Kinanthropometric attributes of elite South African male kata and kumite karateka

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Received: 20 May 2020; Accepted: 29 June 2020; Published online: 22 July 2020

Abstract

Background and Study Aim: Karate performance is based on many factors, such as strength, speed and endurance. Another important factor which can affect performance is kinanthropometric attributes. The cognitive aim of this study was to increase the knowledge about kinanthropometric attributes of South African male athletes participating in karate kata and kumite between the ages of 18-65 years.

Material and Methods: Kinanthropometric data was collected from 101 male karate athletes from the South African Japanese Karate Association (JKA) population. Purposeful random sampling was used to select participants. Participants’ stature, body mass, body fat percentage (BF%), fat mass, lean body mass (LBM), body mass index (BMI), skinfolds, elbow and knee breadths, bicep and calf circumferences, waist circumference, hip circumference, somatotype, cormic index, waist-to-hip ratio (WHR), waist-to-stature ratio (WSR), sagittal abdominal diameter (SAD), body surface area (BSA), conicity index, adiposity body shape index (ABSI) and body adiposity index (BAI) were assessed. Quantitative statistical methods were used as well as an analysis of variance (ANOVA).

Results: No significant (p>0.05) differences were found for the kata group in relation to any of the measured kinanthropometric variables and across all age groups. Conversely, significant differences in the kumite group existed for all measured kinanthropometric variables across all age groups (p≤0.000). The results indicated that there was a significant difference for calf circumference when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.032). Lastly, a significant difference was found in WHR when comparing the 26-45-year-old’s in the combined group to the 46-65-year-old group (p = 0.042).

Conclusions: The kinanthropometric attributes of South African male national and international karate athletes between the ages of 18-65 participating in kata and kumite, are influenced by the high levels of training which they are exposed to, kinanthropometry does influence their karate performance, do have a healthy level of anthropometry and are positively affected by karate training as no kinanthropometric health risks are evident.

Key words: anthropometry • body composition • martial arts • sport performance

Conflict of Interest: Authors have declared that no competing interest exists

Ethical approval: The study was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer-reviewed

Source of support: Departmental sources

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INTRODUCTION

Karate means ‘empty hand’ in Japanese and originated in Okinawa in the early 17th century, a time when all weapons were banned [1]. Karate is a type of martial art that has been around for centuries and has been subject to many studies [2]. Karate has two disciplines which are uniformly significant, kata and kumite.

Kata means “form” and has been described by Imamura [3] as consisting of predetermined series of defensive and offensive karate techniques, which simulate an actual fight against an imaginary opponent. Imamura [3], also illustrated kata as a formal, methodical, slow and smooth, as well as performed in low stances. Kata involves essential elements of martial art that give it merit over an opponent’s performance. These include the expressiveness of karate technique, rhythm and pace of the kata being performed as well as ‘kime’ which can be described as a short isometric muscle contraction performed when each karate technique is concluded within the kata [4].

Kumite is a karate battle which takes place under real match circumstances. Kumite has been explained by Imamura [3], as a karate fight that includes liberally selected defensive and offensive karate techniques executed against a real opponent. Iide et al. [5], stated that kumite involves short bouts of successive karate techniques which are broken up by sporadic bouncing techniques which permit rapid changes in the body position of the karateka, thus is a intermittent interval series of movement [6]. The skill of kumite is seen when the karateka has to exhibit the potential force of their movement and execute their chosen technique using precise control as not to cause harm to their opponent [4].

The cognitive aim of this study was to increase the knowledge about kinanthropometric attributes of South African male athletes participating in karate kata and kumite between the ages of 18-65 years.

MATERIAL AND METHODS

According to Stewart [7], kinanthropometric attributes are multidisciplinary as they are correlated with biomechanical or physiological aspects. This allows kinanthropometry to relate to fields such as physical education, recreation and sport performance to some degree.

Participants

Forty-six apparently healthy volunteer participants were recruited from the South African karate population. Purposeful random sampling at the respective dojos ensured participants had an equal opportunity to be selected. The participants were between 18 and 65 years of age, who were scaled into the following groups; 18-25, 25-45, and 45-65. In order to obtain a sample group with suitable characteristics, the following criteria was met by all the participants: the participants were male, between 18 and 65 years of age, participated in karate and, had more than three accredited grading’s (exams) or had attained a minimum of an orange belt in order to have sufficient anatomical and physiological adaptations specific to karate. Participants were excluded if they were not in the identified age category, were not in the specific belt range, were currently injured or had been injured in the last three months, had any absolute or relative contraindications to the exercise [8], weight was not stable for six months prior to the study and/or were females in order to eliminate physiological and hormonal influence which may compromise the findings of the study. The mean stature in the kata group was 1.74 ±0.09m and was slightly shorter than the kumite group which had a stature of 1.75 ±0.09m The kata group had a mean body mass of 78.63 ±10.11kg and the kumite group had a mean body mass of 75.77 ±10.34kg (Table 1).

