Anthropometric Evaluations of Body Fat Content of Undergraduate Male Students

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Abstract- *Anthropometric measurements are quick and handy methods, predicting the risk of non-communicable diseases (NCDs). Changes in diet, lifestyle and experiencing mental stresses are some of the rapid changes, exhibited in students entering into the residential universities in Sri Lanka. The interest of this study was to identify and compare changes in their body fat and NCD-related risk factors during university life. A cross-sectional study was conducted using 107 male undergraduates with the proportion of Sinhalese: Tamils: Muslims, Catholics as 17.5:5:2:0.5, who were from all batches in the University of Peradeniya. After administrating a pre-tested questionnaire, age, diet pattern, ethnicity and having food or physical activities within 2 hours were questioned, excluding other conditions affecting the body water content. Body weight, body fat percentage and Body Mass Index (BMI) together with muscle mass, bone mass and body water content were reported by the Body Fat Analyzer. All the data drawn were entered and analyzed using SPSS software. Among anthropometric indicators measured, waist circumference (WC) had a slightly better correlation while BMI and waist circumference to height ratio (WHtR) had similar amount of correlations and waist-to-hip circumference ratio (WHR) showed a lower correlation with body fat compared to other indicators. All the mean values of the four batches were below the risk levels of each indicator but it showed a significant increment of body fat from the 1st year to final year and a higher variation in body fat was observed among 1st year students compared to final year students.*

Keywords: Anthropometric measurements, Body fat content, Lifestyle, Non-communicable diseases, Undergraduates.

I. INTRODUCTION

The deposition of excess fat in the human body (obesity) seems to be a leading talk, especially from the last century. It is a natural body maintenance procedure when the body balances required positive energy itself. Unfortunately, it is estimated that globally nearly 700 million people, are suffering from excess body fat condition (Scully, 2012). It has been proven that excess body fat contributes to non-communicable diseases such as dyslipidemia, hypertension, cardiovascular diseases, type-2 diabetes, sleep apnea, etc. Type-2 diabetes has become a major threat to this generation, with about 346 million diabetics across the planet in 2011 and these figures may be doubled by 2030 (Scully, 2012). The effect of social and economic factors in obesity is widespread and has a high impact on healthcare provision in many economic theories. There are various types of fat. The fat that is stored within the abdominal cavity is called Visceral fat (VAT). It can be seen near several organs of the body like the liver and intestine. It can also build up in arteries. This is the fat identified as having a higher risk for cardio vascular diseases (CVD). Another type of fat is subcutaneous fat (SAT), which is the visible fat stored under the skin. Subcutaneous fat is normally considered harmless and may even protect from some diseases. The lower body fat is commonly defined as all adipose tissue caudated to the inguinal ligament anteriorly and the ileac crest posteriorly. Ectopic fat is yet another type of body fat, which is stored in tissues other than adipose tissue, such as skeletal muscle, heart, liver and pancreas. Ectopic fat accumulation in key insulin-sensitive tissues such as liver and skeletal muscle is a critical determinant of insulin resistance and may also predispose to the development of type-2 diabetes (Yki-Jarvinen, 2002). Ectopic fat, though it is normally contained in small amounts, can interfere with a cellular function such as neurotransmission (Thomas et al., 2013). Factors affecting the body fat distribution in the human body among different group of people can be divided into two groups as environmental factors and genetic factors. Diet quality, consumption of alcohol and cigarette and childhood obesity are some of the environmental factors and strong genetic factors are also considered to play a role in regional fat gain and loss. Predominant upper body fat distribution is generally related to increased visceral fat and with an abnormal metabolic profile over a range of body mass indices (Jensen, 2008). Hence morbidity rate of adults and also children are being increased daily due to metabolic derangements (Wickramasinghe et al., 2017). The proposed study has designed since anthropometric measurements are quick and handy methods to predict the body fat content and there is a need to make aware of students that their physical and mental health is changing due to their displacement from home to hostel in the process of adopting to new environment.

II. LITERATURE REVIEW

A. *Fat deposition in the human body*

All the energy produced in our body through food will not be utilized as a whole. Thus, excess energy is turned into a tissue called adipose tissue, which is a specialized tissue for fat storage. This process is called adiposity (Thomas et al., 2013). Preferential fat deposition in the abdomen between and within viscera and retroperitoneal has been linked with risk on health. There is a special tissue named abdominal visceral adipose tissue (VAT) that may have relevance to its biological importance. Apart from that, there is another type of adipose tissue called Subcutaneous Adipose Tissue (SAT) that has depots under skins which lower the metabolic risks. Ectopic fat is another type of fat rather than adipose tissues, needed in small quantities in the normal body functions (Thomas et al., 2013). Studies show that free fatty acids (FFA) which are released by adipose tissues cause main abnormalities in the body (Yki-Jarvinen, 2002). VAT is considered as another ectopic fat that does not release free fatty acids to much extend rather it is enough for influencing metabolic derangement in muscles, β cells in the pancreas and vascular endothelium. Upper body subcutaneous adipose tissue releases systemic FFA to the blood circulation, resulting in enhancement of metabolic risk by upper body fat than lower body fat (Yki-Jarvinen, 2002).

