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BODY SOMATOTYPE AND DIETARY INTAKES OF GOVERNMENT EMPLOYEES IN KUALA TERENGGANU

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ABSTRACT

Nutritional intake is one of the most important aspects that influence body composition and may affect body somatotype. Some previous studies conducted on somatotype in Malaysia have focussed on the aspect of sport performance and physical activities but none were on somatotype with dietary intakes. Thus, this study was conducted to determine the relationship between somatotype and dietary intakes. A total of 308 males and females of uniformed government agencies personnel in Kuala Terengganu were systematically selected to participate into this study. Somatotype was determined by using the Heath and Carter, method. Dietary intakes were measured by using 24-hour dietary recall technique. The mean age of respondents was 38.18 ± 5.23 years. Their mean BMI was 26.09 ± 5.69 kg/m^2, which indicated that they were overweight. Mean somatotype components of the male respondents were (5.71, 4.73, 1.20), while of female respondents were (8.77, 4.99, 0.77). This indicated that the males belonged to mesomorph-endomorph body somatotype while the females belonged to mesomorph endomorph somatotype category. Median calories intake among respondents was 1987 kcal per day. The correlation between endomorphy component with calories, carbohydrate and protein intake were r= -0.083, r= -0.172 and r= -0.226, respectively ($p<0.05$). Mesomorphy component correlated negatively with protein intake of respondents (r= -0.161, $p<0.05$). The ectomorphy component correlated positively with calories (r= 0.151, $p<0.05$), carbohydrate (r= 0.113, $p<0.05$), protein (r= 0.191, $p<0.05$) and fat intake (r=0.112, $p<0.05$). Some vitamins and minerals intake also shows correlation with somatotype components. Generally, this study suggested that dietary intakes influence somatotype components and somatotype measurements can be useful to be used as tools for identifying obesity predispositions.

Key words: Somatotype, endomorph, mesomorph, ectomorph, dietary intakes

INTRODUCTION

Somatotype is a classification of human physique, which gives a quantitative summary of the physique as an integrated whole (Galić *et al.*, 2016). It consists of three components: endomorph, mesomorph and ectomorph. This classification is based on the genetic determination of the level of tissue development (Drywien *et al.,* 2016). The somatotype of a person is often expressed by a three-number rating, in which each number represents a component of the somatotypes (Galić *et al.*, 2016). The first number represents endomorph component, which refers to relative fatness. The second number represents the mesomorph component, which refers to musculoskeletal robustness relative to height, and the last number, represents ectomorph component referring to relative linearity (Carter & Heath, 1990). Each number shows the magnitude of each of the components. Rating on each component of 2 to 2½ is considered low, 3 to 5 is moderate, 5½ to 7 is high and 7½ and above is very high. In theory, there is no upper limit to the ratings. However, a value more than 12 can occur in very rare case. Each component is rated relative to height; thus, somatotype is independent of height (Carter & Heath, 1990; Toth *et al.,* 2014).

Body Mass Index (BMI) is widely used as tool to measure obesity, as it has been found to have the highest correlation with percentage of body fat

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as measured by skinfold and hydro densitometry (Hortobagyi *et al*., 1994; Dulloo *et al*., 2010). BMI can easily be calculated by just dividing the weight (kg) and height (m^2). Since then, BMI determination has been widely used to classify obesity in most research studies. However, BMI cannot distinguish between fat mass and muscle mass in individuals. BMI is unable to distinguish individuals with high muscle mass and low-fat mass, or active people who have low proportion of fat in the body. The calculation of BMI, may classify these people into overweight or obese BMI categories due to their large muscle mass (Dulloo, 2010). A study by Hunma *et al*. (2016) to measure the sensitivity and specificity of BMI to access obesity in healthy adult shows that BMI cut-off points may misdiagnose healthy adults as overweight or obese when body composition is verified by using hydro-densitometry technique. So, this study is conducted to use somatotype as a tool for measuring body physique because somatotype measurement encompasses of a combination of stature, total mass, girth, skinfold and bone width. It represents physique as a three-dimensional numerical descriptor of human physique that can be constructed to describe adiposity, muscularity and linearity, independent of size (Heath & Carter, 1967; Toth *et al.,* 2014).

