EUROPEAN ACADEMIC RESEARCH
Vol. II, Issue 5/ August 2014

Impact Factor: 3.1 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Chronic Energy Deficiency (CED) and its Association with Clinical and Biochemical Parameters, Calorie Intake and Oxygen Consumption Level in Bangladeshi Farmers

TASLIMA KHATUN[1]
Senior Lecturer
Department of Community Nutrition
Faculty of Public Health
Bangladesh University of Health Sciences (BUHS), Dhaka
Bangladesh
MOSARAF HOSSAIN
Department of Biochemistry & Molecular Biology
University of Chittagong, Chittagong
Bangladesh
SADEKA BANU AKHI
Nutritionist
Apollo Hospital, Dhaka
Bangladesh
QUAMRUN NAHAR
Biomedical Research Group, BIRDEM, Dhaka
Bangladesh
LIAQUAT ALI
Department of Biochemistry & Cell Biology
Bangladesh University of Health Sciences (BUHS), Dhaka
Bangladesh

Abstract:

This study was undertaken for the assessment of chronic energy deficiency (CED) of farmers based on BMI, food intake pattern, oxygen consumption, clinical, biochemical parameters. Study subjects were divided into Normal, CED1, and CED2& CED3 according to WHO criteria. Functional characterization was done by working days

[1] Corresponding author: tasumoni11@yahoo.com

per week and by estimating oxygen consumption. Body fat was calculated according to Durnin and Womersley's formula. Hemoglobin was measured by Cyanmethemoglobin method, glucose by glucose–oxidase method, lipid profile by enzymatic colorimetric method, creatinine by alkaline picrate method, SGPT and total protein by spectrophotometicmethod. MUAC, triceps, subscapular and suprailiac of the CED subjects were significantly lower as compared to normal BMI. Anemia seems to be necessarily associated with CED3. Body fat was significantly lower in all CED groups and calorie intake was also significantly lower than normal. TG, Cholesterol & SGPT are significantly lower in CED groups than normal BMI. Oxygen consumption had significant positive correlation with BMI. So, clinical & biochemical markers as well as working capacity of rural males may be affected due to CED.

Key words: BMI, CED, Farmers, nutritional status, oxygen consumption

Introduction

Chronic energy deficiency (CED) have recently been defined as degrees of underweight that is categorized on the basis of BMI, i.e., a 'steady' under-weight in which an individual is in energy balance irrespective of a loss in body weight or body energy stores[1]. CED is caused by inadequate intake of energy accompanied by high level of physical activities and infections[2,3]. World Health Organization (1995)[4] has recommended that anthropometry could be used to assess the nutritional and health status of adults. One such measure now in widespread use is Quetelet's index, which is body weight (in kg) divided by stature (in m^2)[5]. Better known as body mass index (BMI), is the most established anthropometric indicator used for assessment of adult nutrition status[4]. BMI is most widely used because its use is simple, inexpensive, safe and suitable for large scale surveys[6,7]. It is generally considered a good indicator of not only the nutritional status but also the socio-economic condition of a population, especially adult populations of developing countries[8]. A BMI < 18.5 kg/m2 is widely used as a practical measure of chronic energy or hunger deficiency (CED). The condition of low BMI is termed "thinness" graded as mild (grade 1=17.0-18.49), moderate (grade 2= 16.0-16.99), or severe (grade 3<16.0)[9]. CED is caused by inadequate intake of energy accompanied by high level of physical activities and infections[3]. It is associated with reduced work capacity[10], performance and productivity[11], increased morbidity due to suppressed immune function[3,12] and behavioral changes[13]. Oxygen uptake has been shown to be related to the intensity of work performances and cardiac output. This relationship has formed the rationale for cardiovascular function. The exercises condition for including oxygen utilization has usually featured treadmill or bicycle[14].

