Kinanthropometric attributes of elite South African male kata and kumite karateka

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B Data Collection
C Statistical Analysis
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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 kinathropometric variables and across all age groups. Conversely, significant differences in the kumite group existed for all measured kinathropometric variables across all age groups ($p\leq0.000$). 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

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Kinanthropometric - the study of human size, shape, proportion, composition, maturation, and gross function, in order to understand growth, exercise, performance, and nutrition.

Kata (form) – is executed as a specified series of a variety of moves, with stepping and turning, while attempting to maintain perfect form. Kata displays a transition and flow from one posture and movement to another, teaching the karateka proper form and position, and encouraging them to visualize different scenarios for the use of each motion and technique in imaginary bout. There are various forms of kata developed through different karate styles.

Kumite – is one of the three main sections of karate training, along with kata and kihon. Kumite is the part of karate in which a person trains against an adversary, using the techniques learned from the kihon and kata.

Body fat percentage – the body fat percentage (BFP) of a human or other living being is the total mass of fat divided by total body mass, multiplied by 100; body fat includes essential body fat and storage body fat.

Endomorph – an individual with a higher percentage of body fat with less muscle mass.

Ectomorph – an individual with a lean and delicate build of body.

Mesomorph – an individual whose build is compact and muscular.

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;

Table 1. Descriptive data of sampled South African Male Karateka.

Variable	Kata (n = 22)	Kumite (n = 24)	Combined (n = 46)
Age (years)	31.41±14.02	28.25±6.94	33.09±13.14
Stature (m)	1.74±0.09	1.75±0.09	1.73±0.09
Body Mass (kg)	78.63±10.12	75.77±10.34	76.78±9.40

Values are presented as means and standard deviations (±)

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 to the nearest one hundred grams on a calibrated medical scale (Trojan, BSA16056v, Duteck Industrial co. ltd, Taiwan). Participants were asked to step onto the scale wearing minimal clothing and removed their shoes and any jewellery [8]. BMI is used to estimate a healthy body mass range relative to stature. The following equation was used: BMI = body mass (kg) ÷ $(\text{stature})^2$ (m) [8]. The DuBois formula of BSA is a standardised formula [11] which was used and is as follows: BSA $(m^2) = 0{,}20247 \times s\ (cm)^{0{,}725} \times bm\ (kg)^{0{,}425}$.

BF% were calculated using the MOGAP equation: Males BF%= [sum 6SF x 0.1051] + 2.585 [12]. The sum of six skinfolds from the triceps, subscapular, suprailiac, abdominal, thigh and calf regions were required from the right side of the body. Skinfolds were taken and were 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, suprailiac, 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 breadths 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: WHR= waist circumference ÷ 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: WSR: Waist circumference ÷ 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: Conicity index = waist circumference (m) ÷ [0.109 x √ body mass (kg) ÷ stature (m)] [20]. Adiposity body shape index (ABSI) measures abdomen adiposity and is clinically used to estimate mortality risk. The adiposity body shape index was calculated as follows: ABSI = (waist circumference (cm) / [BMI^2/3 x height (m) ^1/2]) [21]. Body adiposity index (BAI) measures adiposity in the body and was created as an alternative to BMI. Body adiposity index correlates highly with the dual-energy x-ray absorptiometry [22]. Body adiposity index was calculated as follows: BAI = (hip circumference (cm) / [stature (m) ^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]:

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

where:

ΣSF= the sum of skinfolds = tricep + subscapular + suprailiac x (170.18÷stature [cm])

Mesomorphic = (0.858 x humerus breadth) + (0.601 x femur breadth) + (0.188 x corrected arm girth) + (0.161 x corrected calf girth) – (stature x 0.131) + 4.5

where:

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

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

Thus, if HWR;

