Wentzel, M. & Travill, A. L. (2015). Relationship among fitness, morphological characteristics, skills and performance in men's fast-pitch softball. South African Journal for Research in Sport, Physical Education and Recreation, 37(2): 175-186
http://hdl.handle.net/10520EJC177822



# Relationship among fitness, morphological characteristics, skills and performance in men's fast-pitch softball

Melissa Wentzel and André L. Travill

## Abstract

Men's fast pitch softball does not have a specific battery of 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. The sample was purposively selected and consisted of 15 provincial and 15 club male players. Anthropometric, fitness and skills test were conducted. Match statistics were obtained from the provincial softball federation for the provincial players and from the club for its members. Data were analysed and interpreted both collectively as a group and separately as teams for the purpose of comparison. The results identified a number of strong significant relationships between the different variables tested. Stature and percentage body fat were found to interact significantly with the two key performance areas, batting and base running. The findings convincingly suggest that coaches should include fitness, morphological and skills tests in their coaching and fitness programmes, team selection and talent identification processes.

## Introduction

There are two forms of softball, which are played around the world, fast-pitch softball and slow-pitch softball and the International Softball Federation governs both forms (International Softball Federation, 2003).

Success in softball, like in any other competitive sport, depends on the optimal combination of various factors, including the fitness, skill and morphological characteristics of the players. In a study conducted by Carvajal *et al*. (2009) on Cuban baseball players, they found significant differences in games won, body weight, bone mass and residual mass when they divided the pitchers into 'lower performance' and 'higher performance' groups. The same study found first basemen to be the tallest and heaviest players; the second baseman, shortstop and third baseman (infielders) were lighter and leaner than other players and they had a slightly larger muscle mass than pitchers; while catchers and outfielders had the highest mean fat mass (Carvajal *et al*., 2009).

Despite the fact that fast-pitch softball is an established sport with a long history, it has received little scientific attention. For example, it does not have a specific battery of fast-pitch softball 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 the structure, function and performance relationships in different sport, including softball, would allow for improved coaching approaches, development of sport specific fitness and skills training programmes, team selection and talent identification in young players (Brown, 2001).

**Purpose of study**

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. A secondary aim was to compare provincial players with club players to establish whether differences in performance are reflected also in their differences in anthropometry and fitness levels.

**Methodology**

**Sample**

The sample was purposively selected and consisted of 15 provincial and 15 club male fast-pitch softball players. All participants were members of an accredited provincial softball federation. Match statistics, the numerical representations of team and individual playing performances, can be divided into offensive statistics (batting and base running), and defensive statistics (pitching, catching and fielding). These were obtained from the relevant provincial softball federation for the provincial players and from the club for the club players.

**Ethical clearance**

The players and coaches were informed as to what the study entails and all signed informed consent forms. The players were also notified that all information would be kept strictly confidential. The players were made aware of the benefits of the tests, how they rate on these tests and their strengths and weaknesses. The players were assured that their participation was voluntary and that that they could withdraw from the study at any time. The aims and objectives, methodology employed and ethics of the research were presented to and approved by the Senate Research Committee of the University of the Western Cape (04/2/14).

**Anthropometric measures**

The postgraduate researcher, who had completed postgraduate courses in Kinanthropometry, administered 10 anthropometric measurements. The measurements were taken in accordance with the standard procedures of the International Society for the Advancement of Kinanthropometry (Marfell-Jones *et al.*, 2006). Technical errors of measurement (TEM) were within acceptable standards (Norton & Olds, 1996). The measurements included height (cm), weight (kg) and skinfolds (mm) (triceps, sub-scapular, supra-iliac, abdominal, thigh, calf). Body density (g.cm-3) was determined by means of the Durnin and Womersley (1974) formula, which was converted to percentage body fat by means of the formula of Brozek *et al.* (1963).