Nutritional assessment of individuals is a complex matter. But it is very important to select the best tool to estimate its real incidence in an easy and effective way. The nutrition and health of adults are of particular importance because people of this age group are primarily responsible for the economic support to the rest of the society. In industrialized countries, although an appreciable proportion of adults are still engaged in activities that require physical stamina and strength, economic productivity depend to a substantial degree on the intellectual and technical skill of the population. In non industrialized societies, however, where agricultural work is still the primary force economic activity, physical capacity and endurance are critical to the ability of adults to sustain the socio-economic and cultural integrity of their community. So it is necessary to know the nutritional status of any country, especially the malnutrition of farmers must be known. For a developing country having an active and healthy adult population is a blessing for the development of the country.

Few published data exist on energy intake, oxygen consumption and Chronic Energy Deficiency (CED) in farmers of rural area in Bangladesh. In the above context the present study was planned to explore the clinical, anthropometric, biochemical incidence of Bangladeshi farmers on the basis of BMI grades and also to assess the links between CED and working capacity. The main objective of the study was to assess chronic energy deficiency by means of anthropometry and to find out an association between dietary intake, oxygen consumption as well as clinical and biochemical examinations among farmers which will ultimately help to assess the physical activity and productivity of this community.

Methods

Cross-sectional study was conducted in six different villages of Keranigonj, Agargaon, Saver and Gazipur of Dhaka Division using standard sample size estimation formula $n = Z^2pq/d^2$. Data was conducted on 139 adult farmers aged 19-45 years upwards. Nonresponsive rate for all the variables of interest was 28.6% all cases. Final analysis was performed on the data of 99 with complete information. Data were collected after obtaining the necessary approval from the subjects; participants were informed about the objectives before the commencement of measurements. Information on age, gender, weight and height were collected on a pre-tested questionnaire by house-to house visit following interview and examination. Body weights were measured in light clothing, without shoes to the nearest 0.1 kg using a digital balance. Heights were measured to the nearest 0.1 cm using the SECA balance with height attachment. The BMI was computed using the following standard equation: BMI = Weight (kg) / height (m^2). Skin fold thickness (triceps, subscapular & supraliac) measurements were taken using the Harpenden skin fold calipers. Total body fat (TBF) & Body fat percentage (BF%) of the study subjects were estimated using the standard equations: TBF=(4.95/Body density- 4.50)* body weight; where, Body density = c-m*log skin fold, where c and m are regression equation constants (c = 1.1398 and m = 0.0738) for the estimation of body density from the logarithm of (biceps + triceps) skinfold thickness & BF % = TBF (kg)/Actual body weight*100[15]. Blood pressure was measured in sitting position, with calf at the level of the heart. Physical examination and the general clinical condition of the subjects were assessed by a qualified physician. Nutritional status was evaluated using internationally accepted BMI guidelines. The cut-off values were CED: BMI <18.5, Normal: BMI = 18.5-24.9, Overweight: BMI = 25.0. CED was further divided into CED III, CED II and CED I as BMI < 16.0, 16.0-16.9 and 17.0-18.4 kg/m^2, respectively[4]. Functional characterization was done by working days per week and estimating oxygen consumption using a treadmill. Oxygen consumption was calculated by following formula: Oxygen consumption (ml/kg/min) = (speed in m/min)* (0.1ml/kg/min) + 3.5 ml/kg/min and Oxygen consumption (L/min) = (Oxygen consumption in ml/kg/min* body weight in kg)/1000[16]. Hemoglobin was measured by Cyanmethemoglobin method. Dietary intake was taken by 24hr recall method. Serum glucose was measured using the glucose–oxidase method, and the fasting serum lipid profile (cholesterol, triglyceride and HDL) was determined by enzymatic colorimetric method, fasting serum creatinine by alkaline picrate method and serum SGPT by UV-spectrophotometric method using commercial kits (Randox Laboratories Ltd., UK). Serum LDL was calculated using the formula of Friedewald[17]. Total protein was measured by spectrophotometic method. All ethical issues related to this research involving human subjects were followed according to the guideline of the of Bangladesh Diabetic Somiti (BADAS) ethical review committee. A written consent was taken from all subjects after full explanation of the nature, purpose and potential risks of all procedures used for the study.