B. *Measuring body fatness*

Thomas et al. (2013) revealed that because of health care, people showed interest in body shape and fatness based on their ages, but changing of behaviors and traditions limited their effort in considering health improvement. Different methods have been developed to measure body fatness for epidemiological field studies or clinical use. Body fat can be measured directly and indirectly.

i. Direct methods: As mentioned earlier, many of body fat can't be measured, having the sub-phenotype including 'thin on the outside, fat on the inside' (TOFI) and 'fat-fit' subjects, which specify the importance of having accurate and reproducible measurements of both the total body-fat and its distribution. Thomas et al. (2013) state that chemical analysis done by macroscopic dissection or lipid extraction under direct measurement has some limitations value as it cannot be related to measurements in vivo.

ii. Indirect methods: Body-mass-index (BMI), skinfold anthropometry, bioelectrical impedance, underwater weighing, and body water dilution are some of the indirect methods. All these methods are having their pros and cons. Sometimes, they will give little or no information on adipose tissue distribution. Moreover, most of these methods depend on indirect measurements of either body water or body volume and need equations to convert these into total fat measurements (Thomas et al., 2013).

iii. Anthropometric measures and body fat depots: Body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR) and waist to height ratio (WHtR) provide evidence of body fat with lesser reliability. But some controlled condition they may be good evidence for body fat content. Each of them is not similarly weighed rather vary with sex, age and ethnicity (intercountry) (Jayave, 2019; Lear et al., 2010). Nevertheless, the values are the same inactive versus sedentary females, are significantly correlated with all anthropometric measures disregarding WHR, while in active males, WC is higher than in sedentary male, rather body fat percentage is the same, and is followed by the same WHR and WHtR values (Lutoslawska et al., 2014).

C. *Factors affecting body fat deposition*

There may be deviation that above anthropometric measurements (WC, WHR, WHtR) convey disease outcome with different factors. The main problem is whether there are systematic differences in the extent to which a given waist circumference or waist–hip-ratio or waist-to-height ratio, convey disease outcomes in different ethnic groups. It could cause overestimation or underestimation for a particular population. In contrast, systematic differences could be related to differences in body composition and differences in disease occurrence for a particular body fat composition. The relative amounts or types of fat in the body is reflected by the body composition. Also, differences between men and women, and with ageing were variations in body fat distribution that can affect all populations (WHO, 2008).

III. METHODOLOGY

A. *Sample selection*

This study was an epidemiological study conducted at the University of Peradeniya. The local undergraduates who study in the university are nearly 12,756 (Annual report, 2018). But this study is focusing on local male undergraduate students who stay in the hostels on university premises. There are 7185 local students are in hostels. Within those 3054 male students are there. The population consisted of male local undergraduate students in each academic year (1st to 4th year). Faculty was not considered as a factor. First of all, data was collected as much as possible in every boys' hostels on university premises. The total number of students in each year is more or less the same. The representative sample size of the larger study was calculated using an estimated 95% confidence interval. The estimated sample size was 342 local undergraduate but the selected sample size (n=107). The sample was categorized into four groups, in which the first year (36), second year (25), third year (13) and the final year (33) were the sampling units. Cluster sampling of each batch (years) was used, with proportional stratification by ethnicity (ratio of Sinhalese: Tamils: Muslims: Catholics was 17.5: 5: 2: 0.5) and the diet pattern of them (vegetarian, non-vegetarian) because it is hard to see lacto-vegetarians, ovo-vegetarians and lacto-ovo vegetarians.