**Physical fitness tests**

The battery of tests for physical fitness included the *vertical jump*, which was used to measure leg power. Johnson and Nelson (1986) reported a validity of 0.79 and a reliability coefficient of 0.93 for the test. The *standing broad jump* test was used to measure leg power in a horizontal rather than vertical direction. Johnson and Nelson (1986) reported a validity of 0.61 and reliability 0.96 for this test. Heights and distances were measured by means of a measuring tape. *Agility*, the ability to stop, start and change the direction of the body rapidly and in a controlled manner, was measured with the Illinois Agility Test (Tomchuck, 2011). The aim of the test is to complete a weaving course marked out with cones, in the shortest possible time. A whistle was used to start the test and times were taken with a hand held stopwatch. A reliability co-efficient of 0.95 and an SEM (variation in subjects' performance from measurement to measurement), of 0.19 were reported for this test (Hachana *et al.*, 2013).

**Skills tests**

Skills were assessed by means of the 'softball throw for distance test', the 'two-base sprint test', the 'batting test' and the 'fielding test'. The tests employed to assess the fundamental softball skills of the participants are similar to those employed in previous studies (Johnson & Nelson, 1986).

**Softball throw for distance**

Equipment used for the 'softball throw for distance' included softballs, a tape measure, marking cones, a field measured in 5m intervals, and a 1.8m restraining area parallel to the 5m field markers. The best of 3 attempts was recorded as the test score.

**Two-base sprint test**

The speed and skill involved in running between 2 bases was measured. The testing area was the softball diamond. The test started with the player in the batter's box, swinging with a bat as if at a pitched ball and releasing the bat under control and running. The timer started when the bat was released and stopped when the player crossed second base. There was 1 practice trial and then 2 timed trials, with the better of the 2 being recorded. For safety, the player had to run through second base. The time was recorded to the nearest 10th of a second (Morrow *et al.*, 2011). Safrit and Wood (1995) reported validity coefficients of 0.89 to 0.95 for the base running test.

**Batting test**

The batting test was administered on a softball diamond. The ball was set on a tee, the player then hit the ball as far as possible. Players were allowed 2 practice trials and 6 test trials (Morrow *et al.*, 2011). The furthest distance achieved was recorded as the test score. Safrit and Wood (1995) reported validity coefficients ranging from 0.69 to 0.91 for the batting test.

**Testing procedure**

Testing was conducted during the competition phase of the season. The anthropometric measurements, starting with body weight in kilograms, height in centimetres and skinfolds, measured with a Harpenden skinfold calliper in millimetres, were taken prior to the physical training sessions. The fitness tests were conducted after

warm-up and stretch sessions, which were conducted by the researcher. The 2 power tests were conducted first followed by the agility test. The vertical jump and standing broad jump tests were measured in centimetres while the results of the agility test were recorded in seconds. The 'softball throw for distance' was measured in metres, the 'two-base sprint test' in seconds, and the 'batting test' (Morrow *et al.*, 2011), and 'fielding test' (Johnson & Nelson, 1986), were recorded as a score (pass/fail). The tests were conducted at different sessions to exclude the possibility of fatigue effects. Tests were administered over a 4-week period for provincial players and over a 2 week period for club players on separate occasions.

**Data analysis**

Since the data did not have a normal distribution, the Spearman's Rank Correlation was used to assess possible relationships between variables (Estep, 2013). The provincial and club squads were compared on 16 measures using the non-parametric Wilcoxon Rank Sum test. A more stringent level of $p<0.01$ was set as so many tests were involved. An alternative approach was used to control the 'False Discovery Rate' (FDR) with the significance level set at $p<0.05$ (Benjamini & Hochberg, 1995).

**Results**

Table 1 illustrates the descriptive statistics of the morphological, fitness and performance characteristics of men's fast-pitch softball players.

Table 1. Descriptive statistics of variables

| Variable | N | Mean±SD |
|---|---|---|
| Height (cm) | 30 | 169.00±7.38 |
| Weight (kg) | 30 | 65.37±14.83 |
| Body fat (%) | 30 | 19.72±4.68 |
| Agility (sec) | 30 | 13.53±2.14 |
| Base running (sec) | 30 | 6.03±0.33 |
| Distance throw (m) | 30 | 50.87±5.31 |
| Batting (pts) | 30 | 20.33±8.33 |
| Batting average (runs) | 30 | 0.24±0.12 |
| Fielding (pts) | 30 | 17.33±3.63 |
| Fielding average (pts) | 30 | 0.92±0.04 |
| Total hits (pts) | 28 | 3.39±2.77 |
| Stolen bases (pts) | 8 | 1.25±0.46 |
| Home runs (runs) | 4 | 1.25±0.50 |