Research design

The research consisted of quantitative research methods. The quantitative research methods involved various kinanthropometric assessments;
stature, cormic index, body mass, body mass index (BMI), body surface area (BSA), body fat percent (BF%), skinfolds, fat mass, lean body mass (LBM), breadths and circumference, waist circumference, hip circumference, waist-to-hip ratio (WHR), waist-to-stature ratio (WSR), sagittal abdominal diameter (SAD), conicity index, adiposity body shape index (ABSI), body adiposity index (BAI) and somatotypes.

**Kinanthropometric Assessment**

Stature was measured to the nearest millimeter, using a standardised wall mounted stadiometer (Seca Stadiometer, 216, Seca, USA). Participants were asked to stand with their back against the stand, heels together, head facing forward, they were asked to take a deep breath while being measured. Measurements were taken barefoot and participants were required to wear minimal clothing [8].

The cormic index is a measure of stature and sitting stature. Sitting stature was measured while the participant was sitting upright on a wooden box or a hard seat while their feet were comfortably flat on the floor [9]. Participants were asked to place their backs (buttocks and scapulae) flat against the wall [10]. The participant took a deep breath and the stature of their trunk was recorded to the nearest millimeter, using a standardised wall mounted stadiometer (Seca Stadiometer, 216, Seca, USA). The seat height was later subtracted [10]. The following equation was used: Cormic Index = Standing stature (cm) - Sitting stature (cm) [9].

Body mass was measured in kilogrammes using a calibrated medical scale (Trojan, BSA16056v, Duteck Industrial co. Ltd, Taiwan). Participants were asked to step onto the scale wearing minimal clothing and to remove any shoes and jewellery [8]. BMI is used to estimate a healthy body mass range relative to stature. The following equation was used: BMI = body mass (kg) ÷ (stature)² (m) [8].

The DuBois formula of BSA is a standardised formula [11] which was used and is as follows: BSA (m²) = 0.20247 x 235 x bm (kg)⁰.⁴²⁵.

BF% were calculated using the MOGAP equation:

Males BF% = \( \frac{\text{sum } 6SF \times 0.1051}{2.585} \) [12].

The sum of six skinfolds from the triceps, subscapular, suprailliac, abdominal, thigh and calf regions were required from the right side of the body. Skinfolds were taken and used to calculate the BF% which was used to calculate the fat mass and LBM of participants. Skinfolds in six regions were taken namely; triceps, subscapular, suprailliac, abdominal, thigh and calf [12]. This was performed using a Harpenden skinfold calliper (Harpenden, HSB-BI, ATICO Medical Pvt. Ltd, United Kingdom). The right side of the body was measured, with each site being measured three times and the median was used in the analysis.

Fat mass consists of body mass and body fat percentage [12]. The following equation was used to calculate the amount of fat in each participant’s body: Fat mass = (Body mass x BF%) ÷ 100. LBM is used to calculate the amount of fat-free mass present in the body [13]. The following equation was used: LBM = body mass – fat mass.

The circumference of the bicep and calf was measured. The arm measurement required the participant to hold their arm out at ninety degrees while the circumference of the bicep is measured using a non-distendable tape measure (Seca 201, Seca, UK). The calf measurement required the participant to be seated and rest the leg at ninety degrees, the measuring tape was placed at the belly of the calf [14]. The breadth of the elbow and knee were measured. The elbow measurement required the arm to be held at ninety degrees, a large spreading caliper (Harpenden anthropometer, Holtain: UK) was placed on either side of the joint and the measurement was recorded. The knee measurement required the participant to be seated and the leg must be placed at ninety degrees, foot flat on the floor. A large calliper was placed on the bones of the knee joint and the measurements were recorded [14]. Waist circumference was measured while the participant was standing with their legs shoulder width apart. The measurement was taken horizontally at the narrowest part of the waist, approximately 2.54 cm above the umbilicus (naval) [8]. All measurements were taken with a non-distendable measuring tape (Seca 201, Seca, United Kingdom). The measuring tape was placed on the skin surface without compressing the subcutaneous adipose tissue. The hip circumference was measured standing with the participants arms on their sides, feet together. The measurement was taken horizontally at the largest area of the buttocks [8]. All measurements were taken using a non-distendable measuring tape (Seca 201, Seca, United Kingdom). The tape was placed on the skin surface without compressing the subcutaneous adipose tissue.
Waist-to-hip ratio (WHR) is a ratio measurement of the circumference of the waist to that of the hip [8]. WHR was calculated by the following equation: $\text{WHR} = \text{waist circumference} \div \text{hip circumference}$. Waist-to-stature ratio (WSR) measures the distribution of body fat in the abdominal region. WSR is the ratio between the waist circumference and stature. The following equation was used: $\text{WSR} = \text{waist circumference} \div \text{stature}$ [15].

