ASSESSMENT OF NUTRITIONAL STATUS AND BODY SOMATOTYPES IN RELATION TO WEIGHT CHANGES AMONG OVERWEIGHT AND OBESE OFFICE WORKERS IN KOTA BHARU, KELANTAN

by

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ABSTRAK

Tujuan kajian ini adalah untuk mengkaji tentang perkaitan antara somatotaip badan dengan status pemakanan dan perubahan berat badan dalam kalangan pekerja pejabat yang berlebihan berat badan dan obes di Kota Bharu. Seramai 97 orang pekerja berlebihan berat badan dan obes dari 9 pejabat kerajaan di Kota Bharu menyertai kajian ini. Pengukuran antropometri (berat, tinggi, lipatan kulit lengan, subskpular, suprailiak dan betis, kelebaran tulang dan ukur lilit lengan dan betis) telah diambil untuk mengenalpasti indeks jisim tubuh (BMI) dan somatotaip badan. Soal Selidik Aktiviti Fizikal Antarabangsa (IPAQ) versi Bahasa Melayu digunakan untuk mengenalpasti tahap aktiviti fizikal responden. Soal Selidik Kekerapan Pengambilan Makanan (FFQ) telah digunakan untuk mengenalpasti corak pemakanan responden. Responden dalam kumpulan intervensi telah diberikan pinggan porsi dan garis panduan cara menggunakannya untuk mengawal kuantiti pengambilan makanan. 35.1% responden adalah lelaki, dan 64.9% responden wanita, yang mana 27.8% dari kalangan responden diklasifiksikan sebagai berlebihan berat badan dan 72.2% adalah obes. Berkaitan somatotaip badan, 64.8% dari kalangan responden mempunyai somatotaip endomorfi, manakala 35.2% mempunyai somatotaip mesomorfi dan tiada yang ectomorfi. 17.8% responden mempunyai tahap aktivti fizikal yang rendah, 58.9% tahap aktiviti fizikal sederhana, dan 23.3% tahap aktiviti fizikal tinggi. Tiada perbezaan yang signifikan berkaitan perubahan berat badan di antara responden yang mempunyai somatotaip endomorfi dan mesomorfi, dan juga di antara peserta yang berlebihan berat badan dan obes. Berat badan dan BMI dilaporkan berkurang dalam kalangan kumpulan intervensi (-2.3 ± 2.2, $p<0.001$ and -0.9 ± 0.8, $p<0.001$), tetapi tiada perubahan ketara dalam kalangan peserta kawalan.

ABSTRACT

The objective of this study was to assess the relationship between body somatotypes with weight changes in overweight and obese office workers in Kota Bharu. A total of 97 overweight and obese office employees from nine government agencies in Kota Bharu, Kelantan were recruited. Anthropometric measurements such as body weight, stature, skinfolds (triceps, subscapular, supraspinale and medial calf), bone breadth and limb girth were taken to determine their body mass index (BMI) and body somatotypes. Short Form - International Physical Activity Questionnaire (IPAQ) was used to determine respondents' physical activity level. Food Frequency Questionnaire (FFQ) was also used to determine the dietary pattern of respondents. The respondents were assigned to two different groups (intervention and control). Respondents in intervention group were provided with portion plate with guideline to use it and were advised to apply it to control their meal portion and food intake. Among respondents, 35.1% are male and 64.9% are female, with 27.8% were classified as overweight and 72.2% were obese according to World Health Organization (WHO). Body somatotype results showed that respondents were mainly endomorph and mesomorph and no ectomorph. The findings were 64.8% and 35.2% who were endomorph and mesomorph, respectively. In terms of physical activity, 17.8% has low physical activity level, and 58.9% and 23.3% has moderate and high physical activity level, respectively. There is no significant different observed on weight changes between endomorph and mesomorph, as well as between overweight and obese respondents. Weight and BMI were significantly reduced in intervention group (-2.3 ± 2.2, $p<0.001$ and -0.9 ± 0.8, $p<0.001$) but no significant changes observed in control group.