Table 2 depicts the relationships between morphological, fitness, skill and performance characteristics. Although different positions vary with regard to the demands of the above characteristics, the sample did not warrant an investigation into the positional variances and only body fat percentage and BMI (Body Mass Index) were analysed by position. Body fat exhibited a significant ($p<0.01$) positive relationship with weight ($r=0.775$) and height ($r=0.594$). Height and vertical jump had a moderate negative relationship, $r=-0.428$ ($p<0.05$). Weight also negatively correlated with jumping ability. However, this relationship was not significant. The relationship between body fat percentage and vertical jump was also found to be moderately negative ($r=-0.427$; $p<0.05$).

Table 2: correlations (spearman's rho) between variables

| Variable | Height | Weight | Body fat | BMI | Vert. jump | St Br. jump | Agility | Base Runs | Dist. Throw | Batting | Fielding | Fielding ave. | Batting ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Height | — | 0.763 ** | 0.594 ** | 0.584 ** | -0.428 * | -0.040 | -0.610 ** | 0.229 | 0.335 | 0.618 ** | 0.008 | 0.159 | 0.439 * |
| Weight | 0.763 ** | — | 0.775 ** | 0.950 ** | -0.283 | -0.024 | -0.534 ** | 0.188 | 0.244 | 0.560 ** | 0.329 | 0.324 | 0.330 |
| Body fat % | 0.594 ** | 0.775 ** | — | 0.787 ** | -0.427 * | -0.264 | -0.356 | 0.402 * | -0.012 | 0.481 ** | 0.292 | 0.436 * | 0.140 |
| BMI | 0.584 ** | 0.950 ** | 0.787 ** | — | -0.201 | -0.041 | -0.454 ** | 0.143 | 0.187 | 0.404 * | 0.406 * | 0.389 * | 0.217 |
| Vertical Jump | -0.428 * | -0.283 | -0.427 * | -0.201 | — | 0.414 * | 0.394 * | -0.681 ** | -0.279 | -0.320 | 0.201 | -0.225 | 0.161 |
| Stand Br. Jump | -0.040 | -0.024 | -0.264 | -0.041 | 0.414 * | — | 0.071 | -0.256 | 0.035 | 0.140 | 0.000 | -0.106 | 0.158 |
| Agility | -0.610 ** | -0.534 ** | -0.356 | -0.454 ** | 0.394 * | 0.071 | — | -0.208 | -0.269 | -0.536 ** | -0.098 | -0.153 | -0.459 * |
| Base runs | 0.229 | 0.188 | 0.402 * | 0.143 | -0.681 ** | -0.256 | -0.208 | — | -0.023 | 0.326 | -0.214 | 0.245 | -0.130 |
| Distance Throw | 0.335 | 0.244 | -0.012 | 0.187 | -0.279 | 0.035 | -0.269 | -0.023 | — | -0.022 | -0.094 | -0.222 | -0.054 |
| Batting | 0.618 ** | 0.560 ** | 0.481 ** | 0.404 * | -0.320 | 0.140 | -0.536 ** | 0.326 | -0.022 | — | 0.055 | 0.273 | 0.541 ** |
| Fielding | 0.008 | 0.329 | 0.292 | 0.406 * | 0.201 | 0.000 | -0.098 | -0.214 | -0.094 | 0.055 | — | -0.030 | 0.386 * |
| Fielding ave. | 0.159 | 0.324 | 0.436 * | 0.389 * | -0.225 | -0.106 | -0.153 | 0.245 | -0.222 | 0.273 | -0.030 | — | -0.041 |
| Batting ave. | 0.439 * | 0.330 | 0.140 | 0.217 | 0.161 | -0.158 | -0.459 * | -0.130 | -0.054 | 0.541 ** | 0.386 * | -0.041 | — |

*p<0.05 (2-tailed) **p<0.01 (2-tailed)

The relationship between the distance achieved in the batting test and height was high with a correlation coefficient of 0.618 ($p<0.01$). There was a strong negative relationship between base running and vertical jumping ($r=-0.681$; $p<0.01$). The relationship between the standing broad jump and base running was small, negative and not significant ($r= -0.256$). A negative, moderate and significant relationship was found between body weight and agility ($r=-0.534$; $p<0.01$).