Dietary intake is one of the factors associated with health outcomes and prevalence of obesity. Besides, nutrition intake is also an important aspect that influence body composition and may affect body somatotype (Raschka & Graczyk 2013; Drywien *et al*., 2016). A study among university students in Warsaw reported that dietary intake was different according to dominant body somatotype (Drywien *et al*., 2016). They found that endomorph respondents have the lowest energy intake, followed by mesomorph and ectomorph respondents. Earlier studies by Raschka & Graczyk (2013), Raschka & Aichele (2014) and Penggalih *et al*. (2016) were few of the studies that particularly relate the somatotype component with dietary intake. Furthermore, these studies were only focused in macronutrients intake and only one study (Drywien *et al.,* 2016) included some selected micronutrients. Studies on somatotype in Malaysia have previously been conducted among athletes (Eiin *et al*., 2007; Nathan, 2015; Soh *et al.,* 2008) and university students (Wan Manan *et al*., 2015). Most of the studies considered the aspect of somatotype with sports performance and physical activities but no study was conducted to look into the relationship between somatotype and dietary intake among working adults especially government employees. To date, this is the first reported study regarding relationship between body somatotype and dietary intake in Malaysia.

MATERIALS AND METHODS

This cross-sectional study was conducted among 308 uniformed personnel from selected government agencies in Kuala Terengganu to determine the association of body somatotype to dietary intakes. Each respondent was selected by systematic sampling. Calculations below showed that the minimum sample size for this study was 264. The estimated sample size needed was calculated based on the following formula (Daniel, 1999).

$$n = Z^2 P (1-P) / d^2$$
$$= (1.96)^2 x\ 0.174\ (1- 0.174) / (0.05)^2$$
$$= 220$$

By taking consideration of 20% drop out rate (equivalent of 44 respondents), the sample size needed was 264.

Where:
n = estimated sample size
z = the standard value at confidence level at 95% = 1.96
p = the estimated prevalence based on the reported prevalence (17.4%) of abdominal obesity among Malaysian adults
= 17.4%
d = the margin of error is set at 5%
= 0.05

Respondents were selected based on the inclusion criteria as follows: (a) Men and women government employees aged between 20 and 59 years. (b) Not having high blood pressure, diabetes mellitus and heart problem as far as they know. (c) Not on medication related to blood pressure, heart diseases or diabetes mellitus. (d) Not pregnant or not planning to conceive.

Anthropometry measurements:

Ten anthropometry data parameters namely weight, height, waist circumference, hip circumference, mid-arm circumference, triceps skinfold, subscapular skinfold, supraspinale skinfold, thigh circumference, mid-thigh skinfold, humerus width and femur width were measured. Accuracy of the anthropometric measurement is very important in determining somatotype. To ensure reliability, single trained anthropometrist recorded all these anthropometric measurements. All these measurements was then used for determining body somatotype among respondents by using the Carter and Heath (1990) equation as below:

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 $\frac{170.18}{\text{height in cm}}$

This is called height-corrected endomorphy and is the preferred method for calculating endomorphy (Heath-Carter, 1990).

2) **Mesomorphy** = 0.858 x humerus width + 0.601 x femur width + 0.188 x corrected arm girth + 0.161 x corrected calf girth – height x (0.131) + 4.5

3) Three different equations were used to calculate **ectomorphy** according to the height-weight ratio (HWR):

a) If HWR is greater than or equal to 40.75, then ectomorphy = 0.732 HWR – 28.58.
b) However, 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

BMI calculation:

Height and body weight was measured. Participants stood without shoes, straight with arms at the sides, with feet together and heels and back in contact with the wall. Measurement was taken from a line drawn by a portable stadiometer (SECA, Germany) and was recorded to the nearest 0.5 cm. Body weight was measured in light clothing without footwear using the Tanita digital body fat scale model: UM-026 (Tanita, UK), recorded to the nearest 0.1 kg. BMI of respondents were calculated by using formula below (Kim *et al.,* 2013).

