73	18.21	23.80	22.30
4	Catcher	21.05	20.37	24.08	23.13
5	Pitcher	21.06	19.12	22.37	22.97

The players in the infield have the lowest body fat percentages and BMIs and this agrees with their requirement of being quick, agile players, capable of quick lateral movement.

Table 6 The Means Procedure – Body fat Percentage and BMI by position

Position	Obs	Variable	N	Mean	Median	Std Dev	Min	Max
Pitcher	6	bf	6	21.06	19.12	4.95	15.09	27.93
		bmi	6	22.37	22.97	2.63	18.21	25.34
Catcher	4	bf	4	21.05	20.37	5.52	16.04	27.41
		bmi	4	24.08	23.13	6.07	18.09	32.00
First base	5	bf	5	20.73	18.21	5.65	14.51	27.50
		bmi	5	23.80	22.30	4.50	19.11	30.93
Other infield	7	bf	7	17.08	15.55	4.49	12.36	25.66
		bmi	7	20.84	21.38	2.57	17.21	23.46
Outfield	8	bf	8	19.74	19.21	3.77	14.76	25.27
		bmi	8	22.82	21.17	4.35	17.87	28.41

The players in the infield have the lowest body fat percentages and BMIs. However, even though the pitcher and catcher also form part of the infield, their fielding and positional requirements are different to the other infielders requirements.

4.6 Comparison Between Club Players and Provincial Players

Tables 5 and 6 give the descriptive statistics for the 24 variables for the club players and Provincial players separately. Table 7 gives the Rank Sum for each variable. The last column of this table gives the unadjusted p – value. Table 8 orders the results by p - value and gives the fdr (false discovery rate) adjusted values as well. The results show the club players are younger, shorter, lighter in weight, more agile and better in the vertical jump. However, the Provincial squad performed better on the batting test and had a better batting average. There were no significant differences in the fielding tests or the fielding average.

Table 7 The Means Procedure: Descriptive Statistics for the Club team

Obs	Variable	N	Mean	Median	StdDev	Minimum	Maximum
15	age	15	15.67	15.00	2.50	14.00	21.00
	ht	15	1.64	1.64	0.06	1.56	1.77
	wt	15	56.53	58.20	11.31	41.90	86.00
	bi	15	5.84	4.80	2.29	3.80	10.00
	tri	15	10.53	8.80	5.01	5.60	24.00
	subscap	15	11.53	8.60	8.79	4.80	37.00
	supra	15	9.52	6.20	7.66	4.40	31.00
	ab	11	15.15	10.80	8.39	7.10	30.00
	thi	11	19.85	17.60	7.03	10.80	35.00
	calf	11	11.18	11.00	2.32	7.20	15.60
	total	10	96.97	79.30	44.50	54.10	165.00
	bf	15	17.76	16.83	3.70	12.36	26.27
	bf_kg	15	10.34	9.02	4.14	5.18	20.91
	lbm kg	15	46.18	46.45	7.53	36.72	65.09
	vert jump	15	55.53	52.00	7.44	47.00	68.00
	st_br jump	15	244.67	241.00	15.73	224.00	286.00
	agility	15	15.05	15.57	1.77	11.60	17.92
	baserun	14	5.91	5.91	0.39	5.27	6.77
	throw4dist	15	50.22	51.20	5.74	40.55	58.43
	batting	15	15.00	14.00	7.50	6.00	32.00
	fielding	15	17.00	18.00	4.05	10.00	23.00
	field_avg	15	0.91	0.91	0.04	0.84	0.98
	bat_avg	15	0.18	0.17	0.08	0.00	0.33
	bmi	15	20.73	19.47	3.14	17.22	28.41

Table 8 The Means Procedure: Descriptive Statistics for the Provincial team

Obs	Variable	N	Mean	Median	StdDev	Minimum	Maximum
15	age	15	24.60	25.00	5.42	14.00	35.00
	ht	15	1.73	1.74	0.06	1.63	1.83
	wt	15	74.20	72.00	12.66	55.00	98.00
	bi	15	9.13	8.00	5.28	4.00	24.00
	tri	15	16.73	17.00	5.47	6.00	26.00
	subscap	15	19.60	18.00	7.79	10.00	35.00
	supra	15	20.06	21.00	11.57	6.00	37.00
	ab	14	24.21	22.50	13.71	7.00	46.00
	thi	14	21.14	21.50	9.05	9.00	40.00
	calf	14	11.21	10.00	5.16	5.00	22.00
	total	14	121.00	114.50	51.59	54.00	208.00
	bf	15	21.68	21.65	4.84	13.71	27.93
	bf_kg	15	16.54	18.40	5.95	8.26	25.39
	lbm kg	15	57.65	57.81	7.41	46.74	72.61
	vert jump	15	48.60	49.00	4.61	39.00	57.00
	st_br jump	15	239.39	240.00	17.49	206.00	269.00
	agility	15	12.02	11.82	1.21	10.52	14.07
	baserun	15	6.14	6.15	0.23	5.63	6.46
	throw4dist	15	51.52	52.00	4.94	41.68	58.43
	batting	15	25.67	25.00	5.13	15.00	32.00
	fielding	15	17.67	18.00	3.27	12.00	24.00
	field_avg	14	0.93	0.92	0.03	0.87	0.98
	bat_avg	14	0.30	0.29	0.14	0.12	0.67
	bmi	15	24.46	23.46	3.73	20.20	32.00

Table 9 The Rank Sum of each variable

obs	variable	Name1	Pvalue1
10	age	PT2_WIL	0.0004
20	ht	PT2_WIL	0.0016
30	wt	PT2_WIL	0.0030
40	bi	PT2_WIL	0.0873
50	tri	PT2_WIL	0.0073
60	Subscap	PT2_WIL	0.0041
70	Supra	PT2_WIL	0.0059
80	Ab	PT2_WIL	0.1662
90	Thi	PT2_WIL	0.7046
100	Calf	PT2_WIL	0.6838
110	Total	PT2_WIL	0.3161
120	Bf	PT2_WIL	0.0361
130	Bf_kg	PT2_WIL	0.0070
140	Lbm_kg	PT2_WIL	0.0018
150	Vert_jump	PT2_WIL	0.0268
160	St_br_jump	PT2_WIL	0.4486
170	Agility	PT2_WIL	0.0008
180	Baserun	PT2_WIL	0.0678
190	Throw4dist	PT2_WIL	0.6365
200	Batting	PT2_WIL	0.0017
210	Fielding	PT2_WIL	0.7568
220	Field-avg	PT2_WIL	0.2845
230	Bat_avg	PT2_WIL	0.0146
240	bmi	PT2_WIL	0.0148

Table 10 The SAS System: representing the p - values and false discovery rate

obs	variable	Name1	cValue1	Raw_p	Bon_p	Fdr_p
1	age	PT2_WIL	0.0004	0.000439	0.01055	0.00850
2	agility	PT2_WIL	0.0008	0.000821	0.01970	0.00850
3	ht	PT2_WIL	0.0016	0.001565	0.03756	0.00850
4	Batting	PT2_WIL	0.0017	0.001717	0.04121	0.00850
5	Lbm_kg	PT2_WIL	0.0018	0.001772	0.04252	0.00850
6	Wt	PT2_WIL	0.0030	0.003012	0.07230	0.01205
7	subscap	PT2_WIL	0.0041	0.004130	0.09911	0.01416
8	supra	PT2_WIL	0.0059	0.005916	0.14199	0.01758
9	Bf_kg	PT2_WIL	0.0070	0.006986	0.16768	0.01758
10	tri	PT2_WIL	0.0073	0.007323	0.17576	0.01758
11	bat_avg	PT2_WIL	0.0146	0.014595	0.35028	0.02953
12	bmi	PT2_WIL	0.0148	0.014767	0.35440	0.02953
13	vert_jump	PT2_WIL	0.0268	0.026813	0.64350	0.04650
14	bf	PT2_WIL	0.0361	0.036057	0.86536	0.06181
15	baserun	PT2_WIL	0.0678	0.067758	1.00000	0.10841
16	bi	PT2_WIL	0.0873	0.087255	1.00000	0.13088
17	ab	PT2_WIL	0.1662	0.166243	1.00000	0.23470
18	Field_avg	PT2_WIL	0.2845	0.284476	1.00000	0.37930
19	total	PT2_WIL	0.3161	0.316061	1.00000	0.39924
20	St_br_jump	PT2_WIL	0.4486	0.448630	1.00000	0.53836
21	Throw4dist	PT2_WIL	0.6365	0.636452	1.00000	0.72737
22	calf	PT2_WIL	0.6838	0.683812	1.00000	0.73519
23	thi	PT2_WIL	0.7046	0.704556	1.00000	0.73519
24	fielding	PT2_WIL				

Figures 11 - 22 below are box and whisker plots that illustrate the variables that are significantly different between the two squads.

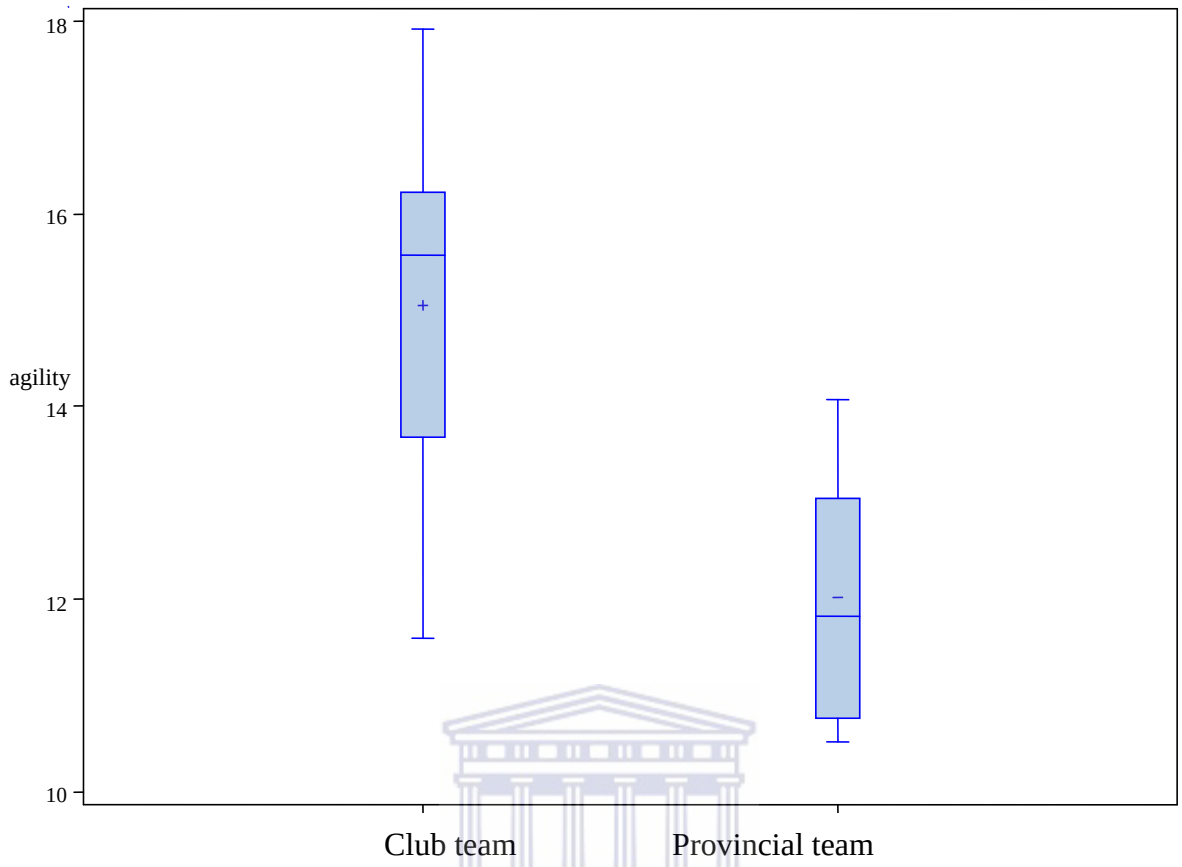


Figure 11 Comparison of the agility of the Provincial team and the club team

The club team's agility scores are weaker than the Provincial team's and range from 11.5 seconds to almost 18 seconds with players averaging 15.05 seconds while the Provincial team has a wider range starting from almost 12 seconds to over 17 seconds and an average of 12.92 seconds. This shows that the wide range of scores can be attributed to the players' specific positional requirements.