Comparison of per cent body fat and BMI of players in different positions

The players in the infield had the lowest percentage body fat and BMI"s (Table 3). This is in line with the demands of their individual positions, which require quick agile players capable of quick lateral movements. However, even though the pitcher and catcher also form part of the infield, their fielding and positional requirements are different to other infielder demands.

**Comparison between club and provincial players**

Descriptive statistics for club and provincial players are shown in Table 4. Table 5 orders the results by p-value and provides the False Discovery Rate (FDR) adjusted values. The results show that the club players were younger, shorter, lighter, and they were more agile and performed a better vertical jump than the provincial players. 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.

The provincial players were taller (173cm vs. 164cm) and heavier (74.2kg vs. 56.5kg) than the club players. The weight advantage of the provincial players was not only because of their greater height but they also demonstrated a higher lean body mass of 58kg compared to the 46kg of the club players. The provincial players had a higher body fat percentage (21%) compared to the club players (17%). This higher body fat percentage was also reflected in a higher BMI in the provincial players (24.4 vs. 20.7)

Table 3. Body fat percentage and BMI by playing position

| Position | Variable | N | Mean±SD | Median |
|---|---|---|---|---|
| Pitcher | BF | 6 | 21.06±4.95 | 19.12 |
| | BMI | 6 | 22.37±2.63 | 22.97 |
| Catcher | BF | 4 | 21.05±5.52 | 20.37 |
| | BMI | 4 | 24.08±6.07 | 23.13 |
| First base fielder | BF | 5 | 20.73±5.65 | 18.21 |
| | BMI | 5 | 23.80±4.50 | 22.30 |
| Other infield fielders | BF | 7 | 17.08±4.49 | 15.55 |
| | BMI | 7 | 20.84±2.57 | 21.38 |
| Outfield fielders | BF | 8 | 19.74±3.77 | 19.21 |
| | BMI | 8 | 22.82±4.35 | 21.17 |

BF= Body fat % BMI= Body Mass Index SD= Standard Deviation

Table 4. Descriptive statistics of variables for club and Provincial team players

| Variable | CLUB TEAM PLAYERS | | | PROVINCIAL TEAM PLAYERS | | |
|---|---|---|---|---|---|---|
| | N | Mean±SD | Median | N | Mean±SD | Median |
| Age (yrs) | 15 | 15.67±2.50 | 15.00 | 15 | 24.60±5.42 | 25.00 |
| Height (cm) | 15 | 164.00±4.04 | 164.00 | 15 | 173.00±5.50 | 174.00 |
| Weight (kg) | 15 | 56.53±11.31 | 58.20 | 15 | 74.20±12.66 | 72.00 |
| Body Fat (%) | 15 | 17.76±3.70 | 16.83 | 15 | 16.54±5.95 | 18.40 |
| Body Fat (kg) | 15 | 10.34±4.14 | 9.02 | 15 | 16.54±5.95 | 18.40 |
| LB Mass (kg) | 15 | 46.18±7.53 | 46.45 | 15 | 57.65±7.41 | 57.81 |
| BMI ($kg/m^2$) | 15 | 20.73±3.14 | 19.47 | 15 | 24.46±3.73 | 23.46 |
| Vert. Jump (cm) | 15 | 55.53±7.44 | 52.00 | 15 | 48.60±4.61 | 49.00 |
| Std. Br. Jump (cm) | 15 | 244.67±15.73 | 241.00 | 15 | 239.39±17.49 | 240.00 |
| Agility (sec.) | 15 | 15.05±1.77 | 15.57 | 15 | 12.02±1.21 | 11.82 |
| Base run (sec) | 14 | 5.91±0.39 | 5.91 | 15 | 6.14±0.23 | 6.15 |
| Throw Dist. (m) | 15 | 50.22±5.74 | 51.20 | 15 | 51.52±4.94 | 52.00 |
| Batting (pts) | 15 | 15.00±7.50 | 14.00 | 15 | 25.67±5.13 | 25.00 |
| Fielding (pts) | 15 | 17.00±4.05 | 18.00 | 15 | 17.67±3.27 | 18.00 |
| Fielding ave. (pts) | 15 | 0.91±0.04 | 0.91 | 14 | 0.93±0.03 | 0.92 |
| Batting ave. (runs) | 15 | 0.18±0.08 | 0.17 | 14 | 0.30±0.14 | 0.29 |

