ANTHROPOMETRIC PROFILING OF STATE LEVEL SEPAK TAKRAW PLAYERS

By

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players

LIST OF ABBREVIATIONS

BMI	Body Mass Index
cm	Centimeter

Kilogram

kg

.

ABSTRAK

ANTROPOMETRI PROFIL PEMAIN SEPAK TAKRAW PERINGKAT NEGERI

PENGENALAN: Data antropometri amat penting dalam mengenal pasti bakat dan menjalankan program pembangunan. Setakat ini, profil komponen antropometri antara pemain sepak takraw di peringkat negeri adalah sedikit . Oleh itu, kajian ini dijalankan untuk menyediakan data komponen antropometri pemain sepak takraw bagi umur di bawah 15 dan 18 terutamanya di peringkat negeri (peringkat pembangunan). TUJUAN: Kajian ini dijalankan untuk menilai profil antropometri dan jenis bentuk badan pemain sepak takraw di peringkat negeri. KAEDAH: Lima puluh empat peserta lelaki (n = 54) telah mengambil bahagian dalam kajian ini, mereka adalah berasal dari Pulau Pinang (n = 30) dan Kelantan (n = 24). Semua peserta kini bermain di peringkat negeri dan berumur antara 13 hingga 18 tahun. Para peserta telah diukur ketinggiaan berdiri dan duduk, berat, ukuran lipatan kulit (8 bahagian lipatan kulit), ukur lilit (betis dan lengan dalam keadaan tegang) dan keluasan (iaitu tulang bahagian tepi siku dan lutut). KEPUTUSAN: Keputusan menunjukkan data antropometri peserta-peserta bagi berat, ketinggian berdiri dan duduk, peratusan lemak badan dan nilai somatotaip. Peserta yang tertinggi di antara ketiga-tiga posisi bagi pemain kategori bawah 15 tahun adalah tekong (165.57 \pm 9.05 cm). Bagi kategori di bawah 18 tahun, pemain yang tertinggi adalah apit kanan (168.31 ± 5.94 cm). Jumlah purata BMI untuk ketiga-tiga posisi untuk pemain bawah 15 dan 18 tahun adalah 19.43 \pm 2.70 kgm⁻² dan 21.40 \pm 2.45 kgm⁻², masing-masing. Ukuran paling tinggi untuk ketinggian duduk antara ketiga-tiga posisi pemain bawah 15 dan bawah 18 tahun adalah tekong dengan nilai 85.56 ± 4.83 cm dan 87.64 ± 3.02 cm. Purata peratusan untuk lemak badan yang tertinggi bagi pemain bawah 15 tahun adalah tekong (6.53 ± 3.15%) manakala nilai terendah adalah apit kanan ($4.45 \pm 1.54\%$). Sementara itu, purata untuk lemak badan tertinggi bagi pemain bawah 18 adalah tekong ($6.52 \pm 3.51\%$). Kemudian, nilai terendah adalah apit kanan ($5.15 \pm 3.14\%$). Akhir sekali, bagi nilai somatotaip, jumlah purata nilai somatotaip untuk pemain bawah 15 adalah 2.3-4.4-3.2 yang dirujuk sebagai kategori *ectomorphic-mesomorph*. Di samping itu, jumlah purata nilai somatotaip untuk pemain bawah 12 adalah 2.3-4.4-3.2 yang dirujuk sebagai kategori *ectomorphic-mesomorph*. Di samping itu, jumlah purata nilai somatotaip untuk pemain bawah 18 tahun adalah 2.2-5-2.8 yang dirujuk sebagai kategori *ectomorphic-mesomorph*. KESIMPULAN: Pengukuran nilai antropometri dan somatotaip pemain sepak takraw di peringkat negeri menunjukkan bentuk tubuh badan dan komposisi badan yang berbeza di antara ketiga-tiga posisi. Data yang terhad dalam kajian sebelum ini menjadikan hasil kajian ini akan memberi maklumat baru dan menyumbang kepada prestasi dan pemilihan atlet dalam sepak takraw.