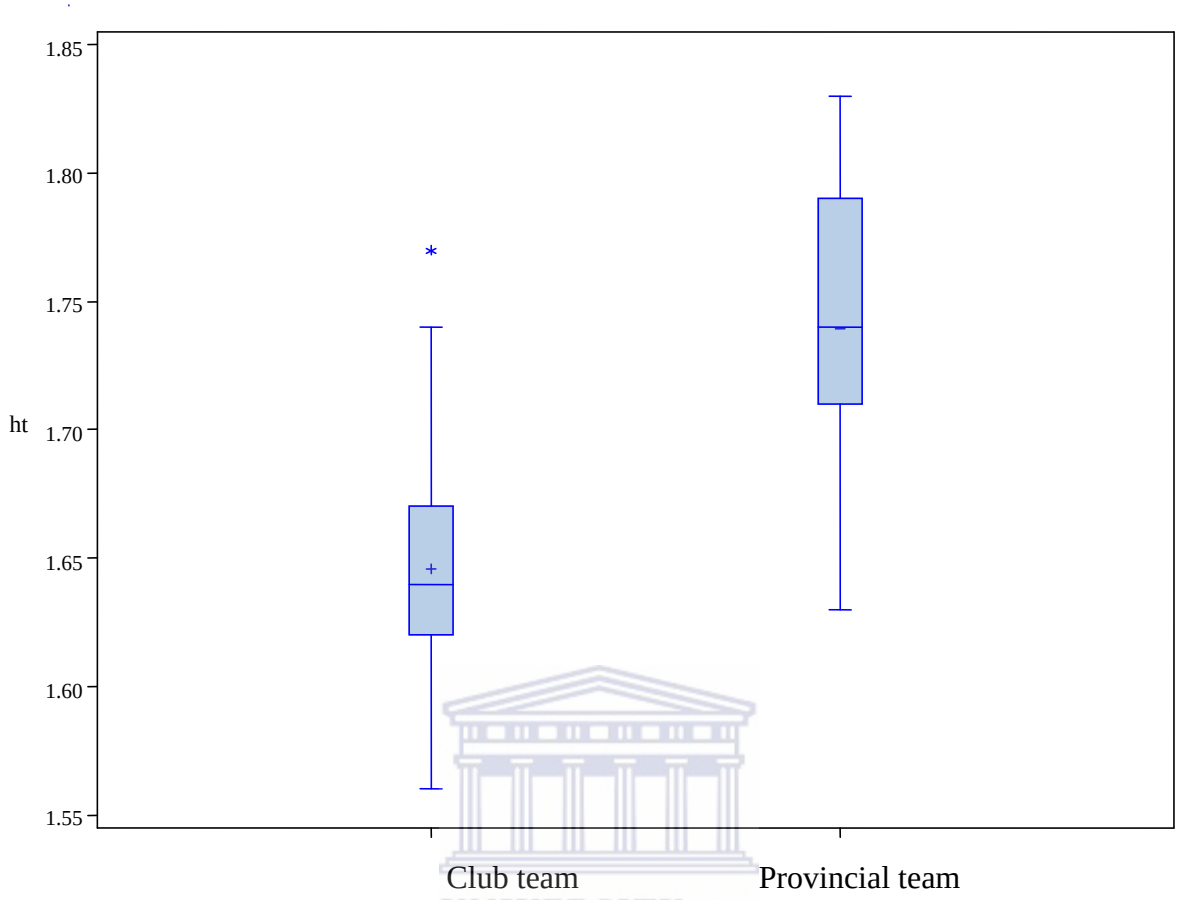


Figure 12 The height of the Provincial team compared to the club team

The club team's players are significantly shorter than the Provincial team with the shortest player being 156cm, the tallest 177cm and the average height 164cm. In the Provincial team the shortest player is 163cm and the tallest player is 183cm and the average height is 174cm.

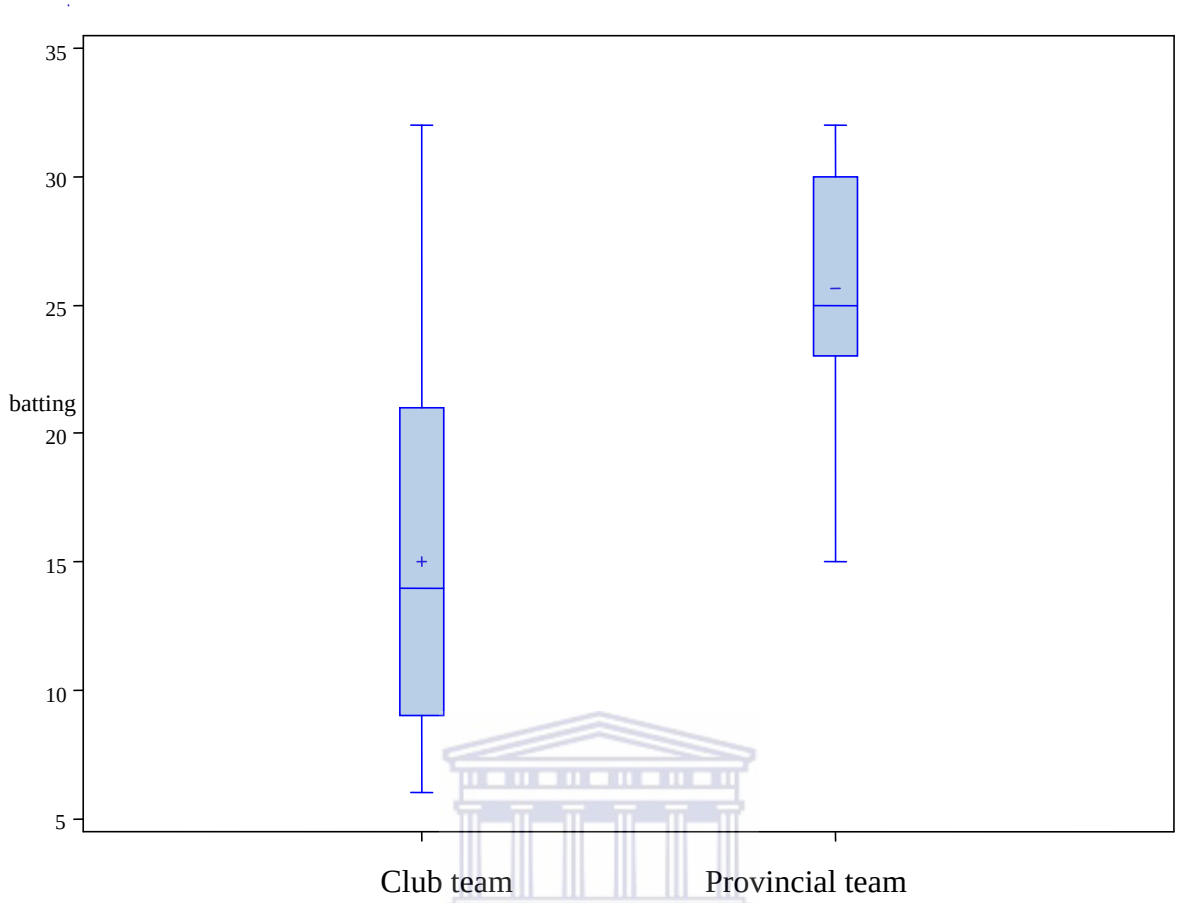


Figure 13 The batting test scores of the Provincial team compared to the club team

The Provincial team players scored much better on the batting test which is a very good indicator of batting technique, power and placement. The lowest score of 15, was the same as the club team's average. Both teams had a maximum score of 32 and the Provincial team's average was 18. It can be seen that in the club team there is a wide range of batting ability, while the Provincial team is more uniform and score in the middle to upper range of the test.