SAD was measured while the participant is standing and ranges from the narrowest part between the last rib and the iliac crest, to the midpoint between the iliac crests [16-18]. All measurements were taken with a non-distendable measuring tape (Seca 201, Seca, United Kingdom). Conicity index measures abdominal obesity and is a good indicator of risk for hyperlipidemia in Western populations [19]. The conicity index was calculated as follows: $\text{Conicity index} = \frac{\text{waist circumference} \div \left[0.109 \times \sqrt[3]{\text{body mass}} \div \text{stature}\right]}{\sqrt[3]{\text{body mass} \div \text{stature}^2}}$ [20].

Adiposity body shape index (ABSI) measures abdominal adiposity and is clinically used to estimate mortality risk. The adiposity body shape index was calculated as follows: $\text{ABSI} = \left[\text{waist circumference} \div \left(\text{BMI}^{2/3} \times \text{height}^{1/2}\right)\right]$ [21]. Body adiposity index (BAI) measures adiposity in the body and was created as an alternative to BMI. Body adiposity index was calculated as follows: $\text{BAI} = \frac{\text{hip circumference}}{\text{stature}^{1.5} - 18}$ [21].

The somatotype of an athlete can be used to identify their body type. There are three types, endomorphic, ectomorphic and mesomorphic. Endomorphic types are defined as having high body fat, mesomorphic types are described as having more lean body mass and are muscular, while ectomorphic body types are defined as being lean with low levels of body fat [23]. The following equations were used to measure the participant’s somatotype [23]:

Endomorphic $= -0.7182 + 0.1451 \times \Sigma SF -0.00068 \times \Sigma SF^2 + 0.0000014 \times \Sigma SF^3$

where:

$\Sigma SF = \text{the sum of skinfolds} = \text{tricep} + \text{subscapular} + \text{suprailiac} \times (170.18 \div \text{stature} \text{[cm]})$

Mesomorphic $= (0.858 \times \text{humerus breadth}) + (0.601 \times \text{femur breadth}) + (0.188 \times \text{corrected arm girth}) + (0.161 \times \text{corrected calf girth}) - (\text{stature} \times 0.131) + 4.5$

where:

corrected girth is the original girth subtract the skinfold measurement for that region.

Ectomorphic: $\text{HWR} = \text{stature} \div \sqrt[3]{\text{body mass}}$

Thus, if HWR:

$\text{HWR} \geq 40.75 : \text{ecto} = 0.732 \times \text{HWR} - 28.58$

$40.75 > \text{HWR} > 38.25 : \text{ecto} = 0.463 \times \text{HWR} - 17.63$

$\text{HWR} \leq 38.25 : \text{ecto} = 0.1$

RESULTS

There was no significant ($p>0.05$) difference in stature when comparing the 18-25 year-old’s stature in the kata group to the 26-45-year-old group ($p=0.970$) and the 18-25 to the 46-65 group ($p = 0.225$). No significant difference in stature was found when comparing the 26-45-year-old group to the 46-65-year-old group ($p = 0.449$). A significant ($p \leq 0.05$) difference was also found between the 18-25 year-old’s stature in the kumite group when compared to the 26-45-year-old group ($p = 0.000$) and also compared to the 46-65-year-old group ($p = 0.000$). Additionally, a significant difference in stature was found when comparing the 26-45-year-old group to the 46-65-year-old group ($p = 0.000$). There was no significant difference in stature when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group ($p = 0.743$) and the 46-65-year-old group ($p = 0.976$). In addition, no significant difference was found in stature when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group ($p = 0.975$).

There was no significant difference in conmic index when comparing the 18-25 year-old’s conmic index in the kata group to the 26-45-year-old group ($p = 0.823$) and the 18-25 group to the 46-65 group ($p = 0.255$). Additionally, no significant difference in conmic index was found when comparing the 26-45-year-old group to the 46-65-year-old group ($p = 0.654$). However, there was a significant difference between the 18-25 year-old’s conmic index in the kumite group when compared to the 26-45-year-old group ($p = 0.000$) and the 46-65-year-old group ($p = 0.000$). Additionally, a significant difference
in cormic index was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s cormic index in the combined group to the 26-45-year-old group (p = 0.951) and the 46-65-year-old group (p = 0.848). Additionally, no significant difference was found in cormic index when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.616). There was no significant (p>0.05) difference in stature when comparing the 18-25 year-old’s stature in the kata group to the 26-45-year-old group (p=0.970) and the 18-25 to the 46-65 group (p = 0.225). No significant difference in stature was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.449). A significant (p<0.05) difference was also found between the 18-25 year-old’s stature in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Additionally, a significant difference in stature was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in stature when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.975).

There was no significant difference in body mass when comparing the 18-25 year-old’s body mass in the kata group to the 26-45-year-old group (p = 0.996) and the 18-25 group to the 46-65 group (p = 0.974). Additionally, no significant difference in body mass was found when comparing the 26-45-year-old group to the 46-65-year-old group (p=0.930). However, there was a significant difference between the 18-25 year-old’s body mass in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in body mass was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s body mass in the combined group to the 26-45-year-old group (p = 0.649) and the 46-65-year-old group (p = 0.884). Additionally, no significant difference was found in body mass when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.995).