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

Determination of dietary intake:

To determine the dietary intake of respondents, a one-day, 24-hour diet recall method was conducted. Researchers conducted a face-to-face interview and respondents were asked to recall all of the food and beverages consumed during the last 24 hours period. Data from dietary recall were entered into Nutritionist Pro software to determine the calories, macronutrients, vitamins and minerals intake of respondents.

Ethical approval and data collection:

Ethical approval that clarified the purpose of this study was obtained from the Universiti Sains Malaysia (USM) Ethical Committee (reference no: USMKK/PPP/JEPem [237.4 (1.110)]. The data collection began in May 2011 and finished in April 2012. Participants were guaranteed anonymity and all information provided is treated with confidentiality.

Statistical analysis:

Data was analysed using the Statistical Packaged for Social Science (SPSS) software version 20.0. The level of significance was set at $p<0.05$. Normality test was carried out to determine the distribution of the data. Independent T-test and Mann Whitney Test were used to measure the difference in mean of two groups when appropriate. While Spearman correlation was used to measure the relationship between somatotype components and dietary intakes.

RESULT AND DISCUSSION

The mean somatotype of all respondents in this study was (7.21, 4.86, 1.12) (Table 1). These respondents belonged to mesomorphic endomorph somatotype category (Carter, 2002). The mean endomorphy component of the respondents was (7.21 ± 2.23), indicated that they have thick subcutaneous fat, roundness of trunk and limbs and has increased storage of fat in the abdomen. Mean mesomorphy component was (4.86 ± 1.49), indicated that respondents had moderate relative musculoskeletal development and had increased muscle bulk and thicker bones and joints, while mean score of ectomorphy component was (1.12 ± 1.15), which showed that respondents had low linearity physique, had great bulk per unit height, were rounded in shape and had relatively bulky limbs (Toth *et al*., 2014). The mean body somatotype among female respondents was (8.77, 4.99, 0.77), while the mean body somatotype among male respondents was (5.71, 4.73, 1.20). Female respondents belonged to mesomorphic endomorph somatotype category, while male respondents belonged to mesomorph-endomorph body somatotype (Carter, 2002). Females have greater endomorph component, slightly higher mesomorph component and lower ectomorph component compared with male respondents. This trend is similar to the results in the earlier studies where investigators found that females are generally more endomorphy than their male counterparts (Kalichman & Kobyliansky, 2006; Chandel & Malik, 2012). Somatotypes differ between genders, because of several factors such as genetics, physical growth, maturation and nutrition (Kaur & Malik, 2016). Differences in body composition among males and females are one of the factors, where female respondents were found to have significantly higher

Table 1. Mean Age, BMI and Somatotype Components Score Among Respondents

	Total Respondents (*n* = 308)	Male (*n* = 157)	Females (*n* = 151)
Age (years)	38.18±5.23	35.80±4.04[a]	40.66±5.31[b]
BMI (kg/m^2)	26.09±5.69	25.16±3.55[a]	27.05±7.16[b]
Endomorphy	7.21 ± 2.23	5.71 ± 1.84[a]	8.77 ± 1.84[b]
Mesomorphy	4.86 ± 1.49	4.73 ± 1.38[a]	4.99 ± 1.60[a]
Ectomorphy	1.12 ± 1.15	1.20 ± 1.37[a]	0.77 ± 0.97[b]

Notes. Independent t-test [a,b] indicate significant difference between genders (p<0.05). Different letter indicates that there is significant different in the p-value. Data are presented as mean values ± S.D, n=308 government employees. Somatotype components score: component is lower than 2.5 it is considered to be low, from 3.0 to 5.0 medium and from 5.5 to 7.0 as high. Values higherthan 7.5 are considered as extreme.