B. *Instruments and procedures*

The data were collected between February 2020 and mid of March 2020. First, students with any illness or on any medication were excluded and they were asked whether they had their meal or physical activities within 2 hours from the body fat measuring time. If any subject had their meal or physical activities within 2 hours, he was informed as ineligible to involve in the study. After informing the eligibility of students, information of the subjects was obtained by self-report, including name, age, contact number, ethnicity, and academic year. So it was easier to get data in at early morning and late at night at the hostel. Dual data were collected from each subject at different times. The hostel canteen was the place where the measurements were taken. Before getting that fat measurement; diet pattern was also asked from the subject whether he was a vegetarian or not. Height was measured with a portable stadiometer (0 to 220 cm) fixed to the wall, to the nearest 0.1 cm. WC and HC were measured with a non-elastic measurement tape to the nearest 0.1 cm according to procedures recommended by the World Health Organization. A bioelectrical impedance analyser using two-point tactile electrodes was used. This device uses a small direct current (DC). Since two tactile electrodes are built into each footplate, the impedance can be measured by standing on the footplates with bare feet, when the subject's arms were stretched alongside their trunk during measurements. This device measures the leg-to-leg impedance and weight, and can automatically display the % TBF using an inherent prediction equation, age and height. The fat-free mass (FFM) is estimated and then total body fat per cent was shown in the display. BMI was also shown. All the data was written down in paper. The average of body fat content was recorded.

C. *Statistical analysis*

IBM SPSS V19 was used as analytical software for the analysis. All the recorded data were analysed between the sampling units and within the sampling units. Median, mean and, minimum and maximum were obtained from descriptive analysis for comparison of anthropometric measures and other related factors. Graphs for anthropometric measures and body fat were plotted down for the easiness of understanding the relationship. Correlation coefficient (R^2) values, which are the best fit with ordinates, are emphasizing the relationship. Pearson's correlation was used to determine the relationship of hypothesized factors with body fat. A descriptive test was used for getting the mean and standard deviation with $P>0.05$. Graphs were illustrated on showing the relationship with correlation coefficient (R^2). The range of the samples and, the minimum and maximum values were indicated showing boxplots. The frequency of all the clustered samples was shown using a pie chart.

IV. RESULTS

Table 1 shows the mean value of each anthropometric measurement studied and the percentage of the students under healthy range as well as under risky condition for non-communicable diseases. Since the Asian cut off value for BMI is less than 22.9 kg/m2, among the students studied, 30% of them show risky BMI levels that can lead to NCDs. Al though none of undergraduates' the waist circumference did not go beyond the normal level (102 cm) for males, WHR and WHtR exceeds the critical value in 12% and 8% of students respectively. But, all the mean values of anthropometric measurements are under the normal range. Among the samples, a higher percentage of risk for NCD is caused by higher BMI levels.

Table 1: Sample characteristics by anthropometric measurements based on mean values and cut off values

Indicators	Mean	SD	Normal	Risk for NCDs
BMI	21.55	3.53	74 (70%) {≤22.9 Kg/m2}	33 (30%) {>23 Kg/m2}
WC	73.80	8.58	107 (100%) {<102cm}	0 {≥ 102cm}
WHR	0.83	0.06	94 (88%) {<0.9}	13 (12%) {≥0.9}
WHtR	0.43	0.05	98 (92%) {<0.5}	9(8%) {≥0.5}

Table 2 illustrates the relationships between anthropometric measures and body fat content. WC shows a higher correlation (0.706) with body fat content while the lowest (0.358) was observed by the WHR. The WHtR and BMI indicators showed approximately equal values (0.672, 0.626) of correlation with body fat percentage. When considering correlation coefficient (R^2) values, all the indicators showed lower mean values ($p<0.05$).

Table 2: Correlation between anthropometric measurements and sample body fat content

Indicators	Pearson's correlation	R^2 value	*P* value
BMI	0.626	0.445	*P*<0.01
WC	0.706	0.498	*P*<0.01
WHR	0.358	0.127	*P*<0.01
WHtR	0.672	0.445	*P*<0.01

Table 3 point outs the mean and standard deviation of average body fat content of all batches. Final year students show higher average fat content than rest of the batches. However, the difference of average fat content among last three batches are very less; approximately similar. Lowest mean fat percentage was observed in first year students and the minimum amount was recorded as 8.10%. At the same time, the deviation among their fat content also higher than other three batches. The median fat content value out of all batches was high among 2nd year students (Figure 1). As the ideal body fat percentage of male ranges between 18-24% (WHO), the mean body fat of all batches exceeds the risky level and can be predicted that they are under obese condition.