There was no significant difference in BMI when comparing the 18-25 year-old’s BMI in the kata group to the 26-45-year-old group (p = 0.960) and the 18-25 to the 46-65 (p = 0.744). Additionally, no significant difference in BMI was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.938). However, there was a significant difference between the 18-25 year-old’s BMI in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Additionally, a significant difference in BMI was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s BMI in the combined group to the 26-45-year-old group (p = 0.999) and the 46-65-year-old group (p = 0.987). Additionally, no significant difference was found in BMI when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.985).

There was no significant difference in bone surface area (BSA) when comparing the 18-25 year-old’s BSA in the kata group to the 26-45-year-old group (p = 1.000) and the 18-25 to the 46-65 group (p = 0.632). Additionally, no significant difference in BSA was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.647). However, there was a significant difference between the 18-25 year-old’s BSA in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in BSA was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s BSA in the combined group to the 26-45-year-old group (p = 0.558) and the 46-65-year-old group (p = 0.878). In addition, no significant difference was found in BSA when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.986).

There was no significant difference in body fat percentage (BF%) when comparing the 18-25 year-old’s BF% in the kata group to the 26-45-year-old group (p = 0.364) and the 18-25...
group to the 46-65 group (p = 0.974). Additionally, no significant difference in BF% was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.525). However, there was a significant difference between the 18-25 year-old’s BF% in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Additionally, a significant difference in BF% was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s BF% in the combined group to the 26-45-year-old group (p = 0.926) and the 46-65-year-old group (p = 0.525). Additionally, no significant difference was found in BF% when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.826). There was no significant difference in ∑SF when comparing the 18-25 year-old’s ∑SF in the kata group to the 26-45-year-old group (p = 0.366) and the 18-25-year-old group to the 46-65-year-old group (p = 0.970). Additionally, no significant difference in ∑SF was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.984). Furthermore, no significant difference in ∑SF was found when comparing the 26-45-year-old group to the 46-65 year-old's LBMs when comparing the 18-25 year-old’s LBMs in the combined group to the 26-45-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s LBMs in the combined group to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in lean body mass (LBM) when comparing the 18-25 year-old’s LBM in the kata group to the 26-45-year-old group (p = 0.638) and the 18-25 year-old group to the 46-65 group (p = 1.000). Additionally, no significant difference in lean body mass was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.704). However, there was a significant difference between the 18-25 year-old’s LBMs in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in LBMs was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s LBMs in the combined group to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). In addition, no significant difference in LBM was found when comparing the 26-45 year-old’s in the combined group to the 46-65 group (p = 1.000). Additionally, no significant difference was found in BF% when comparing the 26-45-year-old’s LBM in the kata group to the 26-45-year-old group (p = 0.550) and the 46-65-year-old group (p = 0.628). Additionally, no significant difference was found in LBM when comparing the 26-45-year-old’s in the combined group to the 46-65-year-old group (p = 0.000).

There was no significant difference in knee breadth when comparing the 18-25 year-old’s knee breadth in the kata group to the 26-45-year-old group (p = 0.934) and the 18-25 to the 46-65 group (p = 0.990). Additionally, no significant difference in knee breadth was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.977). However, there was a significant difference between the 18-25 year-old’s knee breadth in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in knee breadth was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in knee breadth in the combined group when comparing the 18-25 year-old’s knee breadth in the combined group to
the 26-45-year-old group (p = 0.328) and the 46-65-year-old group (p = 0.966). Additionally, no significant difference was found in knee breadth when comparing the 26-45-year-old’s in the combined group to the 46-65-year-old group (p = 0.779).

There was no significant difference in elbow breadth when comparing the 18-25 year-old’s elbow breadth in the kata group to the 26-45-year-old group (p = 0.936) and the 18-25 group to the 46-65 group (p = 0.513). Additionally, no significant difference in elbow breadth was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.810). However, there was a significant difference between the 18-25 year-old’s elbow breadth in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in elbow breadth was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in calf circumference when comparing the 18-25 year-old’s in the combined group to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in calf circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s biceps circumference in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Additionally, no significant difference in biceps circumference was found when comparing the 26-45-year-old’s in the combined group to the 46-65-year-old group (p = 0.000).