Table 2. Somatotype Category versus BMI Category Among Respondents

Somatotype categories	BMI categories				Total
	Underweight	Normal	Overweight	Obese	
Endomorph	0	98	117	46	261
Mesomorph	0	25	10	1	36
Ectomorph	6	5	0	0	11
Total	6	128	127	47	308

skinfold thickness compared with male respondents (Kaur & Malik, 2016).

Cross tabulation was performed on the respondents according to their BMI categories and their dominant somatotype categories (Table 2). The results showed that by using BMI cut-off points, 11 of mesomorph respondents (30.4%) were categorized into overweight and obese BMI category. This finding shows similar trend with study by Wan Abdul Manan *et al.* (2015), that were conducted among university students. This study also showed that by using BMI cut-off points, 24.2% of mesomorph respondents of their study were classified as overweight and obese. Individual who are mesomorph dominant have greater fat-free mass (muscle mass) compared to ectomorph and endomorph dominant somatotype individuals (Bolunchuk *et al.,* 2000). Because muscle mass is denser than fat mass (Cardinal & Loprinzi, 2011). It makes the mesomorph dominant individuals heavier, therefore the use of BMI may misclassify them as overweight and obese (Dulloo, 2010).

Median calories intake per day by respondents was 1987 kcal. Energy intake of males was significantly higher than energy taken by female respondents (p <0 .05). Calories intake for males and females' respondents was 80.8% and 84.8% of Malaysian Reference Nutrient Intake (RNI), respectively (NCCFN, 2005). There was significantly higher intake of protein, carbohydrate, cholesterol, monounsaturated fatty acids (MUFA), sugar, vitamin C, pyridoxine, cobalamin and cooper intake among males compared to female respondents (Table 3).

Table 4 shows the correlation between dietary intakes with each somatotype components among respondents. Calorie intake correlates negatively with endomorphy component (r= -0.183, p<0.05), while correlates positively with ectomorphy components (r= 0.151, p<0.05). Generally, the results showed that there was a relationship between dietary intakes with somatotype components among respondents. The strength of correlation coefficient between dietary intakes, and somatotype components ranged between -0.1 to +0.2, which indicated that there were weak relationships between dietary intakes and each somatotype components. Endomorphy component show inverse relationship with calories intakes and 8 nutrients namely carbohydrates, protein, calcium, cholesterol, mono-unsaturated fatty acids, vitamin C, pyridoxine and cobalamin. Mesomorphy component also show inverse relationship with 7 nutrients namely protein, calcium, iron, cholesterol, saturated fatty acids, poly-unsaturated fatty acids and vitamin E (Table 4). This indicated that respondents with higher endomorphy and mesomorphy components have lower intakes for these nutrients, and vice versa. However, ectomorphy component have

Table 3. Median (IQR) Calories and Macronutrients Among Government employees at selected government agencies in Kuala Terengganu. (n=308)