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CHAPTER 1 - INTRODUCTION

Background of study

Obesity is a widely-known global epidemic that has escalating along with ongoing development of economy, industrialization and urbanization especially in a developing country such as Malaysia. In Malaysia, there are increased in the obesity prevalence observed from 5.5% in 1996 to 14.0% in 2006 (Khambalia & Seen, 2010). Further increase in obesity prevalence can be seen in the report of National Health and Morbidity Survey 2011 (NHMS 2011) where the prevalence was recorded at 27.2%. It is also estimated that over 10% of adult population in the world face the obesity problem (WHO, 2011).

The somatotype is defined as the quantification of the present shape and composition of the human body, expressed in a three-number rating representing endomorphy, mesomorphy and ectomorphy components respectively (J. Carter, 2002). To describe each body somatotype, endomorphy is the relative fatness, mesomorphy is the relative musculo-skeletal robustness, and ectomorphy is the relative linearity or slenderness of a body shape (J. Carter, 2002).

Problem Statement

Overweight and obesity were stated as the fifth leading risks for global deaths according to statistics from WHO (2011), and have been associated with many disease outcomes including cardiovascular diseases, type 2 diabetes mellitus, fertility problems and also some types of cancer (Lam, Lee, Wong, & Wong, 2012). Workplaces are a sedentary setting for many workers and where access to energy-dense food and beverages is common (Anderson et al., 2009).

Most of people in the working population, especially those who work in the office environment, at least 8 hours per day are spent to work and working environment in the office, thus make them tend to be physically inactive and exposed to the risk of obesity. Obesity is associated with increased rates of work absence and decreased productivity. Obese workers take more sick days, have longer sick leaves and incur greater productivity losses than their non-obese colleagues (Oxford University Press, 2011).

Significance of Problem

Worksites have the potential to be an important means to implement the efforts of reducing obesity problem since most adults are working population. Employers may be motivated to provide obesity-related intervention since the costs for obesity-related health care is high (Borak, 2011).

There are limited studies linking body somatotype with nutritional status. Previous researches on body somatotype were mostly focus on somatotype profile with performance in sport such as wrestling and basketball (Tóth, Michalíková, Bednarčíková, Živčák, & Kneppo, 2014). Therefore, the objective of this study is to find out whether there is relation between body somatotypes with weight changes of overweight and obese office worker in Kota Bharu.

Objective

Main Objective: To determine the association of nutritional status and body somatotypes with the changes in weight among overweight and obese office employees in Kota Bharu.

Specific objectives:

1.) To assess the nutritional status of office workers in Kota Bharu.

2.) To assess the body somatotypes of office workers in Kota Bharu.

3.) To assess the physical activity of office workers in Kota Bharu.

4.) To determine the weight changes of overweight and obese office workers after an interventional program.

Hypothesis

1.) **Alternative hypothesis**: There is significant difference in weight changes between overweight and obese office workers in Kota Bharu.

Null hypothesis: There is no significant difference in weight changes between overweight and obese office workers in Kota Bharu.

2.) **Alternative hypothesis**: There is significant difference in weight changes between office workers who have endomorph and mesomorph body somatotypes.

Null hypothesis: There is no significant difference in weight changes between office workers who have endomorph and mesomorph body somatotypes.