Table 3: Body fat percentage by students' academic year

Academic year (n)	Minimum	Maximum	Mean	SD
1st year (36)	8.10	51.20	24.65	10.27
2nd year (25)	11.55	40.65	28.87	7.07
3rd year (13)	16.55	38.05	28.44	6.30
4th year (33)	11.55	48.10	28.96	8.97

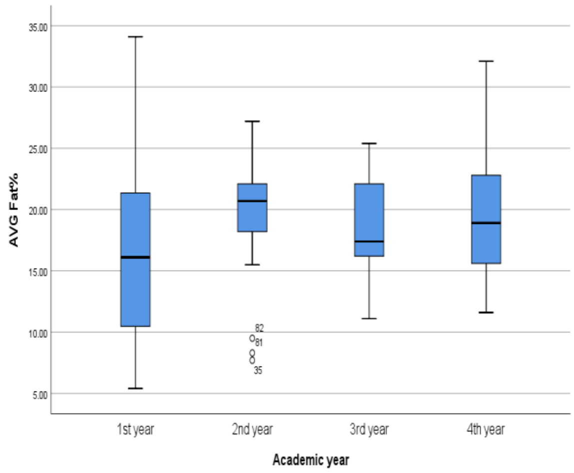

Figure 1: Distribution of body fat content by each academic year

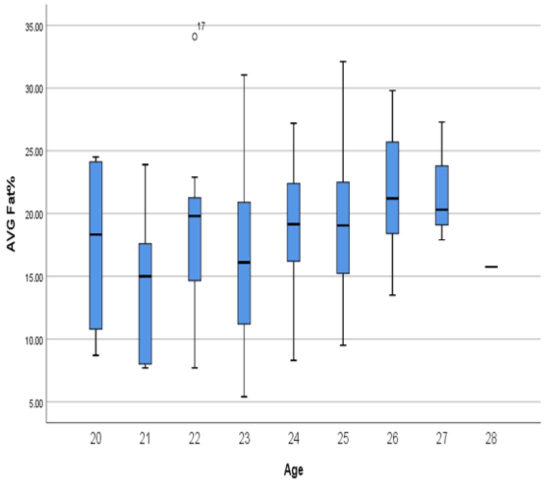

Figure 2: Distribution of body fat content by age of participants

Figure 2 illustrates the fat content of students based on their age. At the age of 21, students' fat content highly deviated and at the age of 26, highest median value has recorded (Figure 2). Results of ethnicity variation in students show that there is no significant variation in body fat content among ethnicity (Table 5). Vegetarians are lower (9.35%) in percentage than non-vegetarian (90.65%) in the study sample and the body fat content of non-vegetarian is highly deviated (Figure 3). The mean body fat of non-vegetarian showed a higher value compared to vegetarians and there are no significant differences in their fat
Table 04: Body fat percentage by ethnicity
content based on their food consumption behaviours (Table 6).

Table 4: Body fat percentage by ethnicity

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5.628	3	1.88	.052	.984
Within Groups	3714.173	103	36.06		
Total	3719.801	106			

Table 5: ANOVA table for different ethnicity groups

Ethnicity	Frequency	Mean	SD
Sinhalese	75	27.41	8.277
Tamils	9	28.11	14.37
Muslim	21	27.36	9.012
Catholics	2	25.35	2.970

Table 6: Body fat percentage by diet pattern

	Maximum fat%	Minimum fat %	Mean fat%	SD	P-value
Vegetarians (10)	33.75	18.75	27.28	5.16	0.865 *P*>0.05
Non-vegetarians (97)	51.20	8.10	27.43	9.20	