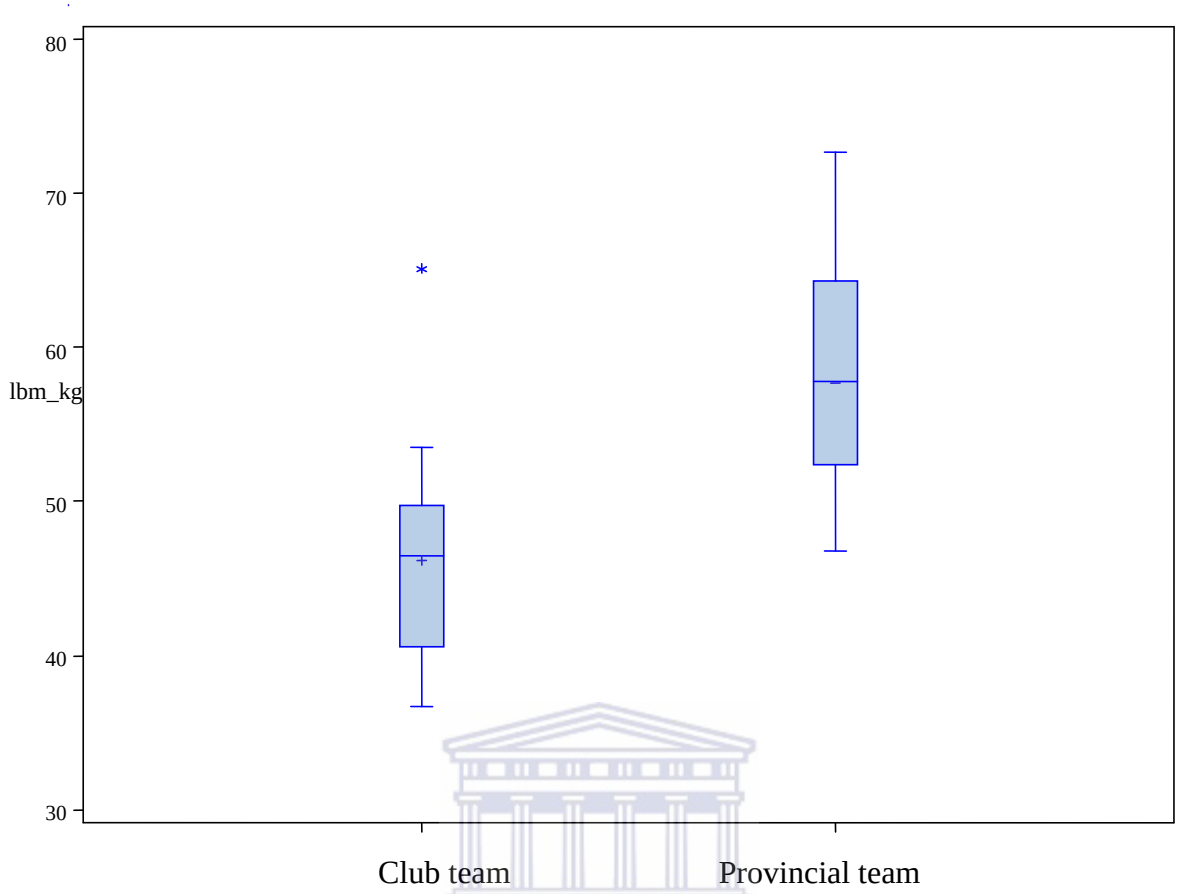


Figure 14 The lean body mass of the Provincial team compared to the club team

The previous figures have shown that the Provincial team players are taller and heavier than the club team players. These players are heavier as a result of having more muscle mass than the club team. In the club team, the lowest lean body mass is 37kg, the highest is 65kg and the average is 46kg. In the Provincial team the minimum is 46kg, the same as the club team average, while the maximum is 73kg and the average is 58kg. This indicates that the average Provincial team player has more muscle mass than the average club team player has total body mass.

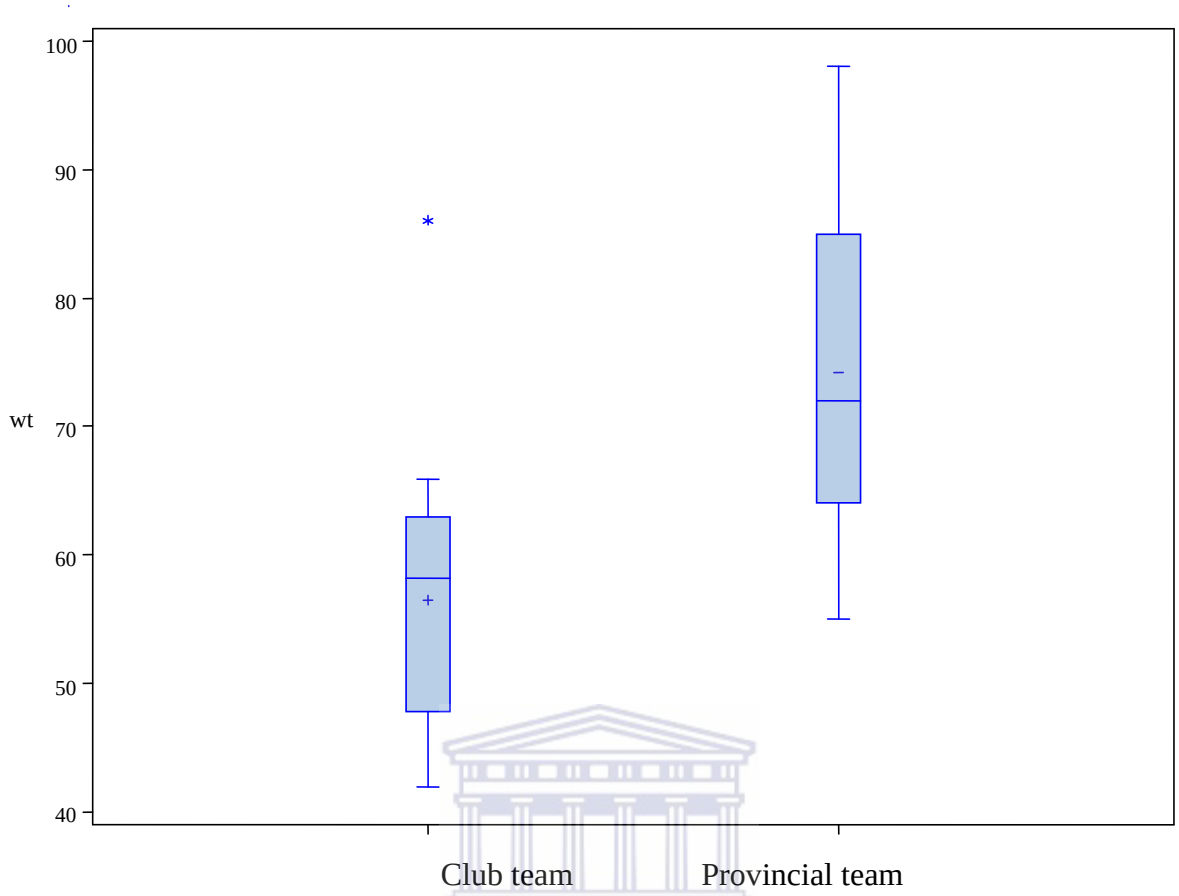


Figure 15 Comparison of the weight of the Provincial team and the club team

The lightest player in the club team weighs 42kg, the heaviest player weighs 86kg and the average weight is 57kg. The lightest player in the Provincial team weighs 55kg, just 2kg less than the club team average, while the heaviest player weighs 98kg and the team average of 74kg is heavier than all of the club team's players with the exception of the heaviest player at 86kg.

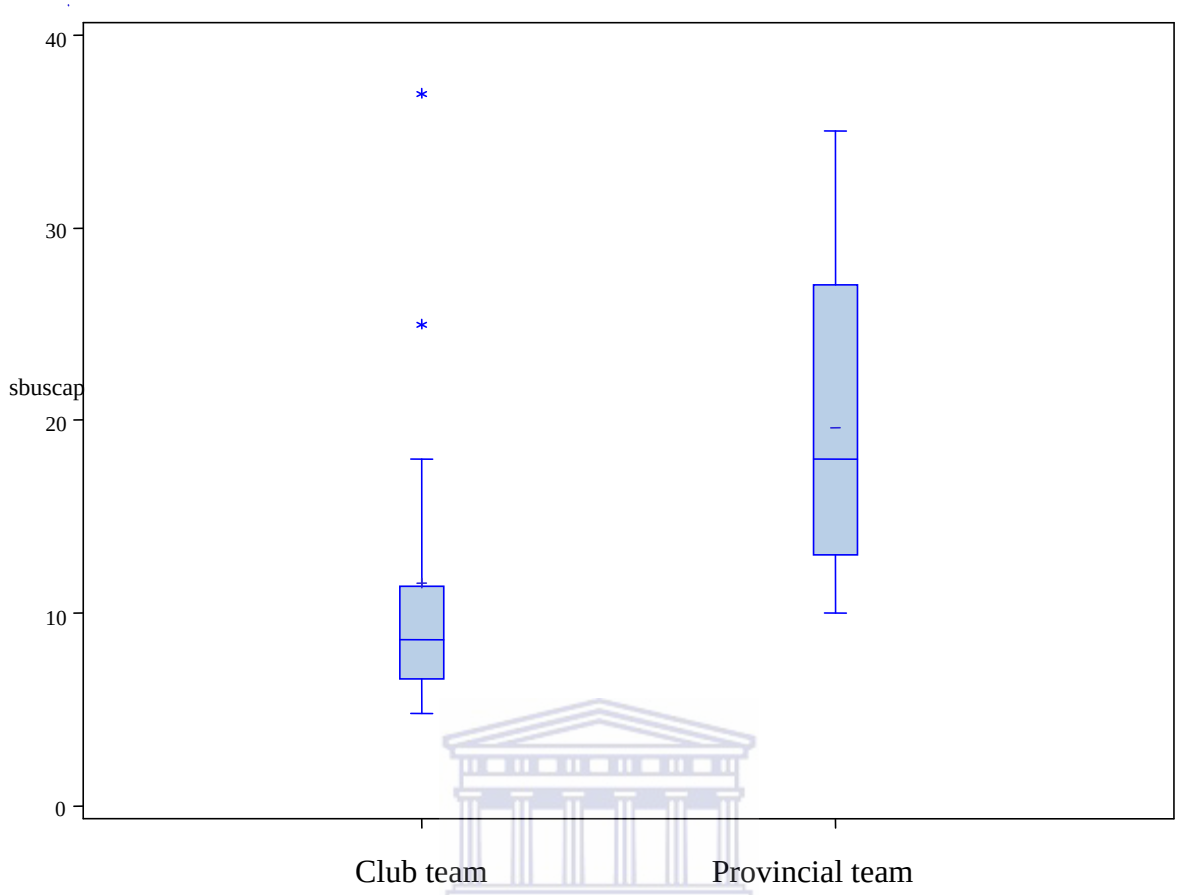


Figure 16 The thickness of the subscapular skinfold of the Provincial team compared to the club team

While the smallest (thinnest) skinfold is 5mm, and belongs to a player in the club team, the biggest (thickest) is 37mm and the average is 9mm. In the Provincial team the smallest is 10mm, the biggest is 35mm (2mm smaller than biggest in the club team) and the average is 19mm (almost twice the size of the club team's average). The skinfolds were used to calculate body fat percentage and thus the bigger the skinfold, the higher the body fat percentage. The Provincial team's players generally have bigger skinfolds and higher body fat percentages than the club team. The skinfolds are bigger on the suprailiac site on the lower abdominal region than on the subscapular skinfold on the upper back region.