Statistical analysis was performed using SPSS (Statistical Package for Social Science) software for Windows version 11.5 (SPSS Inc., Chicago, Illinois, USA). All the data were expressed as mean ± SD (standard deviation), median (range) and/or percentage (%) as appropriate. The statistical significance of differences between the values was assessed by ANOVA or Mann–Whitney U test (as appropriate). A two-tailed p value of <0.05 was considered as statistically significant.

Results

A total of 99 subjects (Farmer) from different parts of rural areas in Bangladesh, aged 19-45 years included in this study. They were assessed clinically and biochemically to find out whether there is any relationship of clinical and biochemically indices in the subjects of different CED grades. This study was planned to explore the anthropometric status of the study subjects on the basis of CED grades and also find out the association between BMI and body composition.

The average age of normal BMI, CED1, CED2 and CED3 groups were 30±7, 31±8, 25±4, 26±7 respectively. BMI was significantly higher (p=0.001) in normal BMI groups compare to CED1. The mean ±SD values of pulse rate of the subjects were 83±18; 81±15; 84±9; 83±16, diastolic blood pressure of the subjects were 83±12; 76±7; 73±9; 74±20 on the basis of CED grades respectively. The mean±SD value of mid arm circumference (MUAC) of normal BMI, CED1, CED 2, CED3 was 271±25, 251±17, 233±33, 235±12 respectively. The values of MUAC were significantly lower (p=0.01, p=0.001) in all three CED groups compared to normal BMI subjects. The mean±SD of triceps skin fold thickness (SFT) (mm) was 9.31±4.82, 6.45±2.15, 5.41±0.91, 6.68±2.25 among the four different BMI groups respectively. A significantly lower value ($p<0.05$) was found in CED2 and in CED3 groups as control subjects. The mean ±SD value of subscapular skin fold thickness (SFT) according to CED grades were 16.76±7.95, 11.78±5.34, 8.48±1.74, 9.04±2.52 respectively among other BMI groups. The mean ±SD values of suprailiac skin fold thickness were 20.38±8.65, 14.43±5.90, 10.33±2.37, 15.80±8.95 on the basis of CED grades respectively. Subscapular skin fold thickness was significantly lower in all three CED groups and suprailiac skin fold thickness was significantly lower in CED1 and CED2 in compare to Normal BMI (Table-I).

According to WHO Expert Committee criteria the distribution of normal BMI, CED1, CED2 and CED3 among the study subjects was 46.5%, 21.2%, 13.1% and 19.2% respectively (Figure-1).

The mean ±SD values of total body fat (kg) of the subjects were 9.55±3.25, 5.77±2.45, 4.08±0.92, 6.24±4.06 on the basis of CED grades respectively. Subjects of CED1, CED2, CED3 had significantly ($p<0.001$) lower fat (kg) as compare with the subjects having normal BMI. Percentage of body fat of the subjects were 16.81±4.09, 11.83±4.50, 8.90±1.56, 11.91±4.71 and the values were significantly (<0.001) lower in all three CED groups than normal BMI group. Hemoglobin (mg/dl) level among the four different groups were 12.48±1.47, 12.45±1.28, 12.09±0.92, 11.22±1.35 on the basis of CED grades respectively. Significant difference was found between normal and CED3 groups. ESR values of four different study groups in 1st hour were 19.90±17.78, 13.24±20.92, 16.38±14.32, 22.95±24.43. No significant difference was noticed considering ESR value (Table-II).

Calorie intake of the study subjects were 2453(1715-3285), 2432(2000-3000), 2308(1892-2535), 2158(1526-2355) on the basis of CED grades respectively. No of working days (weak/day) of BMI classes were 6±1, 6±1, 6±1, 5±0.8

respectively. CED2 and CED3 group intake significantly lower amount of calorie compare to normal BMI group and CED3 group had significantly lower no of working days compare to the normal group. The mean ±SD values of oxygen consumption of the study subjects were 0.71±0.17, 0.65±0.13, 0.64±0.12, 0.59±0.10 on the basis of CED grades respectively. Oxygen consumption was significantly lower (p=0.001) in CED3 groups in compared to normal BMI (Table-III).