Conceptual framework

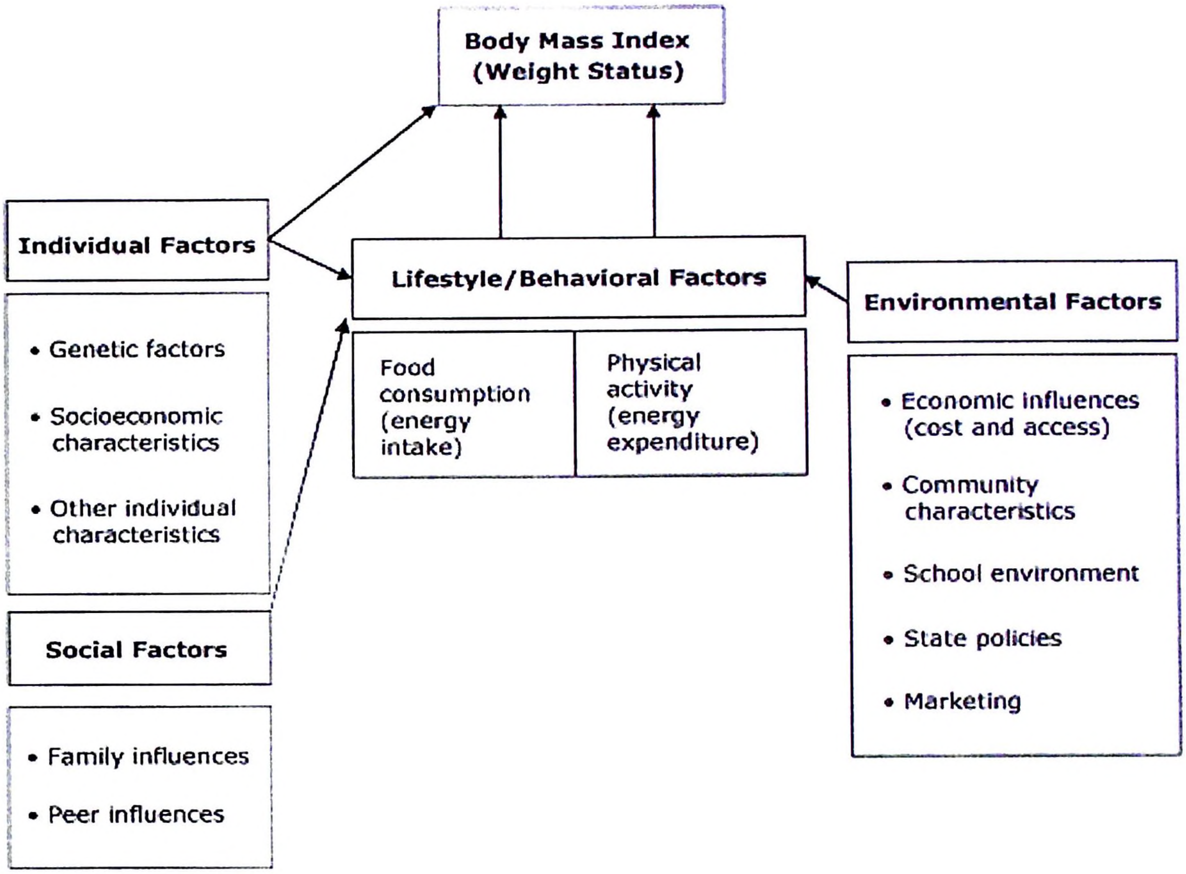

Figure 1: Conceptual model for Robert Wood Johnson Foundation's Bridging the Gap Program (Chaloupka & Powell, 2009).

CHAPTER 2 - LITERATURE REVIEW

Prevalence of Adult Obesity in Malaysia

The prevalence of obesity among adults in Malaysia as reported by National Health and Morbidity Survey (NHMS) in 2011 was 27.2% (IPH, 2011). A greater increase was observed as compared to the prevalence of adult obesity reported by National Health and Morbidity Survey (NHMS) 2006 which was reported at 14.6% (IPH, 2008) as cited in (Wan Abdul Manan, Kum, & Lee, 2015).

Another study to determine the prevalence of overweight and obesity among adults was conducted in five different selected regions including four zones in Peninsular Malaysia and one in East Malaysia to represent Malaysia as a whole and reported a prevalence of 19.5% for obesity (Wan Mohamud et al., 2011). This research also stated that adults in age groups between 45 to 49 years contributed the highest proportion of obesity (Wan Mohamud et al., 2011).This is quite interesting because the age groups mentioned are included in the working population, assuming that office employees' age are in the range of 20 – 59 years.