HWR ≥ 40.75 : ecto = 0.732 x HWR – 28.58

= 40.75 > HWR >38.25 : ecto = 0.463 x HWR – 17.63

= HWR ≤38.25 : 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≤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 the combined group when comparing the 18-25 year-old's stature in the combined group to the 26-45-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 cormic index when comparing the 18-25 year-old's cormic 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 cormic 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 cormic 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 the combined group when comparing the 18-25 year-old's stature in the combined group to the 26-45-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 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 body 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). In addition, no significant difference in ∑SF was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.537). However, there was a significant difference between the 18-25 year-old's ∑SF in the kumite group when compared to the 26-45-year-old group (p = 0.000) and also when compared to the 46-65-year-old group (p = 0.000). Additionally, a significant difference in ∑SF 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 ∑SF in the combined group to the 26-45-year-old group (p = 0.937) and the 46-65-year-old group (p = 0.442). Additionally, no significant difference was found in ∑SF when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.735).

There was no significant difference in fat mass when comparing the 18-25 year-old's fat mass in the kata group to the 26-45-year-old group (p = 0.411) and the 18-25 group to the 46-65 group (p = 0.915). Additionally, no significant difference in fat mass was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.883). However, there was a significant difference between the 18-25 year-old's fat 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 fat 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 fat mass in the combined group to the 26-45-year-old group (p = 0.997) and the 46-65-year-old group (p = 0.703). Additionally, no significant difference was found in fat mass when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.800).

There was no 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 LBM 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 LBM 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 LBM in the combined 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 = 1.000).

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 = 0.997). 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 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 the combined group when comparing the 18-25 year-old's elbow breadth in the combined group to the 26-45-year-old group (p = 0.362) and the 46-65-year-old group (p = 0.993). Additionally, no significant difference was found in elbow breadth when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.700).

There was no significant difference in calf circumference when comparing the 18-25 year-old's calf circumference in the kata group to the 26-45 group (p = 0.597) and the 46-65 group (p = 0.825). Additionally, no significant difference in calf circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.995). However, there was a significant difference between the 18-25 year-old's calf 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). 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). Conversely, no significant difference was found in the combined group when comparing the 18-25 year-old's calf circumference in the combined group to the 26-45-year-old group (p = 0.792) and the 46-65-year-old group (p=0.142). In addition, a significant difference was found in calf circumference when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p = 0.032).

There was no significant difference in biceps circumference when comparing the 18-25 year-old's biceps 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 = 0.979). Additionally, no significant difference in biceps circumference was found when comparing the 26-45-year-old group to the 46-65-year-old group (p = 0.971). However, there was a significant difference between 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). Furthermore, a significant difference in biceps 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 combined group to the 26-45-year-old group (p = 0.989) and the 46-65-year-old group (p = 0.874). Additionally, no significant difference was found in biceps circumference when comparing the 26-45-year-old's in the combined group to the 46-65-year-old group (p = 0.751).

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=0.168). However, there was a significant difference between the 18-25 year-old's waist 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). 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 the combined group when comparing the 18-25 year-old's waist circumference in the combined group to the 26-45-year-old group (p = 0.916) and the 46-65-year-old group (p = 0.819). Additionally, no significant difference was found 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 hip circumference in the combined group to the 26-45-year-old group (p = 0.962) and the 46-65-year-old group (p = 1.000). Furthermore, no significant difference was found in hip circumference when comparing the 26-45 year-old's in the combined group to the 46-65-year-old group (p= 0.980).

There was no significant difference in WHR 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 WHR 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 WHR 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 WHR 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 WHR in the combined group to the 26-45-year-old group (p = 0.961) and the 46-65-year-old group (p = 0.090). However, 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). 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). Additionally, 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 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 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 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 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 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 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 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 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 2. Kinanthropometric attributes of South African male karateka competing in kata.