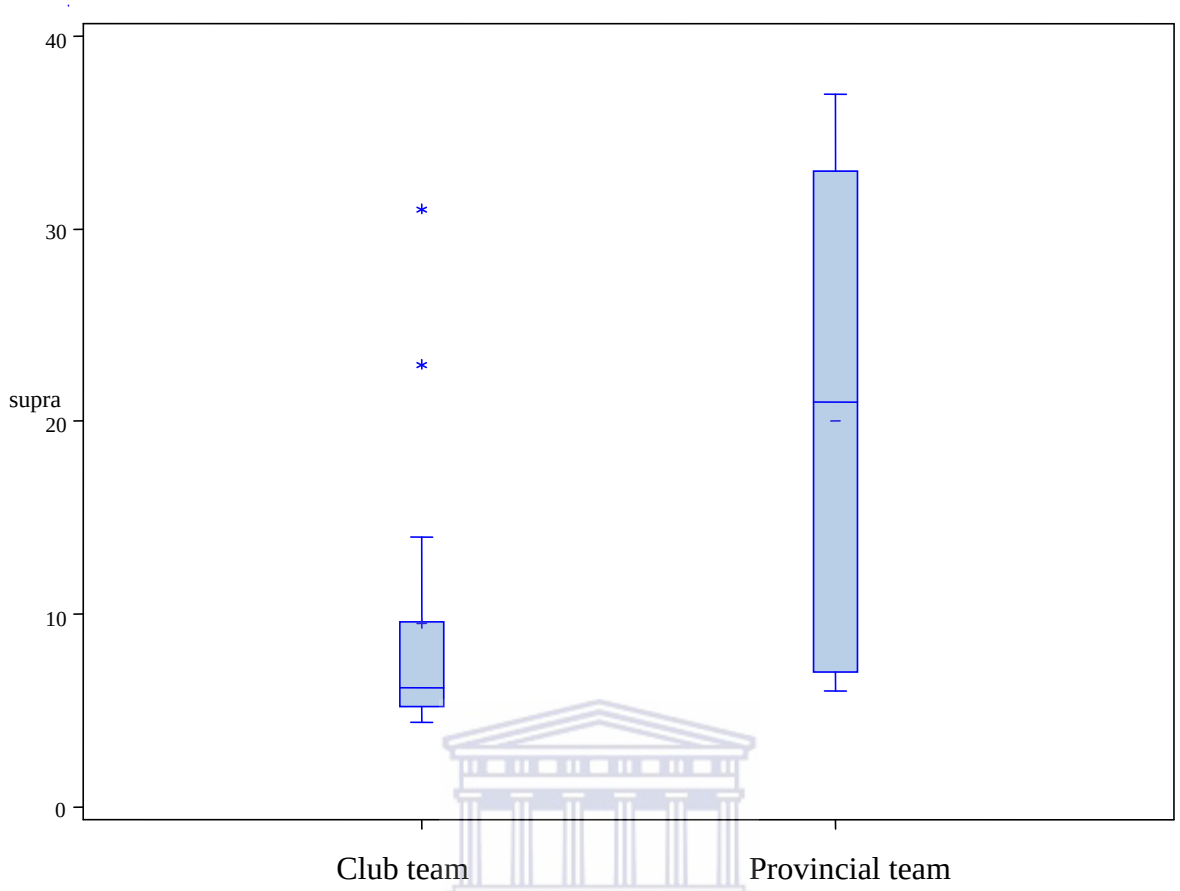


Figure 17 The thickness of the suprailiac skinfold of the Provincial team compared to the club team

The smallest (thinnest) skinfold is 4mm and belongs to a player in the club team. The club team's biggest (thickest) is 31mm and the average is 8mm. In the Provincial team the smallest skinfold is 6mm, not much bigger than the club team's smallest, while the biggest is 37mm and the average is 21mm, more than twice the size of the club team's average. The size of skinfolds can be used to calculate body fat percentage. The bigger the skinfold, the higher the body fat percentage. The Provincial team's players generally have bigger skinfolds and higher body fat percentages than the club team.

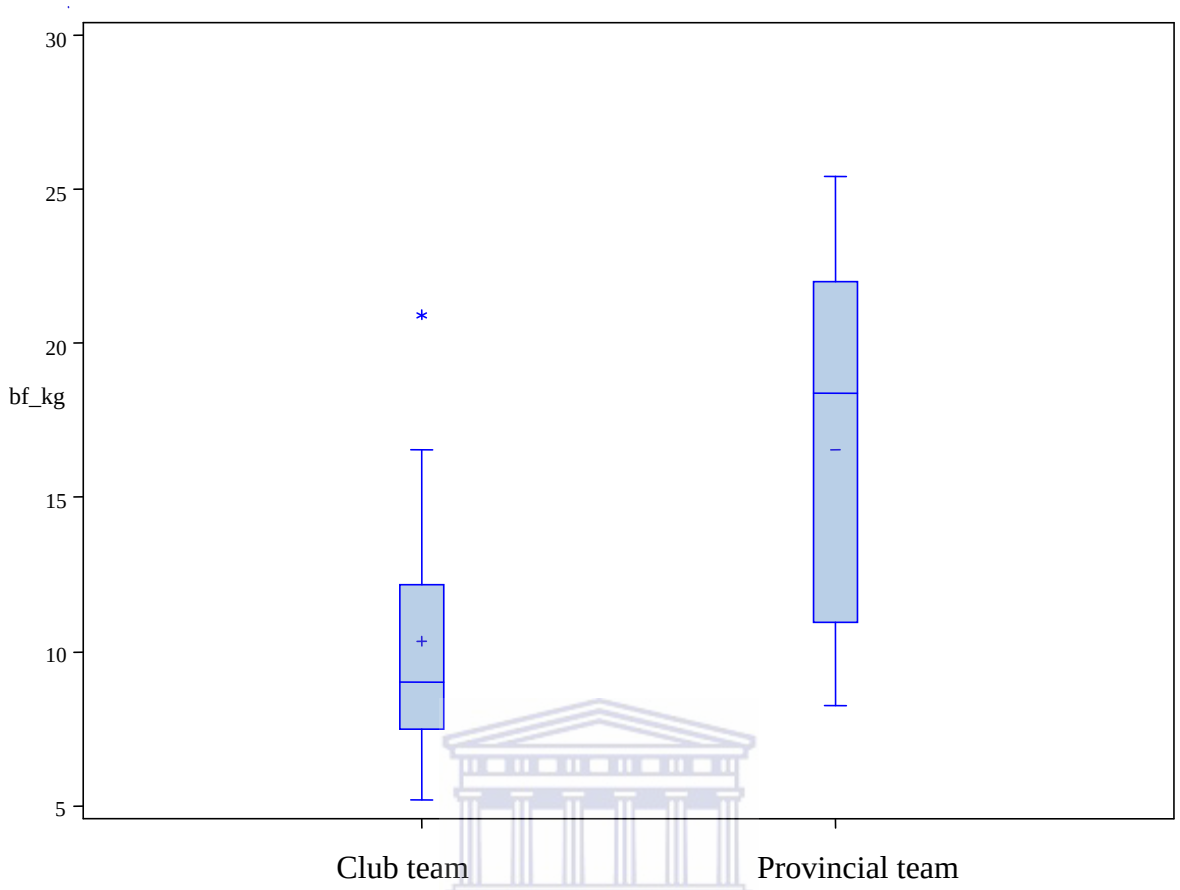


Figure 18 The absolute body fat in kilogrammes of the Provincial team compared to the club team

In the club team the least body fat is and is 5kg, the most is 21kg, the average weight is 10kg and the range is quite wide. In the Provincial team the lowest is 8kg, the heaviest is 25kg, 4kg heavier than the club team's maximum and the average is 17kg. The range in body fat percentage is wider between the teams because percentage is a proportion of body weight and as the Provincial team is heavier than the club team, the weight difference can be attributed to their bigger body size and greater muscle mass.

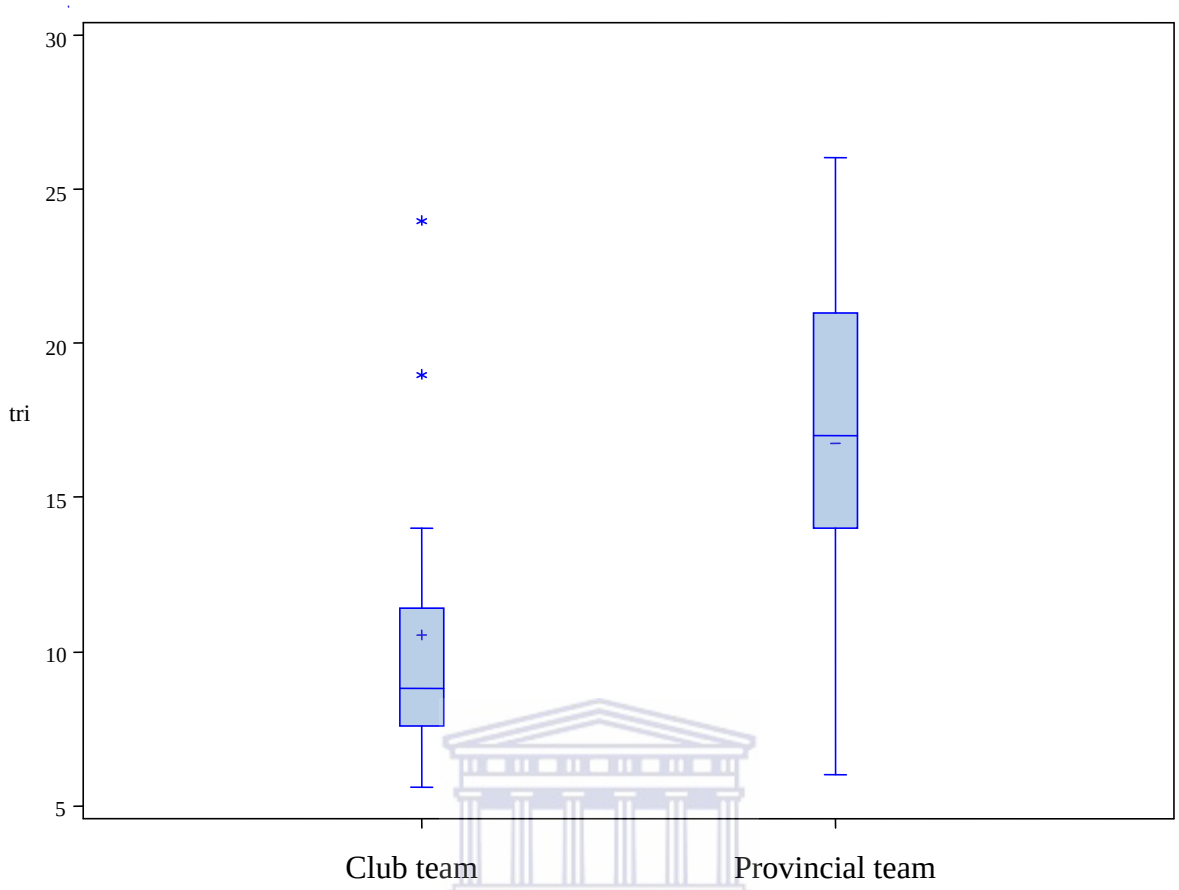


Figure 19 The thickness of the tricep skinfold of the Provincial team compared to the club team

A player in the club team has the smallest (thinnest) skinfold of 6mm, while the biggest (thickest) is 24mm and the average is 10mm. In the Provincial team the smallest is 6mm, not much bigger than the club team's smallest, while the biggest is 26mm and the average is 17mm. In the case of this skinfold located on the posterior surface of the upper arm, the minimum and maximum measures don't vary too much but the difference can be seen in the averages. The size of skinfolds can be used to calculate body fat percentage. The bigger the skinfold, the higher the body fat percentage. The first team's players generally have bigger skinfolds and higher body fat percentages than the club team.