Some remarkable clinical abnormalities were present like bleeding gum, anemia and glossitis among the low BMI rural subjects even in BMI below 16 (CED3). There was no significant difference was found any others clinical parameters of the study subjects (Table-IV).

Serum glucose (mmol/l) level in the BMI classes were 4.81±0.68, 5.34±2.21, 4.67±0.48, 4.67±0.58 respectively. No statically significant difference was observed in any groups. Serum cholesterol (mg/dl) level were 163 (93-248), 168 (104-225) 165(90-199), 141 (87-210) on the basis of CED grades respectively. Serum triglyceride (mg/dl) level were 112(52-25), 103(54-233), 96 (47-148), 102(62-219) on the basis of BMI classes respectively. Serum HDL (mg/dl) level were 35(25-69), 37(22-59), 43(30-59), 33(24-60) on the basis of BMI classes respectively. Serum LDL (mg/dl) value in the BMI classes were 105(24-169), 101(56-172), 106(38-140), 76(28-145) respectively. The results showed that TG and cholesterol levels were significantly lower in CED2 & CED3 respectively in compare to normal BMI group (Table-V).

SGPT (mg/dl) of the study participants in different group were 36.55±22.46, 28.81±15.92, 24.58±19.69, 15.52±5.60. Significantly (p=<0.001) lower SGPT was found in the subjects with CED3 as compared to the subjects having normal BMI. Serum creatinine (mg/dl) value of the study participants in different groups were 1.04±0.16, 1.12±.15, 1.12±.11, 1.14±.14 on the basis of BMI classes respectively. The values were almost similar and were within normal range. No statistical significance was observed between groups. Serum Total protein (gm/dl) value in the BMI classes were 7.65±0.57, 7.62±0.75, 7.56±0.79, 7.28±0.61 respectively. There was no statistical significant difference observed in any groups (Table-VI)

In Pearson's correlation oxygen consumption had significant positive correlation with Body Mass Index (BMI) ($p<0.0001$) of the study subjects (Figure-2).

Discussions:

In a non-industrialized and agricultural dependent zone like Bangladesh nutritional status monitoring is essential since activity and productivity depend on nutritional status of the persons engaged in the developmental works. Low BMI produces low productivity and less income, access to low food, which affect health. This cycle goes on and ultimately affects the economic status of the country. In a developing country like Bangladesh it is an urgent need to survey the nutritional status every few years. No study has so far been conducted regarding the nutritional status and working capacity among Bangladesh rural population. In this study the mean age (yrs) of different CED grades was mostly similar. No relationship was found between ages of the subjects with BMI. Pulse rate systolic blood pressure and diastolic blood pressure among the four different groups of subjects were within normal limit. MUAC value was found significantly lower among different BMI groups and was found to be increased significantly with increasing BMI ($p<0.05$). The entire three CED group had significantly lower triceps, subscapular and supraliac values than controls.

According to WHO Expert Committee criteria the prevalence of normal BMI, CED1, CED2 and CED3 among the study subjects was 46.5%, 21.2%, 13.1% and 19.2% respectively. In a previous study conducted in BIRDEM has been shown the prevalence of Normal BMI, CED1, CED2 and CED3 in urban manual workers were 44.69%, 31.87%, 13.86% and 9.58% respectively. Thus, low BMI (BMI<16.00) is higher in rural population compared to urban manual workers in Bangladesh. Teten et *all* was found 64.0% CED (BMI<18.5) in Rural, Bangladesh[18] and Pryer and Rogers was found 41.0% CED in Dhaka slum area[19]. Among the Malays, prevalence of CED for males and females were 7% and 11% in urban areas and 11% and 14% in rural areas, respectively[20]. In 6th Asian Congress of Nutrition, James and Ralph[21] have been shown that in China 11.3% of males and 13.3% of females were under CED group but they have not considered different grades of CED. They also have found that CED percentage in males and females in India were 50% and 49%, in Malaysia 11% and 15%, in Pakistan 48% and 40%, and in Vietnam 28% and 29%. Desert areas of Western Rajasthan, India[22] found that 45.8% males and 39.5% females showed chronic energy deficiency severe CED in male was 12.7%, which was high and needs attention. The prevalence of CED (among males and females) of the Santals of Purulia, West Bengal India[23], was shown that, in general, the females were highly energy deficient than their male counterpart; females have CED (Grade-III =14.51, Grade-II = 16.40, Grade-I = 32.49) then males (Grade-III = 5.61, Grade-II = 4.59, Grade-I =20.41). The average hemoglobin level of CED1, CED2, and controls (normal BMI) subjects were similar. Significance difference was found among normal and CED3 groups in hemoglobin levels. Lower BMI seems to be necessarily associated with anemia. In previous study has been shown similar result but low BMI female subjects had low ferritin level. Study was conducted Western Rajastan in India[22], Anemia was found 35.6 percent.