There was no significant difference in waist circumference when comparing the 18-25 year-old’s waist circumference in the kata group to the 26-45-year-old group (p=0.993) and the 18-25 group to the 46-65 group (p=0.104). Additionally, no significant difference in waist circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p=0.000) and also compared to the 46-65-year-old group (p=0.000). Furthermore, a significant difference in waist circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p=0.000). There was no significant difference in waist circumference when comparing the 26-45-year-old’s in the combined group to the 46-65-year-old group (p = 0.522).
There was no significant difference in hip circumference when comparing the 18-25 year-old's hip circumference in the kata group to the 26-45-year-old group (p = 1.000) and the 18-25 group to the 46-65 group (p = 0.550). Additionally, no significant difference in hip circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.612). However, there was a significant difference between the 18-25 year-old's hip circumference in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Additionally, a significant difference in hip circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's in the combined group to the 46-65-year-old group (p = 0.980). There was no significant difference in WSR when comparing the 18-25 year-old's waist to hip ratio in the kata group to the 26-45-year-old group (p = 0.999) and the 18-25 group to the 46-65 (p = 0.615). Additionally, no significant difference in WSR was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.704). However, there was a significant difference between the 18-25 year-old's WSR in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in WSR was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's WSR in the combined group to the 26-45-year-old group (p = 1.000) and the 46-65-year-old group (p = 0.861). Furthermore, no significant difference was found in WSR when comparing the 26-45-year-old's in the combined group to the 46-65-year-old group (p = 0.870).

There was no significant difference in sagittal abdominal diameter (SAD) when comparing the 18-25 year-old's SAD in the kata group to the 26-45-year-old group (p = 0.986) and the 18-25 group to the 46-65 group (p = 0.606). Additionally, no significant difference in SAD was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.457). However, there was a significant difference between the 18-25 year-old's SAD in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in SAD was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's SAD in the combined group to the 26-45-year-old group (p = 0.338) and the 46-65-year-old group (p = 0.952). Additionally, no significant difference was found in SAD when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.729).

There was no significant difference in conicity index when comparing the 18-25 year-old's conicity index in the kata group to the 26-45-year-old group (p = 0.999) and the 18-25 group to the 46-65-year-old group (p = 0.273). Additionally, no significant difference in conicity index was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.247). However, there was a significant difference between the 18-25 year-old's conicity index in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in conicity index was found when comparing the 26-45 group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's conicity index in the combined group to the 26-45-year-old group (p = 0.983) and the 46-65-year-old group (p = 0.544). Additionally, no significant difference was found.
in conicity index when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.387).

There was no significant difference in adiposity body shape index (ABSI) when comparing the 18-25 year-old's ABSI in the kata group to the 26-45-year-old group (p = 0.900) and the 18-25-year-old group to the 46-65-year-old group (p = 0.931). Additionally, no significant difference in ABSI was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 1.000). However, there was a significant difference between the 18-25 year-old's ABSI in the kata group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in ABSI was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's ABSI in the combined group to the 26-45-year-old group (p = 0.967) and the 46-65-year-old group (p = 0.511). Additionally, no significant difference was found in ABSI when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.476).

There was no significant difference in body adiposity index (BAI) when comparing the 18-25 year-old's in the kata group to the 26-45-year-old group (p = 0.994) and the 18-25 group to the 46-65 group (p = 0.305). Additionally, no significant difference in BAI was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.426). However, there was a significant difference between the 18-25 year-old's BAI in the kata group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Furthermore, a significant difference in BAI was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's BAI in the combined group to the 26-45-year-old group (p = 0.973) and the 46-65-year-old group (p = 0.998). Additionally, no significant difference was found in BAI when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.998).

There was no significant difference in endomorphic somatotype when comparing the 18-25 year-old's endomorphic somatotype in the kata group to the 26-45-year-old group (p = 0.262) and the 18-25 group to the 46-65 group (p = 0.993). Additionally, no significant difference in endomorphic somatotype was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.530). Conversely, there was a significant difference between the 18-25 year-old's endomorphic somatotype in the kata group when compared to the 26-45-year-old group (p = 0.000) and also compared to the 46-65-year-old group (p = 0.000). Additionally, a significant difference in endomorphic somatotype was found when comparing the 26-45 group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's endomorphic somatotype in the combined group to the 26-45-year-old group (p = 0.952) and the 46-65-year-old group (p = 0.483). Furthermore, no significant difference was found in endomorphic somatotype when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.750).

Additionally, there was no significant difference in mesomorphic somatotype when comparing the 18-25 year-old's mesomorphic somatotype in the kata group to the 26-45-year-old group (p = 0.685) and the 18-25 group to the 46-65 group (p = 0.907). Additionally, no significant difference in mesomorphic somatotype was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.990). There was a significant difference between the 18-25 year-old's mesomorphic somatotype in the kata group when compared to the 26-45 year-old group (p = 0.000) and also compared to the 46-65 year-old group (p = 0.000). Furthermore, a significant difference in mesomorphic somatotype was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old's mesomorphic somatotype in the combined group to the 26-45-year-old group (p = 0.513) and the 46-65-year-old group (p = 0.998). Furthermore, no significant difference was found in mesomorphic somatotype when comparing the 26-45-year-old's in the combined group to the 46-65-year-old group (p = 0.564).