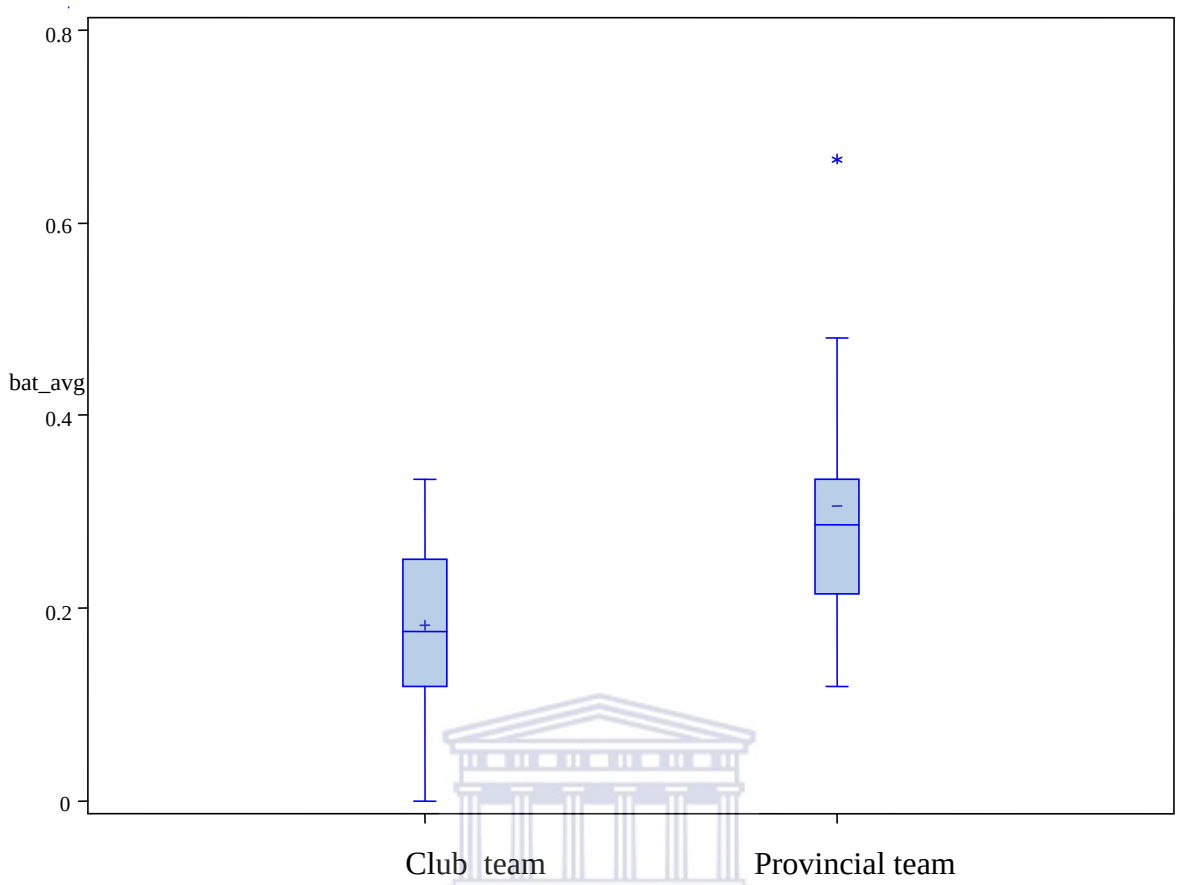


Figure 20 The batting average of the Provincial team compared to the club team

Batting average is a performance measure which gives an indication of a team's ability to score runs and therefore win games. The Provincial team outperforms the second team on this measure more significantly than on any other performance measure, e.g. fielding average.

The club team's lowest batting average was 0.0000, meaning that this particular player / s was unsuccessful at getting a single safe hit during tournament of 9 games. The maximum was 0.3330 and the average 0.1814, indicating a generally very poor result and showing the entire team to be offensively weak. A team that cannot score runs cannot be successful, regardless of how strong they are defensively in terms of pitching or fielding. In the

Provincial team the lowest batting average is 0.8680, much bigger than the club team's lowest, while the highest is 0.9800 and the average is 0.3056. This means that every player made some kind of offensive contribution and in this team some players are quite formidable batters and it appears that in a team that can score runs, weaker batters may be inspired to play above themselves and if a team can score runs they can win games.

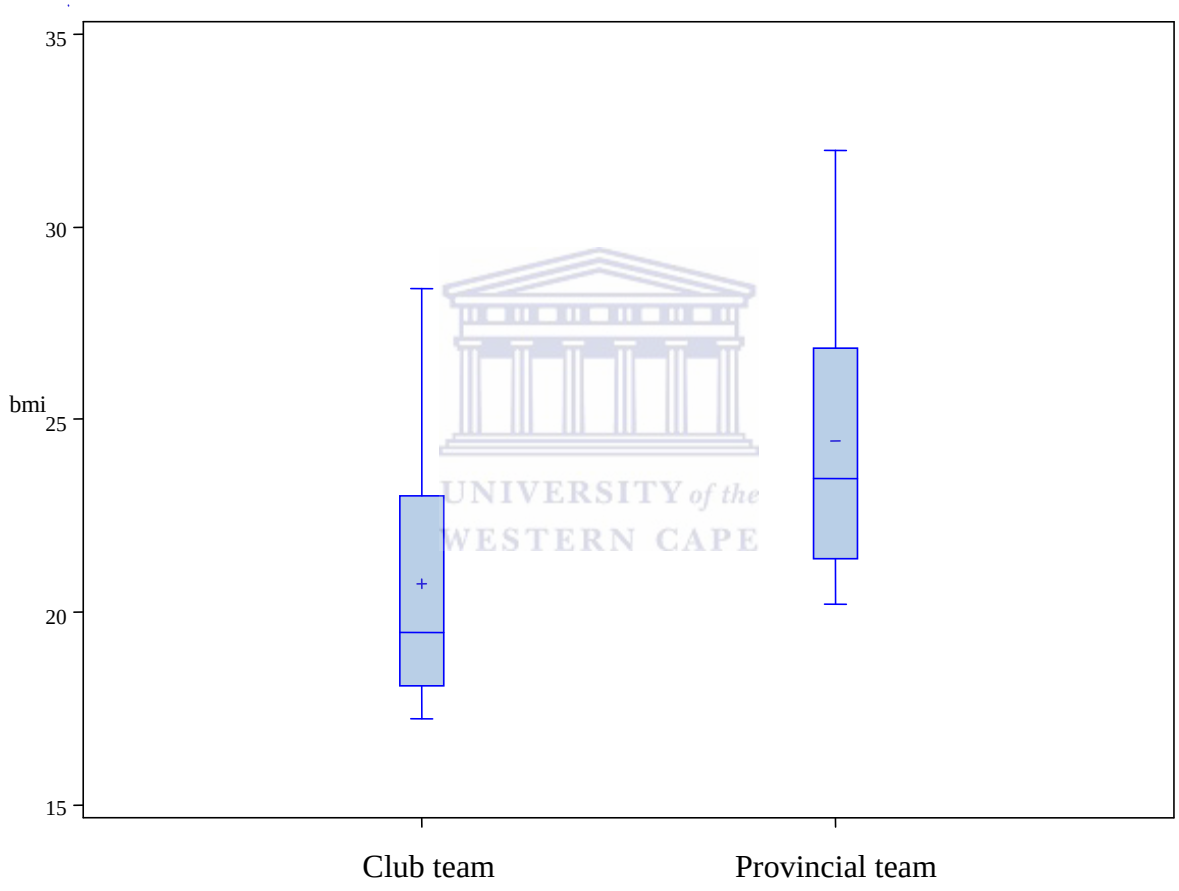


Figure 21 The body mass index of the Provincial team compared to the club team

In the club team the lowest BMI was 17 and according to the BMI categories this player was underweight while the highest was 28 and this player was classified as overweight. The average was 20 and falls within the normal range. In the Provincial team the lowest BMI was

20 and was classified as normal while the highest was 32 and classified as obese (NHLBI, 2012). The average was 24, within the upper limits of normal. From this it is evident that BMI is not a very accurate indicator of what these specific players should be weighing.

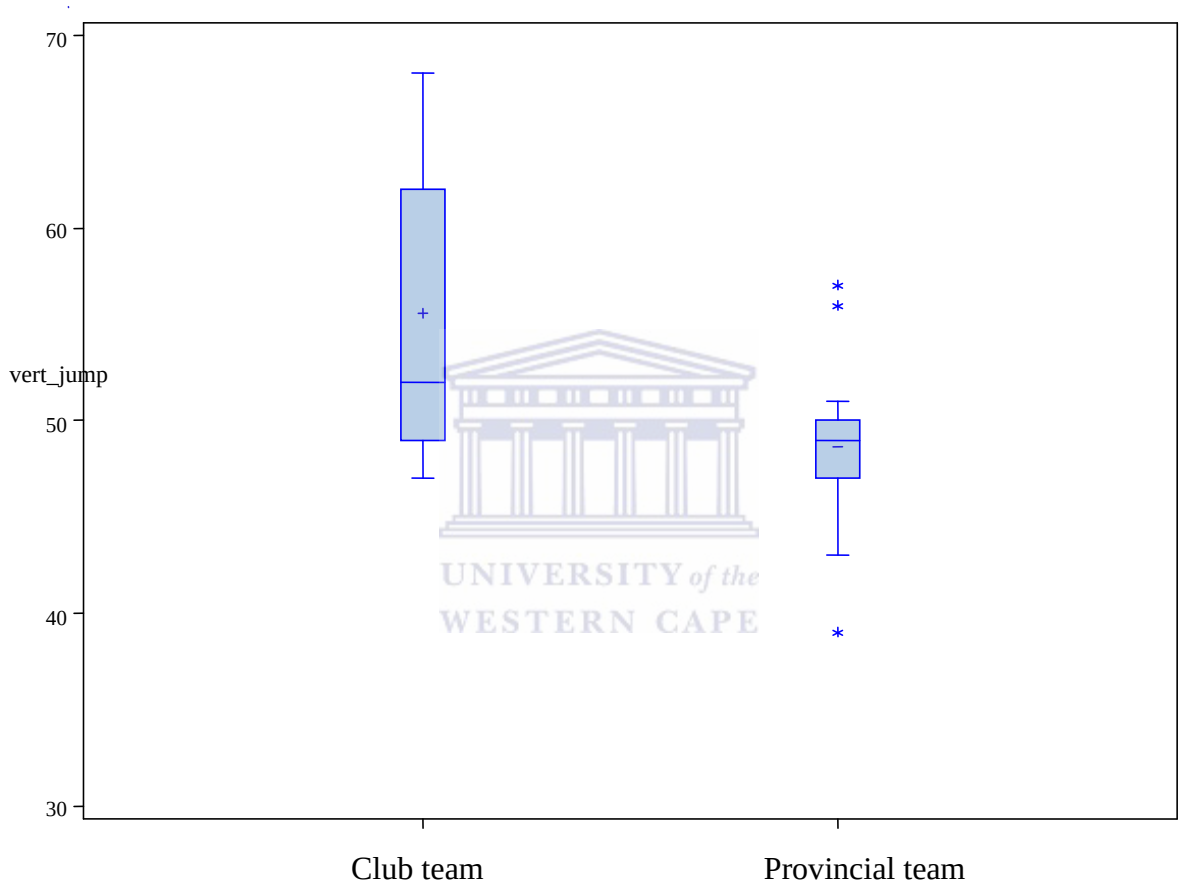


Figure 22 The vertical jump height of the Provincial team compared to the club team

As the Provincial team players are bigger, heavier, have more muscle and more fat mass, they were unable to jump as high as the club team players. In the Provincial team, the highest jump was 57cm and in the club it was 68cm, while the lowest was 39cm compared to the club team's 47cm and the averages were 48cm and 55cm respectively.