In our study the clinical features of the study subjects like chelosis, bleeding gum, angular stomatitis, anemia, edema, glossitis, goiter, hair colour changes, koilonychias, parroted enlargement, pale conjunctiva, were observed by a registered physician, abnormalities was found in bleeding gum, anemia and glossitis. Vitamin A and B complex deficiencies along with anemia were significantly higher in desert areas of Rajasthan, India[22]. The functional capacity was judged by counting their working days in each week prior to blood collection in the prescheduled day. Subjects in normal BMI group and the entire three CED categories have visited in their working place Absenteeism in the working place may not only depend on their physical incapability but also associated with factors such as per day income , recreation, idleness, family demand and life leading pattern . So study subjects to make sure that this absenteeism is only because of their physical incapability. The results have shown that subjects in all the four BMI groups dropped out one or similar working days/ week prior to interview and there is significance difference found among normal and CED 3 groups.

Our studies demonstrate that no significant difference in oxygen consumption was found among normal BMI group (BMI 18.5-25.00), CED1 (BMI 17.00-18.49) and CED2 (BMI 16.00-16.99) group. Subjects having BMI<16.00- showed significantly (P=<0.001) lower oxygen consumption compare to subjects having BMI more than 18.50. This type of study allow for a better understanding of the compositional changes underlying the alterations in physical fitness, which occur during undernutrition. Unfortunately no equivalent studies conducted among rural adult populations in our country. BMI of approximately 18.5 work capacity and productivity starts to decline[23]. Shetty[24] has provided an interesting example where Indian labourer (BMI <17.0) were classified physically fit by standard tests. However, it is difficult to imagine that their work output was optimum. In a study among female teapluckers in Sri Lanka[25], there appeared to be significant relationships between blood haemoglobin values and productivity, but no relationship between BMI and productivity. It is argued that a BMI below 17.0 constitutes a risk to health and could lead to an impaired physical capacity[26], while BMI of 12.0 may be the absolute lower limit compatible with life[27]. Colombian adults, who were described as having CED of varying degrees of severity were studied, the results showed that only the severity "malnourished" grouped had a marked reduction in maximal oxygen consumption which is expressed in total liters of oxygen per minute[2] Similar data are emerging from India, where good correlation has been found between body weight, BMI and work capacity (measured using maximal oxygen consumption) in undernourished individuals in Hyderabad[28].

Comparable published data on the association between BMI and working capacity are not available. It is hoped that the findings of the present study will stimulate further detailed research on the association of low BMI with working capacity, morbidity as well as mortality, particularly in the context of the developing countries.

Conclusion

From the above context the study showed that more than half of the study subjects were sufferer different level of chronic energy deficiency. Anemia seems to be necessarily associated with CED3. Total body fat and percentage of body fat were significantly lower in all CED groups and calorie intake was significantly lower than normal. Bleeding gum, anemia and glossitis are the significant consequences in the CED groups. TG, Cholesterol & SGPT are significantly lower in CED groups than normal BMI. The risk of malnutrition is higher among the farmer whose suffer from chronic energy deficiency. Oxygen consumption had significant positive correlation with BMI. So, it can be concluded that anthropometric parameters, clinical &

biochemical markers as well as working capacity of rural males may be affected due to chronic energy deficiencies (CED).