Moreover, there was no significant difference in ectomorphic somatotype when comparing the 18-25 year-old's ectomorphic somatotype in the kata group to the 26-45-year-old group (p = 0.504) and the 18-25-year-old group to the
46-65-year-old group (p = 0.143). Additionally, no significant difference in ectomorphic somatotype was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.726). However, there was a significant difference between the 18-25 year-old’s ectomorphic somatotype in the kumite group when compared to the 26-45 group (p = 0.000), and a significant difference when comparing the 18-25-year-old group to the 46-6 5-year-old group (p = 0.000). A significant difference in ectomorphic somatotype was also found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.000). There was no significant difference in the combined group when comparing the 18-25 year-old’s ectomorphic somatotype in the combined group to the 26-45-year-old group (p = 0.617) and the 46-65-year-old group (p = 0.370). No significant difference was found in ectomorphic somatotype when comparing the 26-45 year-old’s in the combined group to the 46-65-year-old group (p = 0.920).

Synthetic presentation of the analysed results in Tables 2 and 3.

DISCUSSION

The primary research objectives of this study include, firstly to determine whether kinanthropometric attributes of South African male kata and kumite karate athletes are influenced by high levels of training which they are exposed to, secondly to determine whether kinanthropometric attributes of South African male kata and kumite karate athletes have influenced their performance, thirdly to determine whether kinanthropometric attributes of South African male kata and kumite karate athletes are at a healthy or unhealthy level and finally to determine whether karate training has a positive effect on kinanthropometric health risks.

Compared to a study done by Sánchez-Puccini et al. [24] where participants had a mean stature of 167.4 ±9.3m and Kostovski [25] with a mean stature of 170.30 ±7.43m, the participants in the present study were taller. The present studies kata and kumite groups were also taller than the participants in the kata group from a study done by Vujkov et al. [6] with a mean stature of 163.75 ±5.31m, although they were on par with the same studies kumite

<table>
<thead>
<tr>
<th>Variable (indicator)</th>
<th>18-25 years (n = 9)</th>
<th>26-45 years (n = 8)</th>
<th>46-65 years (n = 5)</th>
<th>Total (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature (m)</td>
<td>1.76±0.06</td>
<td>1.75 ±0.09</td>
<td>1.69 ±0.10</td>
<td>1.74 ±0.09</td>
</tr>
<tr>
<td>Cormic index</td>
<td>88.67±6.44</td>
<td>86.25 ±7.67</td>
<td>82.40 ±3.21</td>
<td>86.36 ±6.59</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>78.77±11.17</td>
<td>79.79 ±9.83</td>
<td>76.54 ±10.52</td>
<td>78.63 ±10.11</td>
</tr>
<tr>
<td>BMI</td>
<td>25.24±3.92</td>
<td>26.00 ±2.73</td>
<td>27.04 ±3.97</td>
<td>25.93 ±3.44</td>
</tr>
<tr>
<td>BSA</td>
<td>1.95±0.13</td>
<td>1.95 ±0.15</td>
<td>1.87 ±0.16</td>
<td>1.93 ±0.14</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>13.31 ±8.68</td>
<td>8.44 ±3.33</td>
<td>11.90 ±5.34</td>
<td>11.22 ±6.53</td>
</tr>
<tr>
<td>Sum of 6 skinfolds (mm)</td>
<td>93.78±76.31</td>
<td>51.13 ±29.35</td>
<td>80.80 ±46.56</td>
<td>75.32 ±57.40</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>10.83 ±8.31</td>
<td>6.72 ±2.71</td>
<td>8.92 ±3.78</td>
<td>8.90 ±5.91</td>
</tr>
<tr>
<td>Lean body mass (kg)</td>
<td>67.94 ±9.41</td>
<td>73.07 ±9.35</td>
<td>67.62 ±11.37</td>
<td>69.73 ±9.70</td>
</tr>
<tr>
<td>Knee breadth (cm)</td>
<td>8.12 ±0.69</td>
<td>7.95 ±0.51</td>
<td>8.02 ±0.87</td>
<td>8.04 ±0.65</td>
</tr>
<tr>
<td>Elbow breadth (cm)</td>
<td>6.53 ±0.48</td>
<td>6.40 ±0.52</td>
<td>6.16 ±0.63</td>
<td>6.40 ±0.52</td>
</tr>
<tr>
<td>Calf circumference (cm)</td>
<td>37.78±4.12</td>
<td>35.75 ±2.71</td>
<td>36.20 ±4.15</td>
<td>36.68 ±3.62</td>
</tr>
<tr>
<td>Bicep circumference (cm)</td>
<td>34.11±5.04</td>
<td>34.25 ±4.46</td>
<td>33.20 ±4.32</td>
<td>33.95 ±4.48</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>76.44±6.30</td>
<td>77.25 ±5.92</td>
<td>85.00 ±8.72</td>
<td>78.68 ±7.40</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>85.11±10.45</td>
<td>85.50 ±7.27</td>
<td>91.80 ±12.48</td>
<td>86.77 ±9.83</td>
</tr>
<tr>
<td>WHR</td>
<td>0.90 ±0.04</td>
<td>0.90 ±0.04</td>
<td>0.93 ±0.05</td>
<td>0.91 ±0.04</td>
</tr>
<tr>
<td>WSR</td>
<td>43.33 ±4.67</td>
<td>44.29 ±5.32</td>
<td>50.77 ±7.89</td>
<td>45.37 ±6.23</td>
</tr>
</tbody>
</table>
### Table 3. Kinanthropometric attributes of South African male karateka competing in kumite.