A systematic review was done by Khambalia and Seen (2010) on trends of overweight and obese adults in Malaysia from 1996 to 2009, and the results indicated that the prevalence of adult obesity has increased dramatically in 1996, 2003, 2004 and 2006 (5.5%, 12.2%, 12.3% and 14.0% respectively), and we can observe that the obesity prevalence has been continue to increase presently.

Possible Determinants of Obesity

Excessive calorie intake and low energy expenditure are the two main factors that closely related to weight gain and eventually contributing to obesity. In other words, obesity is the result of a long-term imbalance between energy intake and energy expenditure, and it might be influenced by factors such as biological and environmental (Kleiser, Rosario, Mensink, Prinz-Langenohl, & Kurth, 2009).

A study by Schulze and colleagues (2006) proposed that consuming foods with high intake of red and processed meats, simple carbohydrates or refined grains, and sweets and desserts on regular basis may lead to long-term weight gain. Research suggested that saturated fatty acids from animal sources are likely to be stored as body fat, while most unsaturated fats may be oxidized, thus it can be concluded that diet high in saturated and trans-fatty acids may increase the risk of developing obesity (Jebb, 2007).

Meanwhile, there is negative association between intake of dietary fibre and weight gain, as evidenced by interventional studies that reported high intake of dietary fibre may be beneficial for weight loss (Howarth, Saltzman, & Roberts, 2001). High-fibre foods have a relatively bulky nature which requires ones to chew more frequently and promote gastric distension, which in turns increase satiety feeling and cut down on further energy intake (Pereira & Ludwig, 2001). In addition, a study by Moreira & Padrão (2006) also supported the stand that consumption of foods such as fruits, vegetables and starchy foods that have low glycemic index that may help to prevent weight gain, thus reducing the risk of obesity.

Despite that, people often resorted to the more palatable, convenient and cheaper food that are highly accessible nowadays. The industry continue to promote the taste, accessibility, convenience and low cost of unhealthy foods, while at the same time suppressing people's preferences towards healthy foods that demand more efforts for preparation and more likely to be perishable (Wyatt, Winters, & Dubbert, 2006). In terms of economic view, the higher household income would have better quality of diets. Whereby they can afford to purchase better quality of meats, fish and more fruits and vegetables as compared to low-income family (Drewnowski & Specter, 2004).

Concerning physical activity as one of the determinants of obesity, before the vast development of technology era, people may have achieved greater level of physical activity through their household chores, during work and transportation. Unlike the present times, where life has been made easier with less of movements are required thanks to the technological-advanced devices at home, automation and computers at work and improved means of transportation that mostly require driving (Sallis & Glanz, 2009). Sallis and Glanz (2009) also stated in their study that living in areas that are lack in recreational facilities and not supporting walking as transportation means are parts of environmental determinants that can lead to increased risks of obesity.

Furthermore, the existence of television, computers, central air-conditioning and electronic devices have negatively-influenced people to stay indoors and doing leisure activities instead of exercising or doing physical activities (Wyatt et al., 2006). Viewing at the home environment, infrastructure built and perceived or real threats around the neighbourhood have probably discouraged people to engage in doing physical activities outdoor (Nestle & Jacobson, 2000).

From sociocultural context, the prevalence of overweight among adult is highest among Indians, followed by Malays, Chinese and aborigines, but the prevalence of obesity by ethnicity determinants was less consistent (Khambalia & Seen, 2010).

However, the ethnic groups in Malaysia that face higher risk of obesity were concluded to be Indians and Malays (Khambalia & Seen, 2010). The Chinese population were always found to be the least obese compared to Malays and Indians probably because of the differences in their dietary habits and physical activity patterns (Wan Mohamud et al., 2011).