References

Khongsdier, R. 2005. "BMI and morbidity in relationto body composition: a cross-sectional study of a rural community in North-East India." *British Journal of Nutrition* 93: 101–107. [1]

Shetty, P.S. & James W.P.T. 1994. "Report of the Food and Agricultural Organization: Body Mass Index: A measure of Chronic Energy Deficiency in Adults." Food and Nutrition Paper No. 56. Rome. [2]

Shetty, P.S., Soares, M.J., James, W.P.T. 1994. "Body mass index: Its relationship to basal met abolic rates and energy requirements." *European Journal of Clinical Nutrition* 48 (suppl 3): S28-S38. [3]

World Health Organization. 1995. "Physical Status: the Use and Interpretation of Anthropometry." Technical Report Series no. 854. Geneva: World Health Organization. [4]

Keys, A., Fidanza, F., Karvonen, M.J. et al. 1972. "Indices of relative weight and obesity." *Journal of Chronic Disease* 25: 329-43. [5]

Lee, R.D. & Nieman, D.C. 2003. *Nutritional Assessment*. New York: McGraw Hill [6]

James, T.P.W., Mascie-Taylor, N.G.C., Norgan, N.G., Bristrian, B.R., Shetty, P.P., Ferro- Luzzi, A. 1994. "The value of arm circumference measurements in assessing chronic energy deficiency in Third World adults." *European Journal of Clinical Nutrition* 48: 883-894. 1994. [7]

Mosha, T.C.E. 2003. "Prevalence of obesity and chronic energy deficiency (CED) among females in Morogoro district, Tanzania." *Ecology of Food and Nutrition* 42: 37-67. [8]

Trinder, P. 1969. “Determination of Glucose in Blood Using Glucose Oxidase with an Alternative Oxygen Acceptor.” *Ann. Clin. Biochem* 6: 24-25. [9]

Durnin, J.V. GA. 1994. "Low body mass index, physical work capacity and physical activity levels." *European Journal of Clinical Nutrition* 48 (Suppl 3): S39-S44. [10]

Kennedy, E. & Garcia, M. 1994. "Body mass index and economic productivity." *European Journal of Clinical Nutrition,* 48 (Suppl 3): S45-S55. [11]

Garcia, M. & Kennedy, E. 1994. “Assessing the linkage between low body mass index and morbidity in adults: Evidence from developing countries.” *European Journal of Clinical Nutrition* 48 (Suppl 3): S90-S97. [12]

Kusin, J. A., Kardjati, S., Rengvist, U.H. 1994. "Maternal body mass index: The functional significance during reproduction." *European Journal of Clinical Nutrition* 48 (suppl 3): S56-S67. [13]

Kasch F.W., Phillips, W.H., Carter, J.E.L., et al. 1966. “A comparison of maximal oxygen uptake by treadmill and step-test procedures.” *J Appl Physiol* 21:1387–1388. [14]

Durmin, J.V.G.A., Womensley, J. 1974. “Body fat assessed from total body density and its estimation from skinfold thickness: measurements of 481 men and women aged from 16 to 72 years.” *Br J Nutr* 32:77-97. [15]

Kasch, F.W., Phillips, W.H., Ross, W.D., Carter, J.E., Boyer, J.L. 1966. “A comparison of maximal oxygen uptake by treadmill and step-test procedures.” *J Appl Physiol*. 21(4):1387-8. [16]

Friedewald, W.T., Levy, R.I., Fredrickson, D.S. 1972. “Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge.” *Clin Chem*. 18: 499–502. [17]

Pryer, J.A., Rogers, S. 2006. "Epidemiology of undernutrition in adults in Dhaka slumhouseholds, Bangladesh." *European Journal of Clinical Nutrition* 60: 815-822. [18]

Ismail, M.N., Zawiah, H., Chee, S.S. and Ng, K.K. 1995. "Prevalence of obesity and chronic energy deficiency (CED) in adult Malaysians." *Mal J Nutr* 1:1-9. [19]