<table>
<thead>
<tr>
<th>Variable (indicator)</th>
<th>18-25 years (n = 10)</th>
<th>26-45 years (n = 13)</th>
<th>46-65 years (n = 1)</th>
<th>Total (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature (m)</td>
<td>1.73 ± 0.07</td>
<td>1.76 ± 0.11*</td>
<td>1.85** ***</td>
<td>1.75 ± 0.09</td>
</tr>
<tr>
<td>Cormic index</td>
<td>84.90 ± 5.78</td>
<td>88.92 ± 8.54*</td>
<td>95.00** ***</td>
<td>87.50 ± 7.60</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>70.52 ± 6.68</td>
<td>79.04 ± 11.34*</td>
<td>85.70** ***</td>
<td>75.77 ± 10.34</td>
</tr>
<tr>
<td>BMI</td>
<td>23.44 ± 1.54</td>
<td>25.48 ± 3.20*</td>
<td>25.04** ***</td>
<td>24.61 ± 2.70</td>
</tr>
<tr>
<td>BSA</td>
<td>1.84 ± 0.12</td>
<td>1.95 ± 0.18*</td>
<td>2.10** ***</td>
<td>1.91 ± 0.16</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>8.13 ± 2.38</td>
<td>9.07 ± 2.22*</td>
<td>13.94** ***</td>
<td>8.88 ± 2.48</td>
</tr>
<tr>
<td>Sum of 6 skinfolds (mm)</td>
<td>49.00 ± 21.68</td>
<td>56.92 ± 20.22*</td>
<td>102.00** ***</td>
<td>55.50 ± 22.60</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>5.72 ± 1.69</td>
<td>7.31 ± 2.63*</td>
<td>11.94** ***</td>
<td>6.84 ± 2.56</td>
</tr>
<tr>
<td>Lean body mass (kg)</td>
<td>64.80 ± 6.58</td>
<td>71.73 ± 9.27*</td>
<td>73.76** ***</td>
<td>68.93 ± 8.64</td>
</tr>
<tr>
<td>Knee breadth (cm)</td>
<td>8.36 ± 0.23</td>
<td>8.00 ± 0.94*</td>
<td>9.10** ***</td>
<td>8.20 ± 0.74</td>
</tr>
<tr>
<td>Elbow breadth (cm)</td>
<td>6.65 ± 0.49</td>
<td>6.64 ± 0.87*</td>
<td>6.70** ***</td>
<td>6.65 ± 0.70</td>
</tr>
<tr>
<td>Calf circumference (cm)</td>
<td>36.30 ± 2.67</td>
<td>36.77 ± 3.06*</td>
<td>39.00** ***</td>
<td>36.72 ± 3.69**</td>
</tr>
<tr>
<td>Bicep circumference (cm)</td>
<td>33.60 ± 3.20</td>
<td>35.08 ± 3.84*</td>
<td>32.00** ***</td>
<td>34.33 ± 3.54</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>77.60 ± 7.71</td>
<td>80.54 ± 7.46*</td>
<td>94.00** ***</td>
<td>79.88 ± 7.96</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>83.10 ± 7.34</td>
<td>88.38 ± 7.82*</td>
<td>88.00** ***</td>
<td>86.17 ± 7.74</td>
</tr>
<tr>
<td>WHR</td>
<td>0.93 ± 0.02</td>
<td>0.91 ± 0.04*</td>
<td>1.07** ***</td>
<td>0.93 ± 0.05**</td>
</tr>
<tr>
<td>WSR</td>
<td>44.89 ± 5.70</td>
<td>45.87 ± 4.99*</td>
<td>50.81** ***</td>
<td>45.67 ± 5.21</td>
</tr>
<tr>
<td>SAD</td>
<td>12.80 ± 3.23</td>
<td>12.54 ± 2.70*</td>
<td>16.00** ***</td>
<td>12.79 ± 2.89</td>
</tr>
<tr>
<td>Conicity index</td>
<td>147.18 ± 14.15</td>
<td>146.57 ± 8.03*</td>
<td>172.34** ***</td>
<td>147.90 ± 11.80</td>
</tr>
</tbody>
</table>
There are similarities between the present study and participants from Huertas et al. [26] (1.75 ± 7.5m). On the other hand, the present study was shorter than Italian participants (1.80 ± 7.0m) [27].