Variable (indicator)	18-25 years (n = 9)	26-45 years (n = 8)	46-65 years (n = 5)	Total (n = 22)
Stature (m)	1.76±0.06	1.75 ±0.09	1.69 ±0.10	1.74 ±0.09
Cormic index	88.67±6.44	86.25 ±7.67	82.40 ±3.21	86.36 ±6.59
Body mass (kg)	78.77±11.17	79.79 ±9.83	76.54 ±10.52	78.63 ±10.11
BMI	25.24±3.92	26.00 ±2.73	27.04 ±3.97	25.93 ±3.44
BSA	1.95±0.13	1.95 ±0.15	1.87 ±0.16	1.93 ±0.14
Body fat (%)	13.31 ±8.68	8.44 ±3.33	11.90 ±5.34	11.22 ±6.53
Sum of 6 skinfolds (mm)	93.78 ±76.31	51.13 ±29.35	80.80 ±46.56	75.32 ±57.40
Fat mass (kg)	10.83 ±8.31	6.72 ±2.71	8.92 ±3.78	8.90 ±5.91
Lean body mass (kg)	67.94 ±9.41	73.07 ±9.35	67.62 ±11.37	69.73 ±9.70
Knee breadth (cm)	8.12 ±0.69	7.95 ±0.51	8.02 ±0.87	8.04 ±0.65
Elbow breadth (cm)	6.53 ±0.48	6.40 ±0.52	6.16 ±0.63	6.40 ±0.52
Calf circumference (cm)	37.78 ±4.12	35.75 ±2.71	36.20 ±4.15	36.68 ±3.62
Bicep circumference cm)	34.11 ±5.04	34.25 ±4.46	33.20 ±4.32	33.95 ±4.48
Waist circumference cm)	76.44 ±6.50	77.25 ±5.92	85.00 ±8.72	78.68 ±7.40
Hip circumference (cm)	85.11 ±10.45	85.50 ±7.27	91.80 ±12.48	86.77 ±9.83
WHR	0.90 ±0.04	0.90 ±0.04	0.93 ±0.05	0.91 ±0.04
WSR	43.33 ±4.67	44.29 ±5.32	50.77 ±7.89	45.37 ±6.23

Variable (indicator)	18-25 years (n = 9)	26-45 years (n = 8)	46-65 years (n = 5)	Total (n = 22)
SAD	14.56 ±3.04	14.13 ±3.18	16.40 ±2.19	14.82 ±2.94
Conicity index	140.04 ±7.24	139.41 ±12.13	150.56 ±14.83	142.20 ±11.51
ABSI	33.26 ±7.93	30.85 ±6.92	30.85 ±9.99	31.83 ±7.77
BAI	18.39 ±5.99	19.13 ±5.29	24.60 ±9.98	20.07 ±6.96
Endomorph	3.97 ±2.66	2.15 ±1.29	3.68 ±2.25	3.24 ±2.22
Mesomorph	0.95 ±3.03	2.19 ±1.63	1.80 ±2.78	1.60 ±2.49
Ectomorph	2.28 ±1.08	1.62 ±0.99	1.05 ±1.15	1.76 ±1.12

Values are presented as: Means±SD; * Significant (p ≤ 0.05) difference between 18-25-year-old group and the 26-45-year-old group; ** Significant (p≤0.05) difference between 18-25-year-old group and 46-65-year-old group; *** Significant (p≤0.05) difference between 26-45-year-old group and the 46-65-year-old group. # Significant (p≤0.05) difference for the combined 18-25-year-old group and the 26-45-year-old group. ## Significant (p≤0.05) difference for the combined 18-25-year-old group and 46-65-year-old group. ### Significant (p≤0.05) difference for the combined 26-45-year-old group and the 46-65-year-old group. m: metres; kg: kilogrammes; BMI: body mass index; BSA: body surface area; %: percentage; mm: millimetres; cm: centimetres; WHR: waist to hip ratio; WSR: waist to stature ratio; SAD: sagittal abdominal diameter; ABSI: adiposity body shape index; BAI: body adiposity index.

Table 3. Kinanthropometric attributes of South African male karateka competing in kumite.