Based on gender aspect, studies found that there was higher prevalence of obesity among women (22.5%) compared to men, only 14.0%. On average, women have lower calorie requirements than men, and therefore, less amount of food should be consumed in order to maintain the energy balance. Dining out in the restaurants could be disadvantageous for women as the portion size of foods are the same regardless of the customer; men or women, thus extra calories might be consumed and the elimination of those excessive calories through physical activity may be difficult and time-consuming and might as well discouraging (Kumanyika et al., 2008). Depression and stress, which is often more common with women, was also found to be associated with increased food consumption and weight gain which eventually would lead to obesity [(Daumit et al., 2003); (Adam & Epel, 2007)].

Consequences of Obesity on Health

Obesity has been long emerging as a major public health concern globally and is associated with increased morbidity and mortality as well as a critical risk factor for chronic diseases such as cardiovascular diseases (CVD), type 2 diabetes and hypertension (Nazri, Imran, Ismail, & Faris, 2008). Previous studies reported that people who have a BMI of >35 are more likely to develop diabetes, heart diseases, hypertension and certain types of cancers as compared to the people of the same sex whose BMI are within the normal range of 18.9 to 24.9 (Wyatt et al., 2006).

Body Somatotypes

The definition of somatotyping according to Sheldon (1940) is a quantification of three primary components determining the morphological structure of an individual expressed as a series of three numerals, termed as endomorphy, mesomorphy and ectomorphy (J. L. Carter & Heath, 1990). In other words, somatotype can be defined as the name of a system describing human physique in terms of three components, namely as endomorphy, mesomorphy and ectomorphy (Genovese, 2009).

Explaining the three components of somatotype according to Sheldon, endomorphy refers to relative predominance of soft roundness throughout the various regions of body (Carter & Heath, 1990). It measures the fat components of the body (Genovese, 2009). Endomorphy can be described as relative fatness with a large number of fat cells, softer musculature appearance, larger waist circumference, rounded shoulder features, a large head, wide face, short neck and relatively short and weak limbs (Tóth et al., 2014).

Mesomorphy is the relative predominance of muscle, bone and connective tissue which normally contribute to heavy, hard and rectangular in outline body physique (Carter & Heath, 1990). Mesomorphy is characterized by strong skeleton and sharp muscular relief broad shoulder and good posture, muscular limbs and a firm, flat abdominal wall (Tóth et al., 2014).

Finally, ectomorphy means relative predominance of linearity and fragility as it has the largest surface area in proportion to mass (Carter & Heath, 1990). Ectomorphy is always the slim and thin type with signs of slenderness, weak muscles and bones, small anterodorsal diameter, a relatively short tors and longer, fragile limbs, but not necessarily a tall figure and most importantly has few fat cells and rapid energy expenditure (Tóth et al., 2014)

Methods of determining body somatotypes

There are several somatotype methods developed by previous researchers after its pioneer, W. C. Sheldon, but the most widely used method of somatotyping today is the Heath-Carter somatotyping method. Based on the Heath-Carter method of somatotyping, the three ways of determining body somatotype are; 1.) The anthropometric method, in which anthropometry is used to estimate the criterion somatotype, 2.) The *photoscopic* method, in which ratings are made from a standardized photograph, and 3.) The *anthropometric plus photoscopic* method, which combines anthropometry and ratings from a photograph - it is the criterion method (J. Carter, 2002)

To determine a body somatotype, ten anthropometric measurements are required, which include body height or stature, body weight, four skinfolds (triceps, subscapular, supraspinale, medial calf), two bone breadths (biepicondylar humerus and femur), and two limb girths (arm flexed and tensed, calf). After all necessary anthropometric measurements have been obtained, the next step is to calculate the anthropometric somatotype in two ways, first, enter the data into equations derived from the rating form, and another way is by entering the data onto a somatotype rating form (J. Carter, 2002)

The equation for a decimal anthropometric somatotype is as follow:

1.) **Endomorphy** = - 0.7182 + 0.1451 (X) - 0.00068 (X 2) + 0.0000014 (X 3)