LB Mass= Lean Body Mass BMI= Body Mass Index SD= Standard Deviation

The club team's agility scores were weaker than the provincial team's scores and ranged from 11.5 seconds to almost 18 seconds with players averaging 15.05 seconds. The provincial team had a narrower range starting from almost 12 seconds to over 17 seconds and an average of 12.92 seconds. The provincial team scored much better on the batting test (25.67) compared to the club team (15.0). The lowest score of 15 was the same as the club team's average.

The club team lacked consistency in their performance as reflected in their wide range of batting ability (SD=7.5), while the provincial team was more consistent and scored in the middle to upper range of the test (SD=5.1). The provincial team outperformed the club team on batting averages, which is an important performance measure as it gives an indication of a team's ability to score runs and therefore win games.

Table 5. SAS system: p-values and false discovery (fd) rate

| Order | Variable | p-Value | Raw p-value | Bon p-value | FD rate |
|---|---|---|---|---|---|
| 1 | Age | 0.0004 | 0.000439 | 0.01055 | 0.00850 |
| 2 | Agility | 0.0008 | 0.000821 | 0.01970 | 0.00850 |
| 3 | Height | 0.0016 | 0.001565 | 0.03756 | 0.00850 |
| 4 | Batting | 0.0017 | 0.001717 | 0.04121 | 0.00850 |
| 5 | Lean Body Mass | 0.0018 | 0.001772 | 0.04252 | 0.00850 |
| 6 | Weight | 0.0030 | 0.003012 | 0.07230 | 0.01205 |
| 7 | Sub-scapular | 0.0041 | 0.004130 | 0.09911 | 0.01416 |
| 8 | Supra-iliac | 0.0059 | 0.005916 | 0.14199 | 0.01758 |
| 9 | Body Fat kg | 0.0070 | 0.006986 | 0.16768 | 0.01758 |
| 10 | Triceps | 0.0073 | 0.007323 | 0.17576 | 0.01758 |
| 11 | Batting ave. | 0.0146 | 0.014595 | 0.35028 | 0.02953 |
| 12 | Batting | 0.0148 | 0.014767 | 0.35440 | 0.02953 |
| 13 | Vertical Jump | 0.0268 | 0.026813 | 0.64350 | 0.04650 |
| 14 | Body Fat % | 0.0361 | 0.036057 | 0.86536 | 0.06181 |
| 15 | Base Run | 0.0678 | 0.067758 | 1.00000 | 0.10841 |
| 16 | Biceps | 0.0873 | 0.087255 | 1.00000 | 0.13088 |
| 17 | Abdominal | 0.1662 | 0.166243 | 1.00000 | 0.23470 |
| 18 | Fielding ave. | 0.2845 | 0.284476 | 1.00000 | 0.37930 |
| 19 | Total | 0.3161 | 0.316061 | 1.00000 | 0.39924 |
| 20 | Stand. Br. Jump | 0.4486 | 0.448630 | 1.00000 | 0.53836 |
| 21 | Distance Throw | 0.6365 | 0.636452 | 1.00000 | 0.72737 |
| 22 | Calf | 0.6838 | 0.683812 | 1.00000 | 0.73519 |
| 23 | Thigh | 0.7046 | 0.704556 | 1.00000 | 0.73519 |
| 24 | Fielding | 0.7050 | 0.705015 | 1.00000 | 0.73519 |

## Discussion

Successful performance in any sport, including men's fast-pitch softball, is dependent on a multitude of factors, which include, among others, fitness, skill, performance and anthropometric characteristics. Match statistics alone do not define a player, especially if based on a single event, such as a tournament, which only lasts for a few days.