ABSTRACT

ANTHROPOMETRIC PROFILING OF STATE LEVEL SEPAK TAKRAW PLAYERS

INTRODUCTION: Data of anthropometric measurement are important for talent identification and developmental program. To date, the profile of anthropometric components among state level sepak takraw players have been scarce. Thus, this study was carried out to provide data on anthropometric components of sepak takraw players for age under 15 and 18 year old especially at the state (developmental) level. PURPOSE: This study was carried out to access the anthropometric profile and body type of state level sepak takraw players. METHOD: Fifty four males participants (n = 54) participated in this study, who originated from Penang (n = 30) and Kelantan (n = 30)24). All participants were currently playing at state level and age ranging from 13 to 18 years old. The participants were measured for their standing and sitting height, weight, skinfold measurement (i.e. 8 sites skinfold), girth (i.e. calf and arm flexed with tensed) and breadth (i.e. humerus and femur). RESULT: The result represented the participants' anthropometric data of the standing height, body weight, sitting height, percentage of body fat and somatotype value. The tallest between all three positions in under 15 category was server 165.57 ± 9.05 cm. Under 18 category, the tallest player was the killer 168.31 ± 5.94 cm. The total mean of BMI for all three positions for under 15 category was 19.43 ± 2.70 kgm⁻² and 21.40 ± 2.45 kgm⁻² for under 18 category respectively. The highest measure for sitting height between all three positions in under 15 and under 18 category was the server (85.56 ± 4.83 cm) and (87.64 ± 3.02 cm). The highest mean percentage of body fat for under 15 category was the server (6.53 ± 3.15 %) while the lowest value was the killer (4.45 \pm 1.54 %). Meanwhile, the highest mean percentage of body fat for under 18 category players was the server $(6.52 \pm 3.51 \%)$.

Then, the lowest value was the killer $(5.15 \pm 3.14 \%)$. Finally, for somatotype, the total mean of somatotype value for players under 15 category was 2.3-4.4-3.2 which is refer to as ectomorphic-mesomorph category. In addition, the total mean of somatotype value for players under 18 category was 2.2-5-2.8 which is refer to as ectomorphic-mesomorph category. **CONCLUSION:** The measurement of the anthropometric and somatotype value of state level sepak takraw players showed different body physique and body composition among all three positions. Since there were limited data in previous study, thus, results of this study will provide new information and contribute to the athletes' performance and selection of athletes in sepak takraw.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Sepak takraw is originated in the South-East Asia and has been traced in 15th century. The first tournament of sepak takraw which was held in Southeast Asian was in the Southeast Asian Games in 1965. The International Sepak Takraw Federation was established in 1992 and has been membership from USA, Korea, China, Japan and many European countries. Sepak takraw is also a main sport that played in Malaysia. The nature of sepak takraw in Malaysia has long grown from year to year. There are several categorical age of the tournament in Malaysia such as under 12, under 15, under 18, under 21 and senior team.

Sepak takraw is the sports that played in a court with two side of two teams. Each team is consisted of three players. Each position consists of a spiker, a server and a feeder. Figure 1.1 shows the three positions in sepak takraw.



Figure 1.1 Position of sepak takraw player

Each team is given chance to hit the ball only with three touches and then the ball has to be delivered to the opponent side without touch the ground. Players also are allowed to touch or juggle the ball of any part of the body except upper body limb. The score line of the sepak takraw game nowadays are involving three sets with 21 points in each set, where a team that wins two sets from the three sets will win the game (Aziz *et al.*, 2003). Sepak takraw needs several skill to execute moving during playing. Each position has different data of their profile.

Limited study have been conducted regarding profiling of sepak takraw players. There are several components in profiling the sports such as physiological, psychological and anthropometric components. One of the interesting component for state level sepak takraw players is anthropometric measurement. Norton *et al.* (1996) stated that anthropometry is the measurement of body dimension and body sites. Several components of anthropometric measurement are somatotype and body composition (which include height, weight, body mass index and percentage and body fat). According to Hoffman (2006), body composition is refered to the proportion of body weight that is from fat relative to the amount of weight that is from lean tissue. Somatotype is the method of describing the quantification of present shape and composition of the human body physique (Carter, 2002). The somatotype value has three numerical values which represent endomorphy, mesomorphy and ectomorphy value.