	All respondents (n = 308) Median (IQR)	Males (*n* = 157) Median (IQR)	Females (n = 151) Median (IQR)
Calories (kcal)	1987 (808)	2057 (929)[a]	1849 (816)[b]
Protein (g)	71.6 (36.9)	75.8 (35.9)[a]	64.5 (34.4)[b]
Carbohydrate (g)	263.5 (121.7)	290.2 (132.8)[a]	249.7 (108.1)[b]
Fat (g)	66.4(38.4)	67.9 (37.7)	65.3(36.7)
Cholesterol (mg)	223.7 (290.8)	288.9 (327.2)[a]	184.1 (263.6)[b]
Saturated fat (g)	10.4 (9.6)	10.5 (8.5)	10.0 (10.5)
MUFA (g)	10.7 (9.2)	11.6 (9.1)[a]	9.7 (8.6) [b]
PUFA (g)	7.3 (9.1)	7.1 (7.1)	7.7 (10.7)
Dietary fibre (g)	2.0 (2.2)	2.0 (2.1)	2.0 (2.3)
Sugar (g)	29.6 (37.2)	32.7 (36.7)[a]	28.4 (35.5)[b]
Vitamin C (mg)	30.9 (43.6)	35.5 (46.7)[a]	24.0 (39.1)[b]
Vitamin E (mg)	4.6 (4.5)	4.3 (4.2)	5.2 (5.6)
Thiamine (mg)	0.7 (0.5)	0.8 (0.4)	0.7 (0.5)
Riboflavin (mg)	1.0 (0.7)	1.0 (0.7)	1.0 (0.7)
Niacin (mg)	11.6 (9.0)	11.8 (11.1)	11.1 (8.6)
Pyridoxines (mg)	0.7 (0.6)	0.8 (0.6)[a]	0.7 (0.6)[b]
Folate (μg)	65.3(55.7)	67.4 (52.4)	63.0 (51.8)
Cobalamin (μg)	2.5 (3.1)	3.1 (3.2)[a]	1.5 (2.6)[b]
Sodium (mg)	1810.5(1534.5)	1649.7 (1566.8)	1851.5 (1599.1)
Potassium (mg)	1382.5 (805.5)	1414.8 (778.6)	1341.5 (830.4)
Calcium (mg)	384.9 (278.5)	389.6 (254.5)	373.6 (281.4)
Iron (mg)	16.8 (19.6)	17.3 (15.6)	16.1 (21.9)
Phosphorus (mg)	1160.3 (899.1)	1196.7 (862.5)	1089.3 (878.6)
Zinc (mg)	4.4 (4.3)	4.7 (4.7)	4.1 (4.0)
Cooper (mg)	0.5 (0.5)	0.5 (0.5)[a]	0.6 (0.6)[b]

Notes. [a, b] indicates statistically significant at p<0.05 Mann-Whitney Test; *n* = 308.

positive correlation with calories intake and other 11 nutrients namely carbohydrates, protein, fat, potassium, calcium, phosphorus, cholesterol, saturated fatty acids, mono-unsaturated fatty acids, cobalamin and zinc. This indicated that respondents with higher ectomorphy component have higher intakes of these nutrients (Table 4). The relationship between somatotype components with dietary intake also has been studied by Raschka & Graczyk (2013) and Raschka & Aichele (2014). These studies found that, the correlation between somatotype and dietary intake were weak, and only few significant relationships were found.

This pattern of dietary intake may be caused by the fact that respondents who have higher endomorphy component score have more fat mass and lower fat free mass. Individuals who have more fat mass and low fat free mass reflected that they have less metabolic active muscle tissue. Thus, they have lower energy demand. While, individual with higher ectomorphy score have less fat mass and higher fat free mass. Thus they have more metabolically active muscle tissue. Therefore, they have higher energy demand (Blundell *et al.,* 2012). So, when respondents have higher endomorphy component, they tend to consume less food because their energy demand based on the metabolic active tissue is lower. While respondents who have higher ectomorphy component tend to consume more food because their energy demand based on the metabolic active tissues are higher (Blundell *et al*., 2012).

As far as we are concerned, this is the first study in Malaysia to show the relationship between somatotype components with macronutrients, vitamins and minerals intake of government employees. The obtained results also show that somatotype can be a useful and used as an appropriate tool for identifying obesity pre-dispositions. This study suggested that dietary intake influences somatotype component. It is demonstrated that the higher endomorphy and mesomorphy components among respondents, they have lower intake of certain nutrients, while the higher ectomorphy component among respondents, they have higher intake of certain nutrients. There is a need for further detailed study to be carried out to validate these findings.