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

2.) **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

3.) **Ectomorphy is calculated based on the height-weight ratio (HWR)**

 a. If HWR is greater than or equal to 40.75, then

 Ectomorphy = 0.732 HWR - 28.58

 b. If HWR is less than 40.75 but greater than 38.25, then

 Ectomorphy = 0.463 HWR – 17.63

 c. If HWR is equal to or less than 38.25, then

 Ectomorphy = 0.1

Factors associated with body somatotypes

The study of body somatotype has been commonly used for the assessment of fitness and athletic and often related with sports and physical activity. An assessment study on young adults in Kelantan indicated that respondents with mesomorphy body shape are more physically active (in terms of total metabolic equivalent (MET) values) than others with different body somatotypes (Wan Abdul Manan, Kum, & Lee, 2015). The lower values of MET were also found among respondents with ectomorphy body shape, as compared to endomorphic respondents, but the difference was not significant, reflecting the lower physical activity in both groups (Wan Abdul Manan, Kum, & Lee, 2015).

In relation to sports, a study on somatotype and body composition of wrestlers suggested that wresters in heavier categories have endomorph-mesomorph body shape, while a balanced mesomorph was found among the lighter weight categories (Sterkowicz-Przybycień, Sterkowicz, & Żarów, 2011).

Linking somatotype with disease, there is a direct significant correlation between endomorphy somatotype with abdominal circumference which indicates the abdominal adiposity in patients with coronary artery disease (CAD), while ectomorphy was inversely related to the signs of general and regional adiposity, but there was no relation of mesomorphy to the indicator (Singh, 2007). Individuals who were found to be at risk of cardiovascular disease are dominated by endomorphic and mesomorphic and less ectomorphic than those who have lower profile of cardiovascular risk (Singh, 2007).

CHAPTER 3 - METHODOLOGY

Research Design

The research design for this study was quasi-experimental study to look at the association between nutritional status and body somatotypes with the changes in weight among obese office employees in Kota Bharu. Samples were assigned to two groups, either intervention group, who involved in "meal portion reduction" for 9 weeks, and the control group. The variables measured included the body mass index (BMI), height and weight, dietary assessment, body somatotypes, as well as physical activity level.

Population and Sample

The sample of the study involved office workers from several different government offices located around Kota Bharu, which is the capital city of Kelantan. Government employees aged between 20 to 60 years and were eligible to the selection criteria were selected. Employees who agreed to join were given detail explanation regarding the study and signed the written informed consent before the study proceeded. The ethical approval for this study was obtained from Universiti Sains Malaysia's Research Ethics Committee (Human).

Sample size calculation

The population size was obtained from previous study which stated that the prevalence of overweight and obese obesity among Malaysians aged 20 years old and above is 33.6% and 19.5%, respectively, from a total of 4428 respondents (Wan Mohamud et al., 2011). The total adult overweight and obesity population was then divided by 14, since there are 14 states in Malaysia, including Kelantan. To calculate the sample size, the online software Raosoft Sample Size Calculator was used and the recommended sample size was 117 for 95% confidence level. After taking into account of 10% drop-out rate, a total of 128 respondents was the desired sample size for this study. A total of 97 respondents participated in this study (participation rate was 76%).

Selection Criteria

Inclusion criteria

- Both male and female
- Aged between 20 and 60
- A full time employee in the government office
- Has a BMI of ≥ 25 kg/m^2
- Lives in Kota Bharu
- Understand Bahasa Malaysia and able to answer the questionnaire

Exclusion criteria

- Not a full time worker in the office

- Having any medical condition that could hinder from doing physical activity
- Pregnancy

Study Intervention

At the intervention sites, participants were provided with The Portion Plate® and a demonstration were done to give participants insight on how to use The Portion Plate® and applied it to their meals. Group program was held once a week, consisted of 60 minutes of health education sessions, addressing various topics specific to this program, such as "Active and Healthy Lifestyle", "Meal Preparation for Family", "Slimming Food Module", and general health interests such as "Men's and Women's Health", "Non-communicable Diseases", "Managing Stress", and "Towards Healthy Aging", and followed by physical activity such as aerobic exercise or/and dumbbell exercise. Participants at control sites were only provided with health education session on general health topics, and meetings were held once per month.