It was found that the present study’s mean body mass was heavier compared to a study done by Sánchez-Puccini et al. [24] with the participants mean body mass of 65.4 ± 12.0kg. Huertas et al. [26] also had a lighter group of participants with a mean body mass value of 66.9 ± 7.0 as well as Pieter and Barcades [28] which had a mean body mass of 64.2 ± 7.0kg. However, the mean weight in a study done by Giampietro et al. [27] was 72.4 ± 8.7kg and is similar to the kata and kumite values of the present study. On the other hand, the participants in a study done by Kostovski [25] had a mean body mass of 83.53 ± 5.06kg and the participants from a study done by Sterkowicz-Przybycień [29] had a mean body mass of 86.1 ± 8.2kg were heavier that the present studies values.

In the present study the mean BMI in the kata group was 25.93 ± 3.44 and was larger than the kumite group which had a BMI of 24.61 ± 2.70. Compared to a study done by Koropanovski et al. [30] where participants in the kata group had a mean BMI of 23.2 ± 1.8 and the kumite group had a mean BMI of 23.5 ± 2.1, the current study had higher BMI values which might be influenced by a heavier body mass.

In the present study the mean body fat percentage in the kata group was 11.22 ± 6.53% and was slightly higher than the kumite group which had a body fat percentage of 8.88 ± 2.48%, this could be due to the fact that the kumite group utilize their anaerobic energy source more than the kata group and thus burn more fat. Compared to a study done by Sánchez-Puccini et al. [24] where participants had a mean body fat percentage of 14.7 ± 4.3% and Huertas et al. [26] with a mean body fat percentage of 14.2 ± 5.3%, the participants in the present study had a lower body fat percentage. This was also the case when comparing the current study to Polish karateka, which had a mean body fat percentage of 16.8 ± 2.5% [29]. On the other hand, testing done by Giampietro et al. [27] resulted in a mean body fat percentage of 8.1 ± 2.4%, which was lower than the participants in the present study.

In the present study the mean endomorphic somatotype in the kata group was 3.24 ± 2.2 and was slightly larger than the kumite group which had a mean endomorphic somatotype of 2.82 ± 1.32. In contrast to a study done by Sánchez-Puccini et al. [24] where participants had a mean endomorphic somatotype of 4.0 and Sterkowicz-Przybycień [29] with a mean endomorphic somatotype of 3.7, the participants in the present study had smaller values. The present study’s kata and kumite group’s endomorphic somatotypes were greater than the participants from a study done by Giampietro et al. [27] which had an endomorphic somatotype of 2.1. The same occurred when compared...
to a similar study done by Huertas et al. [26] and Pieter and Barcades [28], which were endomor-
phic somatotype of 2.7 and 3.7 respectively. 
In the present study the mean endomorphic somatotype in the kata group was 1.60 ± 2.49 
and was much smaller than the kumite group 
which had a mean endomorphic somatotype of 
8.68 ± 2.53, this could be due to the fact that the kumite group need to present more strength as they face real opponents. The kumite group of the present study has much larger values in con-
trast to a study done on Columbian karateka [24] and North American [26] karateka who pre-
sented mesomorphic somatotype values of 4.2 
and 4.3, respectively. Other studies done were 
also larger than the kata group of the present 
study, such as Giampietro et al. [27] who pre-
sented mean mesomorphic somatotype values of 3.5 
for the Italian karate team. In the present study the mean endomorphic somatotype in the kata group was 1.76 ± 1.12 and was slightly lower than the kumite group which had a mean endomor-
phic somatotype of 2.05 ± 1.05, this could be due to 
the premise that endomorphic somatotype is 
best for kata performance. Similarly, a study done by Sánchez-Puccini et al. [24] presented a mean endomorphic somatotype of 2.1. In comparison, a study done by Sterkowicz-Przybycień [29] pro-
vided mean ectomorphic somatotype values of 1.3, which is lower than the present study. On 
the other hand, studies completed on Italian karateka [27] and North American karateka [26] who presented ectomorphic somatotype values of 3.1 and 3.0, respectively, were larger than the pres-
ent study. Other studies done were also larger 
than the current studies values, such as Pieter and Barcades [28], who presented ectomorphic somatotype values of 2.5.

CONCLUSIONS

The research has concluded that kinanthropom-
metric attributes of South African male karate-
athletes between the ages of 18-65 participat-
ing in kata and kumite, is influenced by the high 
levels of training which they are exposed to, does influence their karate performance, is at a mod-
erately healthy level and is positively affected by karate training as no kinanthropometric health 
risks are evident. Further research will benefit 
from comparing physical attributes and anthro-
pomorphic variables of novice and elite karateka 
as well as a control group. This will offer greater awareness and more specific information about the effects of kinanthropometry on karate performance, particularly when more groups for a greater comparison are provided. Martial arts can move from experienced-based training to evidence-based training.

REFERENCES

from the Middle East and native Swedish women: a cross-sectional study. Cardiovasc Diabetol 2007; 6(10)


Cite this article as: Nichas A, Shaw BS, Millard L et al. Kinanthropometric attributes of elite South African male kata and kumite karateka. Arch Budo 2020; 16: 181-194