Generally, sepak takraw is a game that combines the the skills such as kicking, ball control during juggling, acrobatic move, flexibility, agility and power. All these skills associate with the the body physique of players. The combinations between body physique or body type with flexibility, power, strength and agility are needed to get the optimal performance. Usually, the body physical of server and spiker are higher than feeder. Meanwhile, some of the teams have players with almost the same height, i.e between server and spiker and some have taller server than spiker and feeder.

The extent to which the truth about the body composition and body physique of sepak takraw players, is uncertainty. Thus, this research is to examine the components of the anthropometric and somatotype of sepak takraw players which are useful for data references. Anthropometric components are thought to play a major role in the success of participants at all levels of sports competition (Hasan *et al.*, 2007). Claessens *et al.* (1999), stated that optimal performance for each sports is result from the combination of several factors such as body composition, somatotype and anthropometric measurement.

To our knowledge, profiling data of players have become a very important process on the road excellence in sports (Jawis *et al.*, 2005). Since, there are limited study about anthropometric measurement of sepak takraw players. Thus, the present study is warranted to fill in this gap of knowledge of profiling of anthropometric components of sepak takraw players at state level.

1.2 Objective

General objective

 To describe the anthropometric profile and body types of state level sepak takraw players.

Specific objective

- 1. To assess the anthropometric profile of state level sepak takraw players.
- 2. To identify the somatotype of state level sepak takraw players.

1.3 Significance of Study

This study can contribute for development and selection of athlete who are involved in sepak takraw. The data collected can be useed by coaches as reference data for the anthropometric measurement of their state players. This study can also identify the body type or body physique among the sepak takraw players since each position has different anthropometric profile.

CHAPTER 2

LITERATURE REVIEW

2.1 Anthropometry

Anthropometry is an area that associate with the measurement of size, weight and proportions of the human body (Maud and Foster, 2006). The anthropometric technique are including measurement height, weight, body mass index (BMI), girth, breadth and skinfold measurement (percentage of fat) that used to estimate the body ⁻ composition and body size (Lohman *et al.*, 1997). There were various type of techniques to determine body composition and somatotype measurement in sport performance.

2.2 Body Composition

Body composition is the main component that is related to the disease, premature of death and changes with age (Svendsen *et al.*, 1995). Based on Eston & Beilly, (2009), they state that body composition is the technique of assessing of body fatness in relation to health status and performance. Body composition is used to describe the percent of fat, water, bone and muscle in human bodies.

Body composition are important for athletes. Newton's Second Law show that the increasing of fat mass and the force of muscular contraction will decrease acceleration or speed off the mark which is an important factor in most sports (Withers *et al.*, 1987). Besides, the additional fat mass requires extra energy expenditure which increases the relative stress (Withers *et al.*, 1987). Meanwhile, low level of fat free mass will cause the critical condition especially the group of elderly, infants and those with muscle wasting-disease (Dempster and Aitkens, 1995). Too little body fat aslo will risk the health because our body needs certain value of fat for normal function in body.

According to Maud and Foster, (2006), for being overweight (excess body fat) is related to musculoskeletal injuries and reduced performance. For example, every athletic need participants to move body quick and fast, but excess body fat will affect or reduce the speed, agility, jumping and overall performance.

2.2.1 Height, Weight and Body Mass Index (BMI)

To date, there is limited literatures have been published on the anthropometric measurement among sepak takraw players. According to the study by Hamid *et al.* (2014), suitable body weight and body composition were important aspect for athletes. Physical demand of sports also caused the optimal body size and composition characteristics vary from sport to sport. Data that have been collected by Hamid *et al.* (2014), showed that servers were the tallest among the three positions. Thus, server with the longer lower limb was able to contact the ball at higher point of mid-air and downward in sharp service. Hamid *et al.* (2014) reported that the range of body height for sepak takraw player is between 1.68 to 1.75m. Supported by Aziz *et al.* (2003) it was found in their study that the server was taller than feeder. However, Jawis et al. (2005) found that there was no different in the height of sepak takraw players.

Then, based on data represented by Jawis *et al.* (2005), the body weight of sepak takraw players in Malaysia were within Malaysian population norms. Since there was no comparison data of body weight for sepak tkaraw players, so the best comparison with other sports was badminton (court game). When compared to the

badminton data by Campos et al, (2009), the body weight of young badminton athletes from Brazil team show that the body weight almost in the same range to the under 18 malaysian sepak takraw players.