Data Collection

Research tools

The Portion Plate

The Portion Plate® (Figure 2) is consistent with the USDA MyPlate guidelines, in which basically, half of the plate should be consisted of fruits and vegetables, a quarter of the plate should be for protein, and another quarter should be for whole grains. The use of The Portion Plate® might help employees make wise food choices, understand the importance of healthy portion sizes, and develop the habits of balanced eating.

Figure 2: The Portion Plate®

Questionnaires

Food Frequency Questionnaire

The diet diversity of the respondents was determined using the Food Frequency Questionnaire (FFQ) from the Malaysian Adult Nutrition Survey (MANS) which was previously conducted by Ministry of Health. There were 5 options for frequency of the food intake category which are number of times per day, number of times per week, number of times per month, number of times per year and never. The participants were required to fill up only one option.

International Physical Activity Questionnaire (IPAQ – Short Form)

International Physical Activity Questionnaire (IPAQ – Short Form) was used to assess the level of physical activity of respondents. The validated version of IPAQ – Short Form may be publicly assessed on IPAQ's website (www.ipaq.ki.se) and has been already translated into Malay Language. The questionnaire consisted of four parts of physical activity – time spent on vigorous physical activity, moderate physical activity, walking and sitting in a day. Based on the summed up scores calculated using IPAQ Scoring Protocol recommendations, total metabolic equivalent (MET) was obtained, and the level of respondents' physical activity was categorised into three different physical activity levels – low, moderate and high.

Equipment for Anthropometric Measurements

Body weight of office workers was measured to the nearest 0.1 kg using a SECA digital weighing scale (Model 880, Hamburg, Germany). SECA Body meter (Model

208, Hamburg, Germany) was used to measure height of respondents to the nearest 0.1 cm. All the measurements were taken following the standard protocols, at least twice, and the mean value were recorded for data analysis.

Equipment for Body Somatotypes Determination

Equipment that were used to obtain anthropometric measurement for body somatotype determination included small sliding calliper (Campbell 10 small bone caliper), a flexible steel tape measure (LUFKIN W606PM Diameter Tape Measure), and a Harpenden skinfold calliper, as well as the two anthropometric measurement tools mentioned earlier.

Measurements

The nutritional status of respondents and level of physical activities were evaluated and measured by using self-administered questionnaire. Food Frequency Questionnaire (FFQ) was used to assess the nutritional status while IPAQ – Short Form was to determine the level of physical activity.

For the determination of respondents' body somatotype, eight other anthropometric dimensions in addition of the measurements of stature and boy mass were obtained based on the Heath-Carter Manual (2002). The eight components said are four sites of skinfolds (triceps, subscapular, supraspinale, medial calf), two bone breadths (biepicondylar humerus and femur), and two limb girths (arm flexed and tense, calf). All the values from these anthropometric components were then used to determine respondents' body somatotype based on Heath-Carter equations and somatotype rating form for anthropometric somatotype. The equations for decimal anthropometric somatotype are as follow:

4.) **Endomorphy** = - 0.7182 + 0.1451 (X) - 0.00068 (X 2) + 0.0000014 (X 3)

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

5.) **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

6.) **Ectomorphy is calculated based on the height-weight ratio (HWR)**

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       Ectomorphy = 0.463 HWR – 17.63

    f. If HWR is equal to or less than 38.25, then

       Ectomorphy = 0.1

Weight

The weight of respondent was recorded while the subject stood on the weighing scale with minimal clothing and without shoes. The respondent stands on the centre of the scales without support and with the weight distributed evenly on both feet.

Height

The height of the respondent was measured from the respondent's head to the toe while the respondent stood in the upright position. Respondents were barefooted and remove any items from their body, such as accessories and things in their clothing pockets. The respondents stood with their heels together, arms to the side, legs straight, shoulders relaxed, and looked straight ahead. Heels, buttocks, shoulder blades, and back of the head should touch against the wall if possible. Respondents were then asked to inhale deeply, hold the breath and maintain the standing position while the headboard was lowered on the highest point of the head with enough pressure to compress the hair.