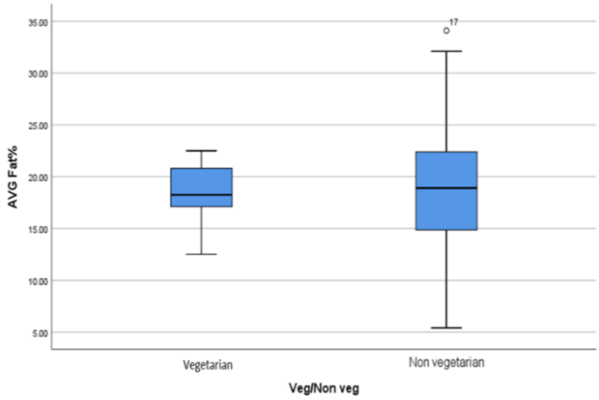

Figure 3: Distribution of vegetarian and non-vegetarian with body fat content

V. DISCUSSION

According to the Asian cut off value of male BMI, it consists of four categories such as underweight (<18.5 Kg/m2), normal (18.5-22.9 kg/m2), overweight (23-27.5 kg/m2) and obese (>27.5 kg/m2) (Liabsuetrakul, 2011). In this study, overweight and obese are considered as a higher risk for non-communicable diseases and, underweight and normal are opposed. The mean of BMI is approximately at the boarder (21.55kg/m2) of critical point of risk. BMI can correlate with body fat to some extent, here it has positive correlation with body fat and correlation coefficient is 0.626. While describing, below half of the sample can be used for interpreting the body fat content using BMI values (R2 value = 0.445). Table 1 emphasizes that all the anthropometric measures other than WC contrasts the presence of risk individuals for NCDs. According to Sharpe and Bradburuy (2015), WC is much effective for female than male. In this study also WC measurement was the indicator detecting lower risk for NCDs. Population mean of WC was below the critical value (<102 cm). It says that the whole population are not at-risk regarding WC while a better indicator related to the correlation coefficient. But this can’t be the best measures for detecting body fat because this model fits less than 50%. WHtR is another measure, revealed as a good indicator for the risk of CVD and diabetes (Wikramasinghe et al., 2017; Sharpe and Bradburuy, 2015). Mean of WHtR in the sample population contrasting lower than the risk level (<0.5) and eight per cent was the risk. It correlates better than BMI with body fat content but lesser than WC and closer to it. WHR is encountered as a lower correlating indicator (correlation co-efficient = 0.358) and has a lower mean (0.83) value than risk level (> 0.9) for NCDs. Singh (1993) has pointed out that WHR is expressed as youthfulness and reproductive status of endocrinology and caused to long term health risk. Other than that, WHR is a strategy while choosing the partner, and hence attractiveness judgment (Tovée et al., 1999; 2002). Thomas et al. (2013) has illustrated that there are some undiagnosed conditions” Thin in outside fat in inside” and “fat fit” conditions caused to an inverse relationship with body fat content. MRS (Magnetic Resonance Spectroscopy, MRI (Magnetic Resonance Imaging) and DEXA (Dual Energy X-ray absorptiometry) are the appropriate methods for body fat analysis. Despite the anthropometric measures having little correlation with body fat, most of the cases are underestimated. Visceral adipose tissue is not only the fat that directs to health risks but also ectopic fat can be caused to metabolic risks like diabetes and heart disease (Neeland et al., 2019). MRI and MRS can estimate the ectopic fat in the liver, heart and pancreas which the anthropometric measures cannot detect. At the entrance to the university, the student shifts from home to hostel life. During that displacement, they may attempt to adapt accordingly. The body fat content of university students may change from 1st year to 4th year due to the change in dietary pattern in hostel life, lower physical activity or lower VO2 max and stress of academic life of the university (Gropper et al., 2012). According to the data, there was a change in the mean of body fat of 1st-year students which increased towards the final year. Body fat content at the beginning of the university is diversified despite the final year is somewhat unique. Hence some other factors may be responsible for the change in the body fat content of undergraduate. Based on the analysed data, students’ mean body fat content from all batches exceeds the risk level of fat content for male, declared by WHO (18-24%), can be taken as they are under risk of obesity. The age of participants varied from 20 to 28 years during undergraduate life while data at 20th age is highly diversified. Because most of the first years are at the age of 20. They are fresh to university life. There is not enough data to discuss with the final year. Age is correlated well with VAT as mentioned by Ferrannini et al. (2008). BMI and WC are increased with age increases. But it cannot be studied using this sets of data. Ethnicity cannot be elaborated as having any significant effect on the body fat content as shown by different ethnicities. Tamils showed deviated body fat content rather than others because of their diet pattern differs much based on their cast variations and some restrictions on their religion based on their cultural behaviours. There are seven different types of vegetarianism. They are vegan, semi-vegetarian, lacto vegetarian, ovo vegetarian, lacto-ovo vegetarian, pollotarian and pescotarian. But these all pattern cannot be seen enough data for analysis. So these categories were split into two main groups as vegetarian and non-vegetarian. A non-vegetarian had diversified body fat content than vegetarian (Janelle and Barr, 1995). But some studies showed that the vegetarian has higher body fat than non-vegetarian (Leelakumari, 2017). The mean fat of non-vegetarian was slightly higher than vegetarian (but not significant at 5% significant level, Table 6), according to these data.

VI. CONCLUSION

Anthropometric measurements are quick and handy methods, predicting the risk of non-communicable diseases (NCDs) while none of methods available is perfect to determine the body fat and health risk for NCDs. But, modern techniques of body fat analysis can be used to determine body fat content precisely. Among the anthropometric indicators used, WC is found to be a good indicator than BMI, WHtR, and WHR, having the best correlation with body fat and risks for NCDs can be diagnosed easily at a lower cost. Changes in lifestyle, food consumption behavior and residence affect the body fat content of male undergraduates in a considerable amount and sudden changes affect little more till they get into an adoption to the environment. Changes in body fat content significantly depends on the age, body structure and the lifestyle. Body fat content of male undergraduates differs much during their residency within university premises and awareness should be addressed in concerning their health.

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