Body mass index (BMI) is the calculation of weight in kilograms divided by height in meter squared and then rounded to one decimal place (Ogden *et al.*, 2008). BMI is a parameter that usually used to screen the excess body fat and it is easy to be determined and correlated with body fat (Ferrera, 2006). Besides, BMI also used to classify obesity and to assess disease risk (Hoffman, 2006). Hamid *et al.* (2014) in their study stated that sepak takraw players have higher BMI. The average BMI that found by them was 21.76 which was within the normal category.

Thus, it is important to have the correct body composition and weight for athletes. Moreover, more studies about body height, body weight and body composition of sepak takraw players are required to confirm these finding. Thus, measurement in anthropometric components very important evaluation for the better selection of sepak takraw players.

2.2.2 Percentage of body fat : skinfold measurement

Skinfold measurement is one of the method of anthropometric measurement. According to Eston and Beilly, (2009), skinfold method is a method of measuring a thickness fold of skin and subcutaneous adipose tissue in certain parts of body. Skinfold measurement is important in profiling anthropometric and to determine percentage of body. There were several equations that have been discovered to determine the percentage of body fat from the measurement of certain skinfold landmarks. For example Jackson and Pollock equation, Sloan equation, Durnin and Womerseley, Parillo calliper method and yuhasz method. Most of the researchers recommended the Jackson and Pollock equation (Ostojic, 2006).

A previous study by Jawis *et al.* (2005) used the four-site equation of Jackson and Pollock method to determine the percentage of fat. While, another previous study by Hamid *et al.* (2014) used bioelectrical impedance analysis (BIA) to determine percentage body fat, but not required measurement of skinfold. There were pro and cons between both methods. There were reliability and validity differences between both methods of measuring percentage of fat. Measurement skinfold method is suitable for outside and field test compared to BIA which is suitable for laboratory test. But, to date it is still not clear which method are more reliable and valid because it depends on the situation and research that is conducted.

Jawis *et al.* (2005) used four site equation to determine percentage of body fat. In their study, they highlighted that percent of body fat between 8 and 12 % of body weight may be required for top level performance in sepak takraw. They also found that sepak takraw players appear leaner and less muscular.

Previous study by Aziz *et al*, (2003) stated that they measured the sum 7 sites of the skinfold among sepak takraw players of national level. The sum of skinfold measurement of the spiker is less than server and feeder. This mean that the spiker had low percentage compared to two others position, server and feeder, respectively.

Hamid *et al.* (2014) in their study found that the mean percentage of fat mass of the participants was in the normal range. Compared to the norm of percentage of fat for athlete, the result of mean percentage of fat mass were still within the acceptable range. This showed that the percentage of body fat of sepak takraw players were under control.

2.3 Somatotype

Somatotyping is defined as the method that express in three-number rating to represent the quatification of the present shape and composition of human body physique (Carter, 2002). Review by Eston and Beilly (2009) stated that somatotype is the human physique that is related to the body shape and composition. Somatotype can describe and compare the physique of athletes at all level of competition and in variety of sports. Besides, somatotyping also is used to describe the changes of posture and physical during the growth, increase of ageing, training and relation to the physical performance. Somatotype consists of three numeral rating (i.e endomorphy, mesomorphy and ectomorphy). For example 3.5-5-1. 3.5 refer to endomorphy, 5 value refer to mesomorphy and 1 is refer to ectomorphy.

Endomorphy refers to the first value of the three numerical value that represent somatotype. The physical characteristic of the endomorphy was described as roundness of the body, softness of the contours, relative volume of the abdominal trunk and distally tapering of the limbs (Eston and Beilly, 2009). In other word, endomorphy can be characterised as stocky, with a large round body, a short thick neck, short arms and legs, and with a tendency to store body fat.

Mesomorphy was the second value of the somatotype components. It characteristics can be described apparent robustness of the body in term of muscle or bone, relative volume of the thoracic trunk and possibly hidden muscle bulk (Eston and Beilly, 2009). In simple word, mesomorphy can be characterised as strongly built, with a broad muscular chest and shoulders, very muscular arms and legs, and little body fat.