4.7 Match Statistics

In the batting test and total hits column of the match statistics, the Spearman correlation was 0.10954. The base running test and Runs / Plate Appearance had a correlation of 0.25 but this was not significantly different from zero (p = 0.1935) based on 28 pairs. The Agility test and Stolen Base / Plate Appearance had a correlation of 0.16 but this was not significantly different from zero (p = 0.4038) based on 29 pairs.

In looking at physical characteristics, there are some correlations that are significantly different from zero. The Agility test and Weight had a correlation of -0.53 which is significantly different from zero (p = 0.0024) based on 30 pairs.

When comparing Body fat percentage by dominant position (with infielders and outfielders grouped), the mean and median values are given in one output with more detail given in an additional output. Although there are some numeric differences, based on a one - way analysis of variance we found no significant difference by position. This was done for BMI as well as Body fat. P - values for the one - way analysis of variance were 0.54 and 0.66 for BMI and BF respectively.

When comparing the at bats, the Provincial team had 230 in total. The average was 15, the modes, of which there were more than one, and were fairly widely distributed, were 3, 25, 28, while the median was 14.5. The highest score was 28 and the lowest score was 2. The average and median were the most consistent, while the mode included one of the lowest values as well as one of the highest. The mode cannot be used as an adequate or true reflection. The poorest batter, as reflected in the final statistics, was the flex player, previously known as the DP or designated player, this may be as a result of playing the

fewest games, which most likely was as a result of an injury but may very well have been because his poor performance kept him out of the team. The best batter, or batters as was the case here were the right outfielder / 2nd baseman / shortstop and the first baseman / pitcher as they had the same number of at bats at 28. However, when other factors were considered, most notably home runs and runs scored, the outfield / infielder was better.

By comparison in the club team, the total number of at bats was 164 compared to the Provincial team's 230, the highest and lowest were 19 and 1 respectively. The best batter was a catcher / second baseman / shortstop and the poorest was a pitcher / right outfielder.

According to Amber and Kavekar (2005), 85% of coaches preferred multi - position players because: "the addition of depth, versatility (invaluable), flexibility; and many infielders become outfielders." The top three positions recruiters are on the lookout for are pitchers, shortstops and catchers and various reasons were given.

Amber and Kavekar (2005) further added that shortstops were often the most athletic players on the team and could play any position proficiently. According to Carvajal, et al. (2009) in a study of Cuban baseball players first baseman were the tallest and heaviest players with the highest number of bases run per hit divided by the times at bat (batting efficiency) meaning they got runs more often than not. Carvajal, et al (2009) also found that first basemen and outfielders were usually offensively strong players and had a higher batting efficiency than other players.

As previously stated, in the Provincial team: the sum was 230, the average was 15, the modes were 3, 25, 28 and the median was 14.5. In a game where the pitcher and opposition were

able to contain the batters and prevent them from scoring, this limited the number of frames they played and consequently their plate appearances and their opportunities at bat. In this particular tournament, the club team faired very poorly and there was a difference of 66 in the total number of at bats in favour of the Provincial team. The Provincial team total at bats were 230 and the club team's total was 164 which affected their other statistics negatively. The Provincial team average was 15, while the club team average was 10.25, meaning the Provincial team had almost 30% more at bats. Interestingly in the club team, the mode was 9 and the median was 9, with the average being 10.25, all very closely clustered with the mean and mode being the most accurate reflection. When compared to the Provincial team's modes of 3, 25, 28 and the median of 14.5, it was evident that the Provincial team had batters of varying skill levels, while the club team's batters were more similar in ability. However, they were all on average weaker than the Provincial team.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The main purpose of this study was to investigate possible interactions between morphological, fitness and skill tests and performance in the sport of men's fast pitch softball in order to assist coaches to better understand the physical and physiological demands of the sport. It would also serve to inform their fitness and training programmes and to make the selection process more objective as it will focus on all aspects which contribute to success in the sport. A further objective was to assess if these interactions are evident when comparing a representative Provincial team with a senior club team.

Successful performance in any sport is dependent on a multitude of factors which include among others, fitness, skill, performance and morphological characteristics. Research into the physique of sportspersons has shown a definite relationship between anthropometric characteristics and successful sports participation at the higher levels of competition. Excess body fat affects sporting performance negatively because the extra weight decreases speed and increases thermal stress as a result of increased body surface area and metabolically inactive tissue. Athletes carrying excessive body weight are also more prone to injury than those who weigh less and have acceptable levels of body fat (Healthline 2011).

In most sport codes fitness tests that mimic the specific sport, form part of the selection criteria as it gives a good indication of how well the player will perform in the game situation. It also informs the players what the requirements and demands of the game and specific positions are and it is also known that players that are in good physical condition are less prone to injury. As a consequence most sports, almost without exception recognises all these factors in their training, coaching and player selection.

Therefore as is the case with most sports, physical fitness, skill and anthropometric characteristics are also important requirements for success in men's fast pitch softball. In the Western Cape however, players tend to be selected to play in representative teams mainly on the basis of match statistics and trials while national teams are also selected similarly at Provincial team competitions. Match statistics alone do not define a player, especially if it is based on a single event such as a tournament which only lasts for a few days.

5.2 Discussion

Due to the dearth of academic sources as mentioned previously at the start of Chapter Two (p.12), a comparison of the results of this study with salient literature about men's fast pitch softball is not possible. Discussion of results obtained from this research with regards to the relationships between the variables studied, is nonetheless possible and follows below.

5.2.1 Interaction Between Morphology, Fitness, Skill and Fast pitch Softball Performance

5.2.1.1 Morphology

Anthropometry is considered to be a very important distinguishing characteristic in fast pitch softball players. In a study conducted by Carjaval, et al. (2009), they found a strong correlation between pitching speed, height, body weight, mesomorphy and muscle mass. The interaction between morphology and fitness, skill and performance was investigated by an analysis of the relationship between these variables. The relationship between weight and body fat was found to be high and significant. Fat is non - contractile tissue and is a burden in activities which require explosive power or sudden change of direction. The inhibiting impact of body fat, as a contributor to body weight, is reflected in the significant negative relationship ($r = - .534$; $p < 0.05$) that was found between weight and agility. Weight appears to be advantageous to batting as measured by the batting skills test. It could be for this reason that fat, as a contributor to weight, is also positively correlated with batting performance.

Weight was also found to corrrelate strongly with height ($r = .763$). Weight, as a proxy for height and height, strongly correlated with batting as tested by the batting test ($r = .618$). Increased height provides a mechanical advantage in batting (longer levers). Height also had a significant correlation with batting as a performance measure (based on match statistics).

Body fat interacted negatively with most fitness variables. However, this relationship was only significant for leg power as measured by the vertical jump test ($r = - .427$; $p < 0.05$).

Body fat not only impacted on fitness variables but also on skills. It was found to have a negative impact on base running (r = .402) (note lower running times denotes faster running speeds – hence the "positive" statistical relationship). The BMI which is also used as an indicator of body fat content had a high positive correlation with the estimated percent body fat and correlated negative with the same variables as body fat. An interesting finding of this study is the significant relationship of BMI with the results of the fielding skills test and the fielding performance as portrayed in the match statistics.

5.2.1.2 Fitness and Performance Measures

The vertical jump, as a measure of leg power, showed an average significant correlation with the standing broad jump ($r = .414$; $p < 0.05$) and the agility test ($r = .394$; $p < 0.05$). The vertical jump test is a lower body explosive power test, and strong muscles make it possible to jump higher. However, when a person has a significant amount of muscle, the extra weight reduces the ability to jump very high. The vertical jump is also strongly correlated with base running. This is expected as leg power is a component of running speed. Base runs showed a strong correlation with "stolen bases" as a performance measure.

Agility, speed and explosive power are key fitness components of fast pitch softball.

However having adequate grip during agility and speed tests affects performance. Therefore footwear plays an important role in the agility test, especially since the tests were conducted outside on the playing fields. The Provincial team always attended squad training sessions in game playing kit including their cleats, while the club players train in less formal gear, from shorts to track suits and always wear trainers, not their game cleats. This resulted in them having less grip with the testing surface and their consequent poorer test scores.

Furthermore agility was found to have average negative correlations with batting performances as reflected by the batting test ($r = -.536$; $p < 0.05$) and the "batting average" (as a performance measure) ($r = -.459$; $p < 0.05$). Agility was also found to have strong negative correlations with weight ($r = -.534$) and height ($r = -.610$). Batting was shown to be favoured by heavier weight while agility had strong negative correlations with weight. One needs to weigh up the importance of each of these qualities in achieving success in softball. Based on statistics and as indicated earlier, team selections are mainly based on match statistics and therefore batting ability appears to be rated higher than being agile on the field despite the fact that "stolen bases" and "homeruns" are also strongly related to agility. Carjaval et al. (2009) found the infielders of Cuban baseball players weighed the least and had the lowest levels of body fat and this corresponded with agile, speedy, quick players.

It is interesting to note that the "throw for distance" test results did not correlate significantly with any of the fitness or performance measures.

5.3 Comparisons Between a Club Team and a Provincial Team

5.3.1 Morphology

The club team's players were found to be significantly shorter than the Provincial team ($p < 0.01$). The Provincial team was also heavier than the club players. According to the correlations found in this study, batting performances are favoured by taller, heavier bodies although they compromise on agility which is negatively correlated with height and weight. The shorter and lighter club players outperformed the Provincial players in the agility test.

It is generally accepted that fast pitch softball players participating at the elite level would in general have a lower percentage of body fat and be lower than the "general population", regardless of their individual playing positions. In the present study the mean percent body fat was found to be 19.7 % which is outside the norms of 6 – 13 % for elite sports persons and more in line with the range for normal or average males which is 18 – 24% http://www.fitwatch.com/weight-loss/what - is - a – normal –body – fat – percentage - 4171.html. The club team average of 17% also falls outside the norms but was significantly lower than that of the Provincial players. The impact of these higher fat percentages is reflected in the agility test of the 2 groups where the club team exhibited a superior performance.

Body mass index (BMI) is a measure of body fat based on height and weight that applies to adults (National Heart, Lung and Blood Institute, 2012). This measure makes no distinction between body fat, bone, muscle, organs, etc. and as such is not the best method of determining an appropriate weight for athletes. It is however easier to calculate than body fat percentage and requires minimum equipment. The wide variation in both BMI and body fat percentage found in this study as reflected in the relatively large standard deviation, suggests that the group is not homogeneous in terms of their body composition. However, due to the limited number of participants, this would need to be investigated further with a much larger sample and could be a topic for further research.

In the current study the club team players weighed less than the Provincial team and they scored better on the agility and base running tests which are major advantages in softball.

When a comparison was made between club players and Provincial players it was found that even though the Provincial players had higher body fat percentage and BMIs than the club players, their muscle mass was also greater. This agreed with the finding of Carvajal, et al. (2009) that the better performing group were more muscular than the lower performing group.