Table 4. Correlation between nutrients intake with somatotype components among government employees at selected government agencies in Kuala Terengganu. (n=308)

Nutrient intake	Endomorphy		Mesomorphy		Ectomorphy	
	r	p	r	p	r	p
Calories	-0.183*	0.001	-0.078	0.170	0.151*	0.008
Carbohydrate	-0.172*	0.002	-0.020	0.728	0.113*	0.048
Protein	-0.226*	0.000	-0.161*	0.005	0.191*	0.001
Fat	-0.083	0.145	-0.094	0.098	0.112*	0.050
Niacin	-0.054	0.344	-0.061	0.290	0.086	0.130
Sodium	0.052	0.362	-0.109	0.057	0.050	0.384
Potassium	-0.057	0.322	-0.092	0.109	0.116*	0.041
Calcium	-0.135*	0.018	-0.128*	0.024	0.120*	0.036
Iron	-0.061	0.284	-0.140*	0.014	0.094	0.099
Phosphorus	-0.082	0.150	-0.101	0.078	0.138*	0.016
Cholesterol	-0.210*	0.000	-0.159*	0.005	0.169*	0.003
Saturated Fat	-0.102	0.073	-0.127*	0.026	0.133*	0.019
MUFA	-0.125*	0.029	-0.101	0.076	0.113*	0.047
PUFA	-0.051	0.376	-0.124*	0.030	0.105	0.066
Dietary Fiber	0.020	0.720	-0.026	0.655	0.003	0.956
Sugar	-0.044	0.439	0.054	0.343	-0.012	0.835
Vitamin C	-0.177*	0.002	-0.034	0.558	0.084	0.144
Vitamin E	-0.054	0.346	-0.114*	0.045	0.089	0.118
Thiamine	-0.041	0.475	-0.021	0.720	0.058	0.306
Riboflavin	-0.009	0.870	0.072	0.206	-0.031	0.585
Pyridoxine	-0.127*	0.026	-0.067	0.244	0.090	0.114
Folate	-0.075	0.190	-0.058	0.314	0.064	0.266
Cobalamin	-0.234*	0.000	-0.070	0.223	0.145*	0.011
Magnesium	-0.040	0.489	-0.071	0.215	0.108	0.059
Zinc	-0.109	.055	-0.096	0.091	0.113*	0.048

Spearman correlation *significant different at p<0.05.

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REFERENCES

Blundell, J.E., Caudwell, P., Gibbons, C., Hopkins, M., Näslund, E., King, N.A. & Finlayson, G. 2012. Body composition and appetite: fat-free mass (but not fat mass or BMI) is positively associated with self-determined meal size and daily energy intake in humans. *British Journal of Nutrition*, **107(3)**: 445-449.

Bolonchuk, W.W., Siders, W.A., Lykken, G.I. & Lukaski, H.C. 2000. Association of dominant somatotype of men with body structure, function during exercise, and nutritional assessment. *American Journal of Human Biology: The Official Journal of the Human Biology Association*, **12(2)**: 167-180.

Cardinal, B.J. & Loprinzi, P.D. 2011. Letter to the editor response. *Sports Health*, **3(6)**: 498-498.

Carter, J.L. & Heath, B.H. 1990. *Somatotyping: development and applications* (V), Cambridge University Press.

Carter, J.E.L. 2002. The Heath-Carter anthropometric somatotype-instruction manual. *San Diego, USA*.

Chandel, S. & Malik, S.L. 2012. Anthropometric somatotype of Kshatriya and Kurmi of Uttar Pradesh: Population and gender differences. *Human Biology Review*, **1(1)**: 1-15.

Daniel, W.W. Biostatistics. A Foundation for analysis in the Health Sciences. 1999. *Hoboken: Wiley*.

Dulloo, A.G., Jacquet, J., Solinas, G., Montani, J.P. & Schutz, Y. 2010. Body composition phenotypes in pathways to obesity and the metabolic syndrome. *International Journal of Obesity*, **34(2)**: S4.