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

Variable (indicator)	18-25 years (n = 10)	26-45 years (n = 13)	46-65 years (n = 1)	Total (n = 24)
ABSI	37.06 ±5.44	**33.79 ±7.31***	**41.60**,***	35.48±6.62
BAI	18.59 ±5.00	**20.02 ±4.66***	**16.97**,***	19.30±4.68
Endomorph	2.35 ±1.03	**3.00 ±1.38***	**5.20**,***	2.82±1.32
Mesomorph	7.33 ±14.92	**10.27 ±28.23***	**1.36**,***	8.68±22.53
Ectomorph	2.36 ±0.73	**1.81 ±1.26***	**2.14**,***	2.05±1.05

Values are presented as Means±SD;
* Significant (p≤0.05) difference between 18-25-year-old group and the 26-45-year-old group;
** Significant (p≤0.05) difference between 18-25-year-old group and 46-65-year-old group;
*** Significant (p≤0.05) difference between 26-45-year-old group and the 46-65-year-old group.
# Significant (p≤0.05) difference for the combined 18-25-year-old group and the 26-45-year-old group.
Significant (p≤0.05) difference for the combined 18-25-year-old group and 46-65-year-old group.
Significant (p≤0.05) difference for the combined 26-45-year-old group and the 46-65-year-old group.
m: metres; kg: kilogrammes; BMI: body mass index; BSA: body surface area; %: percentage; mm: millimetres; cm: centimetres; WHR: waist to hip ratio; WSR: waist to stature ratio; SAD: sagittal abdominal diameter; ABSI: adiposity body shape index; BAI: body adiposity index.

group's mean stature of 173.75m. 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 ±2.22 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 endomorphic somatotype of 2.7 and 3.7 respectively. In the present study the mean mesomorphic somatotype in the kata group was 1.60 ±2.49 and was much smaller than the kumite group which had a mean mesomorphic 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 contrast to a study done on Columbian karateka [24] and North American [26] karateka who presented 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 presented mesomorphic somatotype values of 3.5 for the Italian karate team. In the present study the mean ectomorphic somatotype in the kata group was 1.76 ±1.12 and was slightly lower than the kumite group which had a mean ectomorphic somatotype of 2.05 ±1.05, this could be due to the premise that ectomorphic 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] provided 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 present 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 kinanthropometric attributes of South African male karate athletes between the ages of 18-65 participating 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 moderately 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 anthropometric 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

1. Tabben M, Chaabene H, Franchini E et al. The influence of karate practice level and sex on physiological and perceptual responses in three modern karate training modalities. Biol Sport 2014; 31(3): 201-207
2. Woodward TW. A review of the effects of martial arts practice on health. Wis Med J 2009; 108(1): 40-43
3. Imamura H, Yoshimura Y, Uchida K et al. Maximal oxygen uptake, body composition and strength of highly competitive and novice karate practitioners. Appl Human Sci 1998; 17(5): 215-218
4. Doria C, Veicsteinas A, Limonta E et al. Energetics of karate (kata and kumite techniques) in top-level athletes. Eur J Appl Physiol 2009; 107(5): 603-610
5. Iide K, Imamura H, Yoshimura Y et al. Physiological responses of simulated karate sparring matches in young men and boys. J Strength Cond Res 2008; 22(3): 839-844
6. Vujkov S, Obadov S, Trivić T et al. Differences in physical fitness in kumite and kata performance between female karate athletes. Proceedings of the 1st International Scientific Conference Exercise and Quality of Life; 2009 Sep 25-27; Halkidiki, Greece
7. Stewart A. Kinanthropometry – the interdisciplinary discipline. J Sports Sci 2007; 25(4), 373
8. American College of Sports Medicine (ACSM). ACSM's guidelines for exercise testing and prescription (8th ed.). Baltimore: Lippincott Williams & Wilkins; 2010
9. Ross WD, Marfell-Jones MJ. Kinanthropometry in: MacDougall JD, Wenger HA, Green HJ (eds). Physiological testing of the high-performance athlete. Champaign: Human Kinetics; 1991
10. Fagherazzi G, Vilier A, Boutron-Ruault MC et al. Height, sitting height, and leg length in relation with breast cancer risk in the E3N cohort. Cancer Epidem Biomar 2012; 21(7): 1171-1175
11. Kouno T, Katsumata N, Mukai H et al. Standardization of the body surface area (BSA) formula to calculate the dose of anticancer agents in Japan. Jpn J Clin Oncol 2003; 33(6): 309-313
12. Almeida AH, Santos SA, Castro PJ et al. Somatotype analysis of physically active individuals. J Sport Med Phys Fit 2013; 53(3): 268-273
13. Hume R. Prediction of lean body mass from height and weight. J Clin Pathol 1966; 19(4): 389-391
14. Heyward VH, Wagner DR. Applied body composition assessment. (2nd ed.) Albuquerque: Human Kinetics; 2004
15. Lam BCC, Koh GCH, Chen C et al. Comparison of body mass index (BMI), body adiposity index (BAI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) as predictors of cardiovascular disease risk factors in an adult population in Singapore. PLoS One 2015; 10(4): e0122985
16. Iribarren C, Darbinian JA, Lo JC et al. Value of the sagittal abdominal diameter in coronary heart disease risk assessment: cohort study in a large, multi-ethnic population. Am J Epidemiol 2006; 164(12): 1150-1159
17. Petersson H, Daryani A, Risérus U. Sagittal abdominal diameter as a marker of inflammation and insulin resistance among immigrant women