James, W.P.T. & Ralph, A. 1991. "Human energy requirements." In *Proceedings 6th Asian Congress of Nutrition*, Kuala Lumpur. Chong et al (eds), pp 62-76. [20]

Singh, B., J. Lakshminarayana, Fotedar, R. 2008. "Chronic energy deficiency and its association with dietary factors in adults of drought affected desert areas of Western Rajasthan, India." *Asia Pac J Clin Nutr* 17 (4):580-585. [21]

Das, S. and Bose, K. 2010. "Body Mass Index and Chronic Energy Deficiency among Adult Santals of Purulia District, West Bengal, India." *International Journal of Human Sciences*. 7(2): 488-503. [22]

Strickland, S.S. 2002. "Functional consequences of adult malnutrition in developing countries." *Journal of Physiological Anthropology and Applied Human Science* 21: 1-9. [23]

Shetty, P.S. 1984. "Adaptive changes in basal metabolic rate and lean body mass in chronic undernutrition." *Hum Nutr Clin Nutr* 38C:443-451. [24]

Selvaratnam, R.R., de Silva, L.D., Pathmeswaran, A., de Silva, N.R. 2003. "Nutritional statusand productivity of Sri Lankan tea pluckers." *Ceylon Medical Journal* 48: 114-118. [25]

James, W.P.T., Ferro-Luzzi, A. & Waterlow, J.C. 1988. "Definition of chronic energy deficiency in adults." *Eur J Clin Nutr* 42:969-981. [26]

Henry, C.J.K. 1990. "Body mass index and the limits of human survival." *Europ J Clin Nutr* 44:329-335. [27]

Satyanarayana, K., Venkatarkakmana, Y., Rao, S.M. 1989. "Nutrition and work erforance: studied carried out in India." International union of nutritional societies, Seoul. 306-309. [28]

Table I: Age, pulse, blood pressure and anthropometric status of the study subjects

BMI classes	**Age (Years)**	**Pulse**	**SBP (mmHg)**	**DBP (mmHg)**	**MUAC (mm)**	**Triceps SFT (mm)**	**Subscapular SFT (mm)**	**Suprailiac SFT (mm)**
Normal BMI	30 ±7	83±18	123±14	83±12	271±25	9.31±4.82	16.76±7.95	20.38±8.65
CED1	31±8	81±15	100±31	76±7	251±17	6.45±2.15	11.78±5.34	14.43±5.90
CED2	25±4	84±9	110±11	73±9	233±33	5.4±0.91	8.48±1.76	10-33±2.37
CED3	26±7	83±16	114±11	74±20	135±12	6.68±2.25	9.04±2.52	15.80±8.95
P value								
Normal vs CED1	1.00	1.00	<0.001	0.16	<0.01	<0.03	<0.03	<0.04
Normal vs CED2	0.13	1.00	0.16	<0.001	<0.001	<0.01	<0.001	<0.001
Normal vs CED3	0.12	1.00	0.49	0.49	<0.001	0.07	<0.001	0.23

Normal (BMI 18.5-25), CED1 (BMI 17.00-18.49), CED2 (BMI 16-16.99), CED3 (BMI<16). Anova (Bonferroni) was performed as a test of significance. A p value <0.005 is significant; SBP=Systolic blood pressure, DBP= diastolic blood pressure, MUAC= mid upper arm circumference, SFT= skin fold thickness.

Table II: Body fat, ESR and Hemoglobin status of the study subjects

BMI classes	TBF (kg)	BF %	ESR(in 1st hour)	Hemoglobin(mg/dl)
Normal BMI	9.55±3.25	16.81±4.09	19.90±17.78	12.48±1.47
CED1	5.77±2.45	11.83±4.50	13.24±20.90	12.45±1.28
CED2	4.08±0.92	8.90±1.56	16.58±14.32	12.09±0.92
CED3	6.24±4.06	11.91±4.71	22.95±24.43	11.22±1.35
	P value			
Normal vs CED1	<0.001	<0.001	1.00	1.00
Normal vs CED2	<0.001	<0.001	1.00	1.00
Normal vs CED3	<0.01	<0.001	1.00	0.001

Normal (BMI 18.5-25), CED1 (BMI 17.00-18.49), CED2 (BMI 16-16.99), CED3 (BMI<16). Anova (Bonferroni) was performed as a test of significance. A p value <0.005 is significant; TBF= total body fat, BF= body fat, ESR= erethrocytic sedimentation rate.