Ectomorphy was the last value among the three numerical value of the somatotype. Eston and Beilly (2009) described ectomorphy as the body relative

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'stretched-outness', fragility of the limb and absence of any bulk (muscle, fat or other tissues). It also can be simplified that body would be tall and thin, with a narrow body, thin arms and legs, little body fat.

According Eston and Beilly, (2009), figure 2.1 shows to the region of the somatotype categories.



Figure 2.1 Region of somatotype.

1.Ectomorphic mesomorph = Mesomorph is dominant and ectomorph is greater than endomorph

2.Mesomorphic ectomorph = Ectomorphy is dominant and mesomorphy is greater than endomorphy

3.Endomorphic ectomorph = Ectomorphy is dominant and endomorphy is greater than mesomorphy

4.Ectomorphic endomorph = Endomorphy is dominant and ectomorphy is greater than mesomorphy

5.Mesomorphic endomorph = Endomorphy is dominant and mesomorphy is greater tha ectomorphy

6.Endomorphic mesomorph = Mesomorphy is dominant and endomorphy is greater than ectomorphy

Different categories represent different physique body characteristics. In this study, somatotype measurement had been used for data analysis. However, to our best understanding, there was no study that have been reported in the literature about somatotype of sepak takraw player that can be reviewed for comparison or references. Thus, for further review of study, somatotype calculation is important to determine the body type of each position. But, in a previous study, Jawis et al. (2005) stated that sepak takraw player was appeared leaner and less muscular. This mean that sepak takraw player was categorised as Ectomorphy group.

Generally, sepak takraw player of each positions consisted of server, killer and feeder with different physique characteristics. The server is usually tallest and most muscular. The killer is usually taller than the feeder but is smaller than the server, and

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less muscular in arm and leg as well as having broad chest. Meanwhile, feeder is usually the smallest among the three position and less muscular with thin arms and legs.

Last but not least, body composition and were important factors to determine performance in sports.

CHAPTER 3

METHODOLOGY

3.1 Participants

Fifty four (n=54) male sepak takraw players were recruited in this study, aged between 13 to 18 years old and currently selected to represent the state team.

3.2 Sample size calculation

Purposive sampling was used in this study. Participants were recruited among state levels sepak takraw players from Kelantan and Penang. Sample size was calculated using population estimation, with 95% confident interval, 5% margin error and population size of 60 of current state level athletes, The required sample size was 54. This study was conducted at the schools.

3.3 Procedure

Firstly, permission letter was sent to the head coach of the Kelantan and Penang of Sepak Takraw players. Following the initial contact with the team, ethical approval was obtained from the Ethical Committee Council of *Universiti Sains Malaysia* (USM).

A specific date was chosen for conducting the test with the participants. Before this research started, the participants were briefly explained about the background and the purpose of the research. The participants were asked to fill and sign the information form and consent forms as the confirmation to participate in the research. There were four stations set up for the measurement during conduct the participants. At first station, participants were measured for body height and body weight. Participants were marked for skinfold site at the second station. Then, the reading of skinfolds measurement were taken at the third station. At the last station, participants were measured for breadth and girth measurement.

3.4 Statistical analysis

The data was analysed using SSPS version 22 and expressed in descriptive statistics in mean and standard deviation for anthropometric measurements. Somatotype application of calculation and analysis version 1.2.6 was used to determine the somatotype plotting value on somatochart.

3.5 Research design



- N:54
- Sepak takraw player
- Level : state level
- Age : 13 to 18 years old
- Participantants : State players from Kelantan and Penang.



- Measure body height and body weight
- Skinfold measurement
- Somatotype calculation and measurement



3.6 Instruments and materials

The instruments and materials that were used in this research were stadiometer, weighing scale, skinfold callipers, measuring tape, small sliding calliper, pens, somatochart and aerobic step box.

3.6.1 Body weight and body height

SECA stadiometer was used to measure the body height. OMRON weighing scale (model Karadan scan) was used to measure the body weight.

3.6.2 Skinfold thickness

Harpenden skinfold callipers was used to measure the skinfold thickness. In addition, a pen were used to mark the site that need to be measured.