Further, as is indicated in Table 5, all players are more muscular than lean and when comparing players by position, infielders were the leanest median body fat percentage 15.55 – 18.21. The pitchers had a median body fat percentage of 19.12 while catchers had a higher median body fat percentage of 20.37 than that of infielders 15.55 – 18.21. Outfielders had a median body fat percentage of 19.21. These findings agree with the findings of Carvajal, et al., 2009.

When comparing body fat percentage by dominant position (with infielders and outfielders grouped), the mean and median values are given in one output (Table 5: Body fat percentage and BMI by position) with more detail given in an additional output (Table 6: The MEANS procedure body fat percentage and BMI by position). Although there are some numeric differences based on a one - way analysis of variance, we find no significant difference by position. This was done for BMI as well as body fat. P - values for the one - way analysis of variance were 0.54 and 0.66 for BMI and BF respectively.

5.3.2 Fitness

To be effective in softball, all players, regardless of their individual fielding positions must possess the common fitness characteristics of power for batting, sprinting speed and agility

for base running and chasing the ball when hit by the opposition as well as leg power to jump when catching high balls.

Speed and agility are necessary to be effective defensively in fielding and offensively for base running. Although the club players were found to be faster and more agile than the Provincial players, these are only two of a myriad of factors which determines success in softball and does not necessarily translate into better overall performers.

The physical fitness requirements of the game demand that all players be fast, agile and good base runners. The more power you have the more force you can generate with minimal effort, the greater your power the quicker you can respond and the more force you can generate with less exertion. Also, an explosive first step generates the speed needed to get to balls hit farther away. The standing long jump, also called the broad jump, is a common and easy to administer test of explosive leg strength.

5.3.3 Skill Tests

The Provincial team performed better on the batting test and had a better batting average. This may be mainly due to the fact that they are seasoned players with years of experience. The Provincial team players also had the advantage of being taller, having longer limbs and so longer levers mean that they are able to generate more force as a result as well as having more muscle weight. Bigger stronger muscles have more muscle fibres to recruit and as a result can contract more forcefully.

Games are won by scoring runs and runs can only be scored by players getting onto bases and players get on base by batting. So in the case of the Provincial team players, the less agile players are able to get on base with more frequency by being stronger, more powerful batters with better batting technique.

There is a very weak correlation coefficient of .021 between batting test and total hits and this can be explained in term of the way in which the batting test is administered. When doing the batting test, the batter hits a ball off a tee, whereas in the game situation the batter faces a pitcher throwing a ball at various speeds and in different places within the strike zone. The difficulty increases when the ball is moving, and also for total hits in the game for match statistics, hits only qualify as hits when they are safe hits.

However this study reflects the research findings provided by Amber and Kavekar (2005) by indicating that the two best Provincial batters were players that didn't specialise in one position and are flexible enough to play three and two different positions respectively. Both these players also played at shortstop, again a finding that agreed with that of Amber and Kavekar (2005). There was also agreement with the research of Carvajal, et al (2009) concerning batting efficiency in that the best batter also happened to be an outfielder.

5.4 Conclusion

Success in any sport, including men's fast pitch softball, is determined by a number of interacting physiological and skill variables. It is therefore imperative that the training and selection of fast pitch softball players be based on scientific evidence which links science to practice. Softball is a complex game with many facets requiring many specialized functions.

In addition to these testable variables, others like match statistics and psychological and social factors like attitude and work ethic or coachability, also require consideration.

From an anthropometric perspective, height is an advantage as longer limbs means longer levers which can generate greater force. This study also found a significant strong correlation between height and batting performance. The importance of height is further emphasised by the difference in heights between the elite Provincial players and the club teams.

Excess fat has no practical role in activities such as sprinting between bases, jumping to catch high flying balls or fielding, and is regarded as dead weight in that it negatively impacts acceleration. The prescribed fat percentage should at least be in line with the general guidelines for sport persons and could be position specific. The negative relationship between body fat and agility is also clearly demonstrated in the current study.

Softball entails situations in which the athlete must exhibit high levels of agility which involves sudden changes of direction and acceleration. These instances are evident in actions such as fielding when a player must move suddenly and quickly to cover a base drive or in base running when a player must quickly recover or return to base. The importance of agility is also highlighted by Stockton (1984) who indicated that catchers in softball must be exceptionally agile and coordinated to be effective fielders.

Pitching, batting, throwing and base running are all actions of fast pitch softball which involve explosive and dynamic actions. These explosive actions require high levels of power.

5.5 Recommendations

Based on the relationships established in the current study, reinforced by differences found between Provincial and club players, it is recommended that the following components are included when compiling a fitness test battery: speed and the ability to jump for height (the vertical or Sargent's jump test and also the standing broad jump test); speed and agility for base running as every player gets the opportunity to become a batter and then a base runner (the base running test (Safrit, et al.) as well as the agility T - test (Johnson & Nelson, 1986) and the Illinois agility test (Getchell, 1979).

The results further suggest that although a certain level of fielding proficiency is required, the main indicators of success are the performances on the batting test and the batting average as recorded in the match statistics. A pitching test would be a beneficial and appropriate tool in the selection process and as an indicator of skill.

The fielding test will need to be revised as it only imitates a specific aspect of the game and the players have an idea of the area in which the ball will be travelling and also the speed at which it will be travelling, more or less. This test specifically tests the player's ability to field a ground ball and make a single static play. In the game situation, plays are always changing and as players need to be able to think on their feet, there's even a term in softball known as fielder's choice. This means that there are a few options and the situation will dictate what the best play will be. Tests should make provision for such options and allow testees to exercise them.

In the game situation fielders face fly balls, ground balls and line drives. They may be required to play the baseman, touch the base while having control over the ball, tag a runner, "check the runner" (feint a throw to prevent a runner advancing) or they may need to make a double (two outs) or triple (three outs) play. This test is then better suited as a skills acquiring test for beginner to intermediate level players, or as a drill in a training session than as a selection tool for Provincial teams. This is because it only tests the clean pick up and throw to one place or base. In the game situation the ball will not be coming at the player within a contained area and isn't limited by the tester (or examiners) ability to throw within a confined area for a number of throws.

Balls batted in a game can and do go anywhere and the speeds at which they can travel have been known to injure players, especially with the improvement in bat technology. Added to this unpredictability of the ball, there may also be a number of options the fielder has to decide on, the options depending on the number of runners, the runner's closest to the fielding player, the runner closest to home base, the number of outs, etc. Experience in fielding is also vital. The fielding test has to reflect the game situations as closely as possible.

The batting test does not closely imitate the game situation because the ball is stationary and batted off a tee. In the game situation the ball is thrown or pitched by a pitcher whose main objective is to prevent the batter from becoming a runner and makes every effort to make the ball as hard to hit as possible. However, in the test, to ensure reliability and repeatability, the ball is batted off a tee set at the same place in the strike zone for everyone. A pitching machine could also deliver different pitches at different speeds to the batter more consistently and is more game - related than batting off the tee and therefore more legitimate as a test of

batting. Similarly tossing the ball to the batter is also more realistic than batting a stationary ball off a tee.

The relationships established in this research strongly recommend that coaches include fitness, morphological and skills tests in their coaching and fitness programmes and they should further be used in team selections processes as they are strong indicators for success and will make the selection process more objective.

Gathering valid information regarding coaching techniques and philosophies employed by coaches of the various teams across Provincial league levels in the Western Province Softball Federation in the Western Cape could be a relevant study area. Findings from such a study could assist in the development of the standard of softball by determining best local practices and the formulation of norms for coaching and team selection strategies. Such information would be invaluable to coaches.

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APPENDICES

APPENDIX A

THE PLAYER CONSENT LETTER

Dear Player

I am conducting research on the relationship between fitness, morphology, skills and match statistics in male fast pitch softball players in the Western Cape.

The testing will be conducted on the training premises, City Park, under the supervision of trained researchers. The tests will include the taking of measurements of the body (height, weight, skinfolds, etc.), physical fitness, skills and flexibility. There is no part of the examination that can be harmful in any way. For instance **NO** blood samples will be taken.

The fitness test battery will measure the following:

- height
- weight
- skinfolds
- vertical jump
- standing broad jump
- fielding test
- batting test
- agility test
- base running test

- softball throw for distance

All the bodily measurements will be taken by a female researcher.

The tests will be explained and demonstrated to you prior to your signing the consent form.

If you agree to be part of the study, please sign the form and return it to the researcher. Your co-operation is sincerely appreciated. YOU HAVE THE RIGHT TO WITHDRAW FROM THE RESEARCH AT ANY TIME.

The results of the investigation will be treated confidentially and will only be published as group data. If you have any questions pertaining to the project please feel free to ask me at any time. PLEASE NOTE THAT PARTICIPATION IN THIS PROJECT IS ENTIRELY VOLUNTARY.

I …….. born on …….. agree to be examined by trained researchers from the University of the Western Cape.

Date: ……..

Signature: ……..

If you are willing to participate in the project please answer the following two questions to the best of your knowledge.

Do you suffer from any illnesses? ……

Please specify if any.

……

……

……

Have you had any operations or been admitted to hospital? ……

Please specify the illnesses and operations.

……

……

……

APPENDIX B

THE COACH/ MANAGER CONSENT LETTER

Dear Coach / Manager

I am conducting research on the relationship between fitness, morphology, skills and match statistics in male fast pitch softball players in the Western Cape.

The testing will be conducted on the training premises, City Park, under the supervision of trained researchers. The tests will include the taking of measurements of the body (height, weight, skinfolds, etc.), physical fitness, skills and flexibility. There is no part of the examination that can be harmful in any way. For instance **NO** blood samples will be taken.

The fitness test battery will measure the following:

- height
- weight
- skinfolds
- vertical jump
- standing broad jump
- fielding test
- batting test
- agility test
- base running test
- softball throw for distance

All the bodily measurements will be taken by a female researcher.

The tests will be explained to you and your players prior to their signing the consent form.

If you agree that your players be part of the study, please sign the form and return it to the researcher. Your co-operation is sincerely appreciated. YOUR PLAYERS HAVE THE RIGHT TO WITHDRAW FROM THE RESEARCH AT ANY TIME AND THEIR CONSENT IS ALSO REQUIRED. (They will be asked to complete a player consent form).

The results of the investigation will be treated confidentially and will only be published as group data. If you have any questions pertaining to the project please feel free to ask me at any time. PLEASE NOTE THAT PARTICIPATION IN THIS PROJECT IS ENTIRELY VOLUNTARY.

I …….. as Coach / Manager of the senior male squad agree that all players be examined by trained researchers from the University of the Western Cape.

Date: ……..

Signature: ……..