## Anthropometry

Anthropometry is considered a very important distinguishing characteristic in fast-pitch softball players. Carjaval *et al.* (2009) found a strong correlation between pitching speed, height, body weight, mesomorphy and muscle mass of Cuban baseball players. The relationship between weight and body fat in the current study 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 ($r = -0.534$; $p<0.05$) that was found between weight and agility. Weight appears to be an advantage to batting as measured by the batting skills test. For this reason, it could be that fat, as a contributor to weight, also positively correlated with batting performance. Spaniol (2009) also identified body composition as an important factor in baseball performance especially for fielding and base running, and further highlighted the high positive correlation found between lean mass and bat speed and batted-ball velocity.

Weight was also found to relate strongly with height ($r=0.763$). Weight, as a proxy for height, and height, strongly correlated with batting as tested by the batting test ($r=0.618$). Increased height provides a mechanical advantage in batting. 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 ($r=-0.427$; $p<0.05$). Body fat not only impacted on fitness variables but also on softball skills. It was found to have a significant impact on base running ($r=0.402$; $p<0.05$) (note lower running scores denote faster running speeds – hence the positive statistical relationship).

**Physical fitness and performance measures**

The vertical jump, as a measure of leg power, showed an average significant correlation with the standing broad jump ($r=0.414$; $p<0.05$) and the agility test ($r=0.394$; $p<0.05$). Agility, speed and explosive power are key fitness components of fast-pitch softball. The vertical jump 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 basis" as a performance measure. Spaniol (2009) identified leg power as important for hitting, running and throwing, as they all require forceful movements, which are generated from the ground up.

Agility was found to have average negative correlations with batting performances as reflected by the batting test ($r=-0.536$; $p<0.05$) and the "batting average" (as a performance measure) ($r=-0.459$; $p<0.05$). Agility was also found to have strong negative correlations with weight ($r=-0.534$; $p<0.01$) and height ($r=-0.610$; $p<0.01$). Batting was shown to be favoured by heavier weights 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. 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. Kohmura *et al.* (2008) reported significant correlations between strength and

batting, and between the standing broad jump and base running. The significant relationships found by Kohmura *et al.* (2008) are in concert with current research, which also reported significant correlations between certain fitness parameters and performance.

**Comparisons between club players and provincial players *Anthropometry***

The club players were found to be significantly shorter and lighter than the provincial players ($p<0.01$). According to the correlations found in this study, taller heavier bodies favour batting performances although they compromise on agility, which is negatively correlated with height and weight. The shorter and lighter club players out performed the provincial players in the agility test.

It is usually accepted that fast-pitch softball players participating at the elite level would have a lower percentage body fat in general than average males, regardless of their individual playing positions. In the present study, the mean percentage body fat was found to be 19.7 %, which is outside the norms of 6 to 13 % for elite sportspersons, and more in line with the range of 18 to 24% for normal or average males (Gleeson, 2013). The club team's average of 17% also fell 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 two groups where the club team exhibited a superior performance.

**Physical fitness and performance measures**

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 (Spaniol, 2009). 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 were, these are only two of a myriad of factors that determine success in softball and do 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. In addition, an explosive first step generates the speed needed to get to balls hit farther away (Spaniol, 2009). The provincial team performed better on the batting test and had a better batting average. Being taller with more muscle weight, the provincial team players could have generated more force during their swing when batting (Schoenfeld, 2010).

Games are won by scoring runs. Players can only score runs by getting onto bases, and players get on base by batting. In the case of the provincial team players, the less agile players were able to get on base more frequently by being stronger, more powerful batters with better batting technique. There was a very weak correlation coefficient of 0.021 between the batting test and total hits and this can be explained in terms of the way in which the batting test was administered. When doing the batting test, the batter hits a ball off a tee, whereas in the game situation the batter faces a ball pitched at various speeds and in different places within the strike zone.

**Conclusions and recommendations**

A number of interacting physiological, morphological and skill variables determine success in any sport, including men's fast-pitch softball. 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, which requires many specialised functions.

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 and strong correlation between height and batting performance. The importance of height is further emphasised by the difference in height between the elite provincial players and the club players.

Excess fat has no practical role to play in activities, such as sprinting between bases, jumping to catch high flying balls or fielding. It is regarded as dead weight that negatively affects 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 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 actions like base running, when a player must recover quickly or return to base. Stockton (1984) indicate that catchers in softball must be exceptionally agile and coordinated to be effective fielders also highlights the importance of agility.