3.6.3 Somatotype

Somatotype calculation was determined by using Heat-Carter scale on somatochart with 4-site skinfold equation.

3.6.4 Breadth

Breadth measurements of femur and humerus were measured using Rosscraft small sliding calliper.

3.6.5 Girth

Girth measurement was measured using Rosscraft flexible measuring tape.

3.7 Study Protocol

Based on Norton *et al.* (1996), the anthropometric measurement protocol was used as below:

3.7.1 Standing height, sitting height and weight

During the research, the measurement of standing height, sitting height and body weight of participants were recorded. The measurement of standing height required the participants to stand with the heel and feet together, buttock and upper back touched the wall. The head was placed in the Frankfort plane. The Frankfort plane achieved when the lower edge of the eye socket was in the same horizontal plane as the notch superior to the tragus of the ear. The participants was instructed to hold a deep breath and kept the head in Frankfort plane. Then, the measurement was taken at the end of deep inward breath.

The measurement of the sitting height required the participant to sit on step box. Their hand rested at the side of their thigh. Then, the participant was instructed to take and hold a deep breath and kept the head in the Frankfort plane and the measurement was taken at the end of deep inward breath.

The measurement of body weight required the participant in minimal clothing. The reading of scale was ensured in zero. Then, the participant was instructed to stand on the centre of the scale without support and the measurement was taken.

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3.7.2 Body fat composition: Skinfold measurement

. The skinfold measurements were taken twice with Harpenden calliper, and when the difference between two trials were more than 10%, the third trial should be taken (Claessens *et al.*, 1999). Measurement can be used from 5 to 9 different standard anatomical sites around the body. The right side was usually only measured because for consistency. Eight sites of skinfolds were measured in this research. Eight sites of skinfold technique was selected because of its low relative cost, quick and less invasive when compared to reference methods such as hydrodensitometry, air displacement plethysmography, and dual-energy X-ray absorptiometry (Barreira *et al.*, 2013). In this study, the skinfold sites were triceps, subscapular, biceps, supraspinale, abdominal, thigh, iliac crest and medial calf.

Dick *et al.* (1975) stated the procedure of skinfold measurement. For triceps skinfold, participants were relaxed in standing position with left arm hanging by side and the right arm with the shoulder joint slightly externally rotated. Then, the elbow extended by the side of the body. The skinfolds were in parallel to the long axis of the arm.

For subscapular skinfold, the participants were relaxed in standing position with the arms hanging by the sides. Then, the line of the skinfold was determined by the diagonal natural fold line of the skin. The reading of the skinfold measurement was taken.

For biceps skinfold, the participants were relaxed in standing position with the left arm hanging by the side. Then the skinfold was measured in parallel to the long axis of the arm.

For iliac crest skinfold, the participants were relaxed in standing position with the left arm hanging by the side. The right arm abducted or placed across the trunk. Then, the line of skinfold slightly downward posterior-anterior and the fold was determined by natural fold and the skinfold measurement was taken.

For supraspinale skinfold, the participants were relaxed in standing position with the arm hanging by the sides. The fold was run medially downward about 45° angle as to determine the supraspinale skinfold measurement and the reading of measurement was taken.

For abdominal skinfold, the participants were relaxed in standing position with the arm hanging by the sides. 5cm fold horizontally from umbilicus was marked. After that, the skinfold was measured in vertical fold and reading of measurement was taken.

For thigh skinfold, the participants were in opposition at the edge of the box with the torso erect and the arms hanging by the sides. Then, participants were bent the right knee at a right angle. The measurement was taken by standing face the side of the participants on the lateral side of the thigh. The skinfold measurement was taken while the knee was bent.

For medial calf skinfold, the participants were relaxed in standing position with the arms hanging by the sides and the right foot placed on the box. Then the knee was bent about 90°. The participants were placed the right foot on a box with the calf relaxed. Then, the fold was parallel to the long axis of the leg and the reading of measurement of skinfold was taken.

All the sites of skinfold were repeated three time and the mean of the measurement was used to determine percentage of body fat.