BMI

The BMI of respondents were calculated as outcome variable after both height and weight were obtained using equation: weight in kilogram divided by height in meter square; BMI = weight (kg) / height (m^2). BMI categorization was defined as underweight with BMI <18.5 kg/m^2; normal with BMI 18.5 – 24.9 kg/m^2; overweight with BMI 25.0 – 29.9 kg/m^2; and obese with BMI ≥30 kg/m^2 (World Health Organization (WHO), 2006).

Skinfolds

Harpenden skinfold calliper was used to measure skinfolds. To obtain skinfold measurements, thumb and index finger of left hand was used to grasp a double fold of skin and subcutaneous adipose tissue. The calliper tips were placed on the site where the sides of the skinfold were approximately parallel and about 1 cm distal from where the skinfold was grasped. The calliper dial was then positioned and the reading was obtained about 4 seconds after the calliper tips was placed on the skinfold.

For triceps skinfold measurement, the respondent was in a relaxed, standing position with the right arm hang loosely at the side. A fold of skin at the back of the arm, at the midway between the lateral projection of the acromion process of the scapula and the olecranon process of the ulna, was grasped.

The subscapular skinfold was measured with respondent stood and arms relaxed to the site. From the inferior angle of the scapula, a fold of skin was grasped on the line of axis 45-degree angle directed down and to the right side to obtain subscapular skinfold measurement.

For supraspinale skinfold, it was measures just above the iliac crest at the midaxillary line. The fold of skin was grasped about 1 cm posterior to the midaxillary line and skinfold was measured at the midaxillary line while the respondent stood upright with feet together and arms hung to the sides.

To measure medial calf skinfold, respondent was required to take a seat with right leg flexed about 90 degrees at the knee with the sole of the foot flat on the floor. A point of maximum circumference was first marked at the medial site of the calf. A vertical skinfold was grasped approximately 1 cm above the marked site and skinfold was measured at the site.

Bone breadths

Bone breadths were measured using small sliding calliper. To hold the calliper, the calliper body was laid on the back of the hands while the thumb rested against the inside edge of the calliper, and the extended index fingers were along the outside of the branches. The middle fingers were then free to palpate the bony landmarks on which the calliper faces were to be placed, while the index fingers able to exert pressure to reduce the thickness of any underlying soft tissue.

To obtain the measurement of bioepicondylar humerus, the respondent was required to be in the relaxed standing or seated position, while the right arm was raised anteriorly to the horizontal and the forearm flexed at right angles to the arm. While gripping the small sliding calliper, the middle fingers were used to palpate the epicondyles of the humerus, starting proximal to the sites. The calliper's face was placed on the epicondyles and strong pressure was maintained with index fingers while the value was recorded. The measured distance of epicondyles may be quite oblique, as the medial epicondyle is normally lower than the lateral epicondyle.

Bioepicondylar femur measurement was taken with respondent on a relaxed seated position and hands clear of the knee region. The right leg was flexed at the knee to form a right angle with the thigh. The bone breadth was measured between the medial and lateral epicondyles of the femur. The middle fingers were used to palpate the epicondyles of the femur, beginning proximal to the sites. Similar to the method of obtaining humerus breadth, the calliper's face was placed on the epicondyles and strong pressure was maintained with index fingers while the measurement was read.

Limb girths

Measurements of limb girth were taken at two sites, which are upper arm girth and calf girth. For measurement of upper arm girth, the respondent was in a standing position with the left arm hanging by the side, while right arm was raised anteriorly to the horizontal with the forearm flexed at about 45-90 degree to the arm. The respondent was encouraged to contract the arm muscles as strongly as possible and hold it while measurement was taken at the greatest girth.

To measure calf girth, respondent was required to stand in an elevated position and legs slightly separated to ensure weight was evenly distributed. The measuring tape was passed around the calf and measurement was taken at the maximum circumference.