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. Based on the relationships established in the current study, it is recommended that speed, leg power and agility be included when compiling a test battery for fast-pitch softball. The importance of these relationships were emphasised by the differences found between provincial and club players. 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.

Based on the relationships established in this research, it is strongly recommended that coaches include fitness, morphological and skills tests in their coaching and fitness programmes. Furthermore, the results of these tests should be used in team selection processes, as they are strong indicators of success and would make the selection process more objective.

**References**


BENJAMINI, Y. & HOCHBERG, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society (Series B [Methodological])*, 57(1): 289-300.

BROWN, J. (2001). *Sports talent: How to identify and develop outstanding athletes*. Champaign, IL: Human Kinetics.

BROZEK, J.; GRANDE, F.; ANDERSON, J.T. & KEYS, A. (1963). Densitometry analysis of body composition: Revision of some quantitative assumptions. *Annals of the New York Academy of Sciences*, 110: 113-140, September.

CARVAJAL, W.; RIOS, A.; ECHEVARRIA, I.; MARTINEZ, M.; MINOSO, J. & RODRIGUES, D. (2009). Body type and performance of elite Cuban baseball players. *MEDICC Review*, 11(2): 15- 20.

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

ESTEP, J.R. (2013). *Statistics, not sadistics! A practical guide to statistics for non-statisticians*. Louisville, KY: Lincoln Christian Seminary.

GLEESON, M. (2013). "Normal ranges of body weight and body fat." Hyperlink [humankinetics. com/excerpts/excerpts/normal-ranges-of-body-weight-and-body-fat]. Retrieved on 15 April 2013.

HACHANA, Y.; CHAABÈNE, H.; NABLI, M.A.; ATTIA, A.; MOUALHI, J.; FARHAT, N. & ELLOUMI, M. (2013). Test-retest reliability, criterion related validity and minimal detectable change of the Illinois agility test in male team sport athletes. *Journal of Strength Conditioning Research*, 27(10): 2752-2759.

INTERNATIONAL SOFTBALL FEDERATION (2003). "The history of softball." Hyperlink [http://www.isfsoftball.org/english/the_isf/history_of_softball.asp]. Retrieved on 12 May 2014.

JOHNSON, B.L. & NELSON, J.K. (1986). *Practical measurements for evaluation in Physical Education* (4th ed.). Minneapolis, MN: Burgess Publishing.

KOHMURA, Y.; AOKI, K.; YOSHIGI, H.; SAKURABA, K. & YANAGIYA, T. (2008). Development of a baseball-specific battery of tests and a testing protocol for college baseball players. *Journal of Strength and Conditioning Research*, 22(4): 1051-1058.

MARFELL-JONES, M.; OLDS, T.; STEW, A. & CARTER, L. (2006). *International standards for anthropometric assessment*. Sydney (Australia): International Society for the Advancement of Kinanthropometry.

MORROW, J.R. Jnr.; JACKSON, A.W.; DISCH, J.G. & MOOD, D.P. (2011). *Measurement and evaluation in human performance* (4th ed.). Champaign, IL: Human Kinetics.

NORTON, K.I. & OLDS, T. (1996). *Anthropometrica: A textbook of body measurement for sport and health courses*. Sydney (Australia): UNSW Press.

SAFRIT, M.J. & WOOD, T.M. (1995). *Introduction to measurement in Physical Education and exercise science*. Philadelphia, PA: Mosby.

SCHOENFELD, B.J. (2010). The mechanisms of muscle hypertrophy and their application to resistance training. *Journal of Strength and Conditioning Research*, 24(10): 2857-2872.

SPANIOL, J. (2009). Baseball athletic test: A baseball specific test battery. *Strength and Conditioning Journal*, 31(2): 26-29.

STOCKTON, B.A. (1984). *Coaching baseball: Skills and drills*. Champaign, IL: Human Kinetics. TOMCHUCK, D. (2011). *Companion guide to measurement and evaluation for kinesiology*. Mississauga, Ontario (Canada): Jones & Bartlett Learning.