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Nevill *et al.* (2008) stated the Jackson and Pollock method in determine the percentage of body fat for male is based on the formula as below:

% body fat = [0.29288 x sum of skinfolds] – [0.0005 x (sum of skinfolds)²] + (0.15845 x age) -5.76377,

Sum of skinfold (included abdominal, triceps, thigh and suprailiac) was measured in millimeter (mm).

3.7.3 Somatotype calculation

Somatotype is a method that expressed in three-number rating to represent the quatification of the present shape and composition of human body physique (Carter, 2002). It is the value that determine the somatotype which were represent endomorph, mesomorph and ectomorph. There were ten anthropometric dimensions to determine the somatotype measurement. Measurement of the body height and body mass, skinfold thickness of triceps skinfold, supraspinal, skinfold, subscapular skinfold and medial calf skinfold, biepicondylar breadths of humerus and femur as well as circumference dimensions of upper arm circumference and calf circumference in contraction situation.

Carter (2002) stated that the initially height was needed to measured. The height was measured by using a height scale. The participants stood straight and touched close to the wall. Then, both upper ear and lower border of the eye were adjusted horizontally and the participants were asked to breathe in and held, then the reading of the body height was recorded. Secondly, the body weight of participants was measured by using a weighing scale. The participants were stood on the centre of the platform weighing scale and the reading of weight was recorded.

Thirdly, the skinfold of triceps was measured. The participants were losen their arm and then a fold was raised at the back of arm and the reading of the skinfold measurement were taken.

Then, the subscapular skinfold was measured. The participants were raised the subscapular in the direction that is diagonal and laterally 45 degrees and reading of subscapular skinfold was taken.

The fifth anthropometric dimension that has been taken was supraspinale skinfold. Anterior superior iliac spine was raised the fold 5-7 cm above on diagonal line downwards and medially at 45 degrees. After that, reading of skinfold was recorded.

Then, the medial calf skinfold was measured. The participants were stood properly and raised a vertical skinfold on the medial side of the calf and at the maximum circumference of the calf. The Harpenden calliper was and the reading of skinfold was taken.

Then, the biepicondylar breadth of humerus and femur were measured. The reading was taken of the right side. For measurement of biepicondylar breadth of humerus, the participants flexed their elbow 90 degrees and the calliper was applied at the angle. Light pressure was given on the crossbars, so that the subcutaneous tissue was compressed. For the femur, the participants sat with knee right angle, then, the distance of lateral and medial epicondyles of femur was measured with light pressure on the crossbar, so that the subcutaneous tissue was compressed.

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Last two dimensions (i.e upper arm circumference and calf circumference in contraction condition) were measured. The measurements at the right side of upper arm and calf were measured. For the upper arm, the participants were done flexed and tensed their elbow at 90 degrees and 45 degrees, respectively. Then, the elbow extensors and flexors were contracted and the greatest reading of the circumference was taken.

While, for the calf circumference, measurement was done on the right side of calf. The participants were stood with feet slightly apart. After that, the flexible measuring tape was put around the calf and the greatest circumference of the calf was recorded. All the measured parts of the anthropometric were taken three times for mean calculation.

According to Carter (2002), the somatotype equations are :

Endomorphy equation

Endomorphy = $-0.7182 + 0.1451(X) - 0.00068(X^2) + 0.0000014(X^3)$

Where X= (sum of triceps, subscapular and supraspinale skinfold) multiplied by (170.18/height in cm)

Mesomorphy equation

Mesomorphy = 0.858 x humerus breadth + 0.601 x femur breadth + 0.188 x corrected arm girth + 0.161 x corrected calf girth - height 0.131 + 4.5

Ectomorphy equation

According to height-weight ratio (HWR), there are 3 different equations.

If HWR is greater than or equal 40.75,

Ectomorphy = 0.732 HWR - 28.58

If HWR is less than 40.75 but greater than 38.25,

Ectomorphy = 0.463 HWR - 17.63

If HWR is equal to or less than 38.25,

Ectomorphy = 0.1

Somatoplots

The equations below was used in order to calculate the somatotype value of the participants for plotting somatochart:

x-coordinate = ectomorphy - endomorphy

y-coordinate = 2 × mesomorphy – (endomorphy + ectomorphy)



Figure 3.1 Example of somatochart