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

18. de Almeida Paula HA, de Cássia Lanes Ribeiro R, de Lima Rosado LEFP et al. Relationship between waist circumference and supine abdominal height measured at different anatomical sites and cardio-metabolic risk factors in older women. J Hum Nutr Diet 2012; 25(6): 563-568
19. Mantzoros CS, Evagelopoulou K, Georgiadis EI et al. Conicity index as a predictor of blood pressure levels, insulin and triglyceride concentrations of healthy premenopausal women. Horm Metab Res 1996; 28(1): 32-34
20. Taylor RW, Jones IE, Williams SM et al. Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3–19 y. Am J Clin Nutr 2000; 72(2): 490-495
21. Thomson CA, Garcia DO, Wertheim BC et al. Body shape, adiposity index, and mortality in premenopausal women: findings from the women's health initiative. Obesity 2016; 24(5): 1061-1069
22. Ramirez R, Gonzalez K. Body adiposity index in Colombian elite athletes: a comparison between the body mass index and other measures. Rev Colomb de Cardiolog 2015; 22(1): 22-26
23. Carter JL, Heath BH. Somatotyping: development and applications (Vol. 5). Cambridge University Press; 1990
24. Sánchez-Puccini MB, Argothy-Bucheli RE, Meneses-Echávez JF et al. Anthropometric and physical fitness characterization of male elite karate athletes. Int J Morphol 2014; 32(3): 1026-1031
25. Kostovski Z. Factorial structure of karate elements in sport fight and their influence on the achievement effects on karate sportsman (cadets) from R. Macedonia. Sportske nauke i zdravlje (Sport Sci Health) 2016; 1(2): 81-88
26. Huertas G, De-Los-Santos H, Bersain D et al. Estudio antropométrico de la elite sudamericana juvenil de karate. ISEF Digital 2006; 8: 1-37
27. Giampietro M, Pujia A, Bertini I. Anthropometric features and body composition of young athletes practicing karate at a high and medium competitive level. Acta Diabetol 2003; Supplement: 1: S145-148
28. Pieter W, Bercades LT. Somatotype of national elite combative sport athletes. Braz J Biomotricity 2009; 3(1): 21-30
29. Sterkowicz-Przybycień KL. Body composition and somatotype of the top of polish male karate contestants. Biol Sport 2010; 27: 195-201
30. Koropanovski N, Berjan B, Bozic PR et al. Anthropometric and physical performance profiles of elite karate kumite and kata competitors. J Hum Kinet 2011; 30: 107-114

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