APPENDIX C

MEN'S FAST PITCH SOFTBALL FITNESS TESTS

Name: _____ Age:_____

Playing position: _____ Squad: _____

Anthropometry

Height: _____ Weight: _____

Body Composition

Skinfolds:

Bicep - _____

Tricep - _____

Subscapular - _____

Suprailiac - _____

Abdominal - _____

Thigh - _____

Calf - _____

Total - _____ BF% - _____

Category - _____

Power

Vertical jump:

Trial 1: _____ Trial 2: _____ Trial 3: _____

Result: _____ Category: _____

Standing Broad jump:

Trial 1: _____ Trial 2: _____ Trial 3: _____

Result: _____ Category: _____

Speed and Agility

Illinois Agility run:

Trial 1: _____ Trial 2: _____

Result: _____ Category: _____

Base running Test (2 bases)**:**

Trial1: _____ Trial 2: _____ Trial 3: _____

Result: _____ Category: _____

Skill:

Softball throw for distance:

Trial 1: _____ Trial 2: _____

Error 1: _____ Error 2: _____

Softball batting test:

Warm-up 1: _____ Warm-up 2: _____

Trial 1: _____ Trial 2: _____ Trial 3: _____

Trial 4: _____ Trial 5: _____ Trial 6: _____

Result (total distance in m): _____

Fielding ground balls test:

Trial 1: _____ Trial 2: _____ Trial 3: _____

Trial 4: _____ Trial 5: _____ Trial 6: _____

Result: _____ Category: _____

APPENDIX D

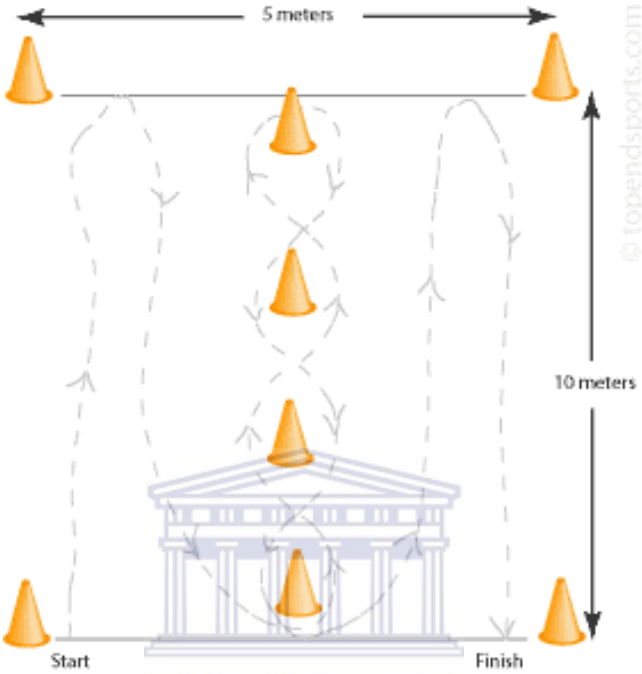
Body fat percentage regression formulae:

Males

Age (yrs)	Formulae
-17	D = 1.1533 – (0.0643 X L)
17-19	D = 1.1620 – (0.0630 X L)
20-29	D = 1.1631 – (0.0632 X L)
30-39	D = 1.1422 – (0.0700 X L)

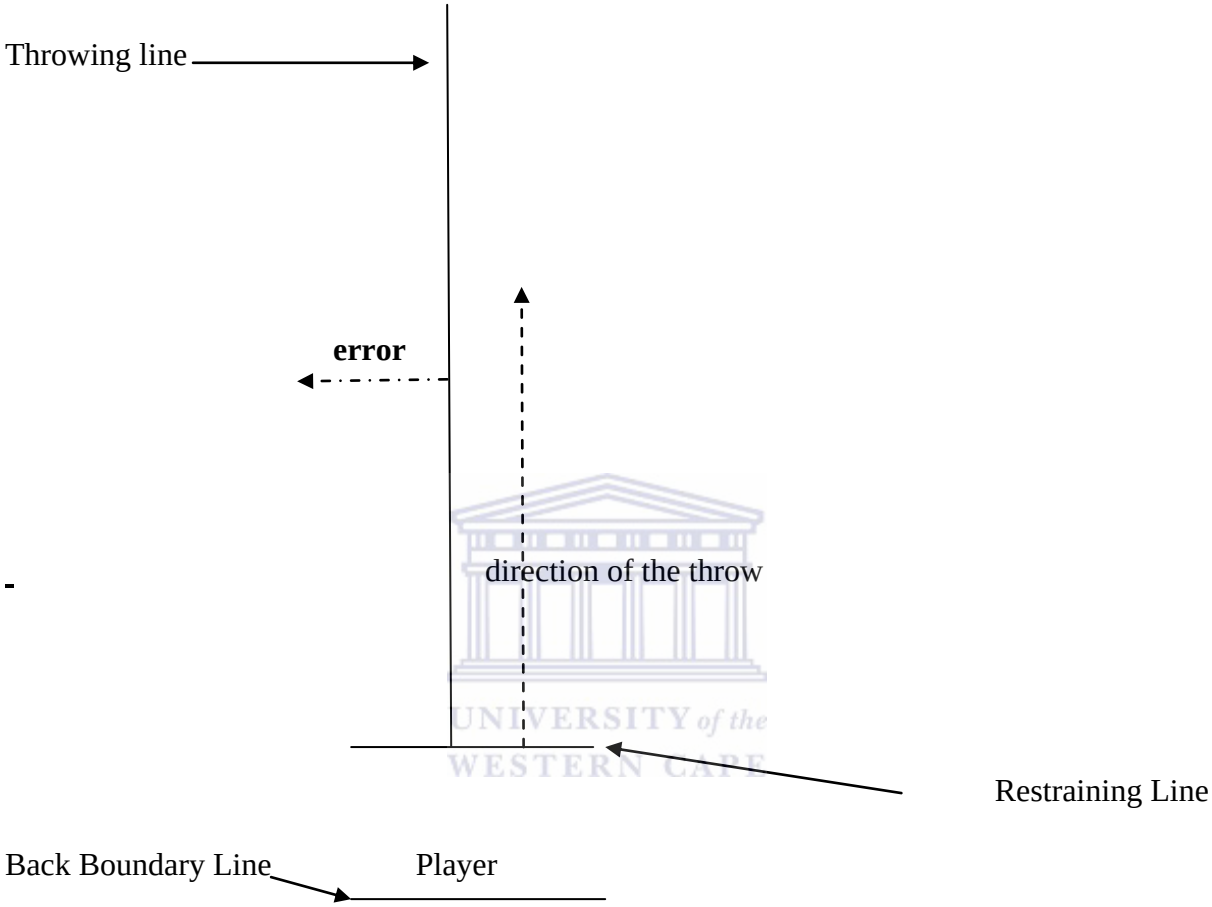
APPENDIX E

The Illinois Agility Test



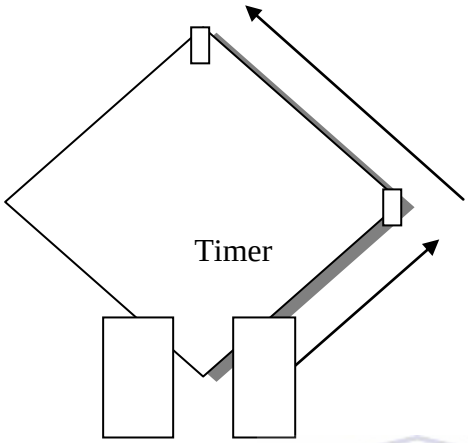
APPENDIX F

The Softball Throw for Distance Test



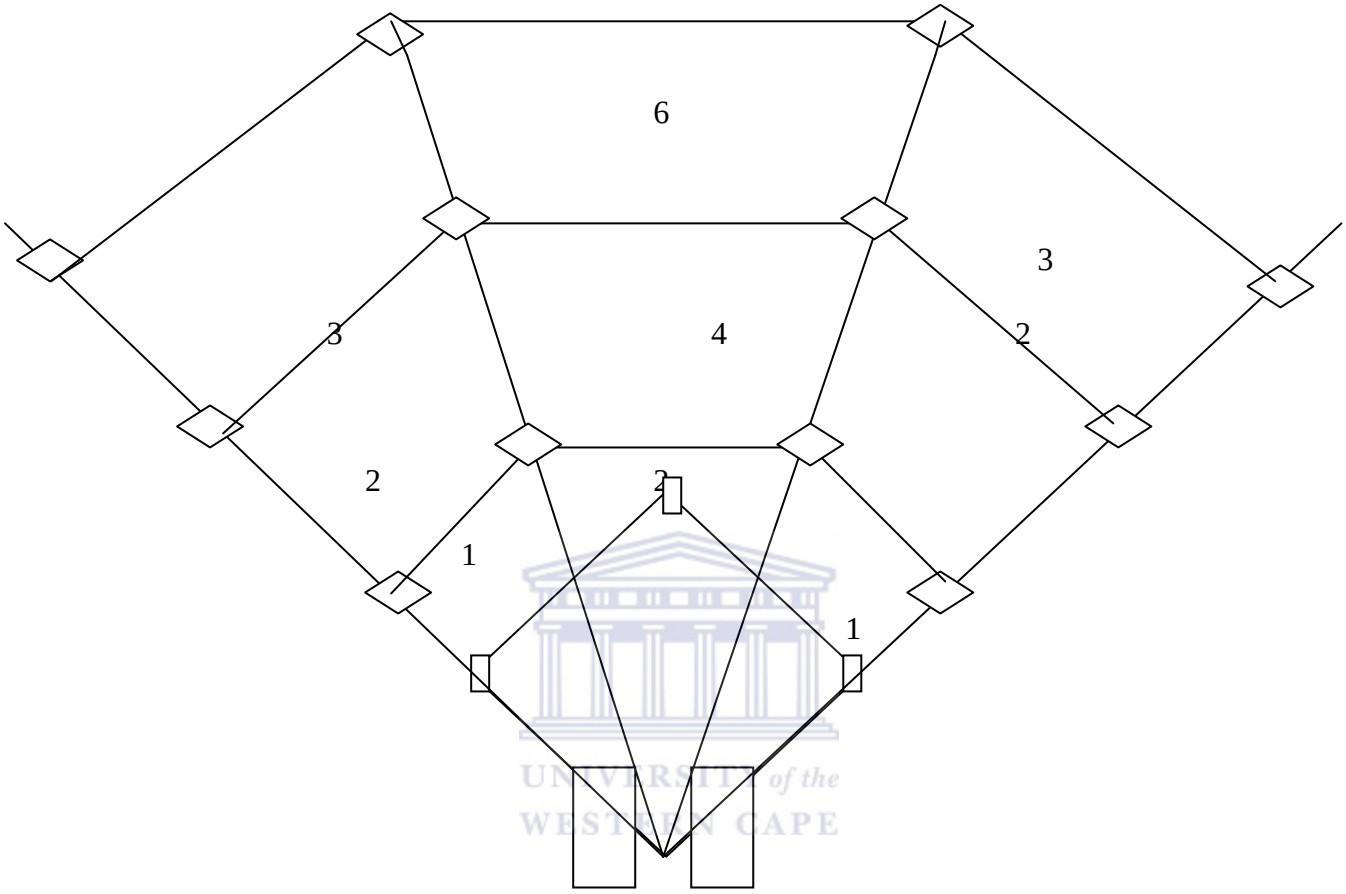
APPENDIX G

The Base Running Test



APPENDIX H

The Batting Test



APPENDIX I

The Fielding Test