Drywien, M., Frackiewicz, J., Górnicka, M., Wielgosz, J., Sobolewska, A. & Kulik, S. 2016. Influence of the somatotype on intake of energy and nutrients in women. *Anthropological Notebooks*, **22(3)**: 147-157.

Eiin, W.J., Flyger, N. & Wilson, N. 2007. Somatotypes of young Malaysian track and field athletes. *Asian Journal of Exercise & Sports Science*, **4(1)**.

Galić, B.S., Pavlica, T., Udicki, M., Stokić, E., Mikalački, M., Korovljev, D. & Adamović, D. 2016. Somatotype characteristics of normal-weight and obese women among different metabolic subtypes. *Archives of Endocrinology and Metabolism*, **60(1)**: 60-65.

Heath, B.H. & Carter, J.L. 1967. A modified somatotype method. *American Journal of Physical Anthropology*, **27(1)**: 57-74.

Hortobagyi, T., Israel, R.G. & O'Brien, K.F. 1994. Sensitivity and specificity of the Quetelet index to assess obesity in men and women. *European Journal of Clinical Nutrition*, **48(5)**: 369-375.

Hunma, S., Ramuth, H., Miles-Chan, J.L., Schutz, Y., Montani, J.P., Joonas, N. & Dulloo, A.G. 2016. Body composition-derived BMI cut-offs for overweight and obesity in Indians and Creoles of Mauritius: comparison with Caucasians. *International Journal of Obesity*, **40(12)**: 1906.

Kalichman, L. & Kobyliansky, E. 2006. Sex-and age-related variations of the somatotype in a Chuvasha population. *HOMO-Journal of Comparative Human Biology*, **57(2)**: 151-162.

Kaur, H. & Malik, S.L. 2016. Magnitude of Sex difference in Body Physique of Sainis of Punjab. *Human Biology*.

Kim, J.Y., Oh, S., Chang, M.R., Cho, Y.G., Park, K.H., Paek, Y.J. & Song, H.J. 2013. Comparability and utility of body composition measurement vs. anthropometric measurement for assessing obesity related health risks in Korean men. *International Journal of Clinical Practice*, **67(1)**: 73-80.

Nathan, S. 2015. Coaching school hockey in Malaysia: a exploratory analysis and effect of improvised TGfU pedagogical model on small sided game play. *Journal of Physical Education and Sport*, **15(4)**: 712.

NCCFN 2005. Recommended Nutrient Intakes for Malaysia. A Report of the Technical Working Group on Nutritional Guidelines. National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia, Putrajaya.

Penggalih, M.H.S.T., Juffrie, M., Sudargo, T. & Sofro, Z.M. 2017. Correlation Between Dietary Intake with Anthropometry Profile on Youth Football Athlete in Indonesia. *Asian Journal of Clinical Nutrition*, **9**: 9-16.

Raschka, C. & Graczyk, J. 2013. Correlations between somatotypes and nutritional intake in members of a fitness studio. *Papers on Anthropology*, **22**: 145-152.

Raschka, C. & Aichele, S.K. 2014. Correlations between somatotypes and nutritional intake in sports students. *Papers on Anthropology*, **23(2)**: 96-104.

Soh, K.G., Soh, K.L., Sofian, O.M., Fauzee, O., Marjohan, J., Ong, S.L. & Noorzaliza, O. 2008. Body fat and somatotype among Malaysian school sports council netball players by playing position: kinanthropometry. *African Journal for Physical Health Education, Recreation and Dance*, **14(4)**: 456-462.

Wan Abdul Manan, W.M., Kum, C.S. & Lee, Y.Y. 2015. Activity of College-Age Adults in Selected Institutions of Higher Learning in Kelantan, Malaysia. *Malaysian Journal of Nutrition,* **21(1)**: 45-55.