Table-III: Calorie intake, working day and oxygen consumption of the study subjects

BMI classes	Calorie intake (kcal/day)	Working day (Weak/day)	Oxygen consumption (l/min)
Normal BMI	2453(1715-3285)	6±1	0.71±0.17
CED1	2432(2000-3000)	6±1	0.65±0.13
CED2	2308(1892-2535)	6±1	0.64 ±0.12
CED3	2158(1526-2355)	5±1	0.52±0.09
	U/P value	*P value*	
Normal vs CED1	318/0.91	1.00	0.83
Normal vs CED2	121/<0.02	1.00	0.86
Normal vs CED3	171/<0.02	<0.01	<0.001

Normal (BMI 18.5-25), CED1 (BMI 17.00-18.49), CED2 (BMI 16-16.99), CED3 (BMI<16). Anova (Bonferroni) was performed as a test of significance. A p value <0.005 is significant.

Table IV: Distribution of Clinical parameters among the study Subjects (n=99)

Clinical Status		Normal (n=46)		CED 1 (n=21)		CED 2 (n=13)		CED 3 (n=19)	
		Number	%	Number	%	Number	%	Number	%
Chelosis	Absent	46	100	21	100	13	100	19	100
BG	Absent	45	97.8	20	95.2	10	76.9	16	84.2
P value	Normal vs CED 2: **0.04**								
AS	Absent	46	100	21	100	13	100	18	94.7
P value	Normal vs CED 3: 0.235								
Anemia	Absent	41	89.1	20	95.2	12	92.3	12	63.15
P value	Normal vs CED 3: **0.02**								
Edema	Absent	45	97.8	20	95.2	13	100	19	100
P value	Normal vs CED 1: 0.691								
Glossitis	Absent	46	100	21	100	13	100	13	68.4
P value	Normal vs CED 3: **0.02**								
Koilony	Absent	46	100	21	100	13	100	19	100
PE	Absent	46	100	20	95.2	13	100	19	100
P value	Normal vs CED 1: 0.289								
PC	Absent	45	97.8	21	100	11	84.6	18	94.7
P value	Normal vs CED 2: 0.128								
LSF	Absent	46	100	21	100	13	100	19	100
HCC	Absent	46	100	21	100	13	100	19	100
Goiter	Absent	46	100	21	100	13	100	19	100
BS	Absent	46	100	21	100	13	100	19	100
XP	Absent	46	100	21	100	13	100	19	100
MMC	Absent	46	100	21	100	13	100	19	100

Normal (BMI 18.5-25), CED1 (BMI 17.00-18.49), CED2 (BMI 16-16.99), CED3 (BMI<16). Anova (Bonferroni) was performed as a test of significance. A p value <0.005 is significant.BG= Bleeding gum, AS= Angular stomatitis, PE= Parotid enlargement, PC= Pale conjunctiva, LSF= Loss of subcutaneous fat, MW= Muscle wasting, HCC= Hair color change, BS= Bitots spot, XP= Xeropthalmia, MMC= Mucous membrane change.

Table V: Glucose and Lipid profiles among the study subjects (n=99)

BMI classes	**S Glucose (mmol/l)**	**TG (mg/dl)**	**Cholesterol (mg/dl)**	**HDL (mg/dl)**	**LDL (mg/dl)**
Normal BMI	4.81±0.68	112(52-25)	163(93-248)	35(25-69)	105(24-169)
CED1	5.34±2.12	103(54-233)	168(104-225)	37(22-59)	101(56-172)
CED2	4.67±0.48	96(47-148)	165(90-199)	43(30-56)	106(38-140)
CED3	4.67±0.58	102(62-292)	141(87-210)	33(24-60)	76(28-145)
	p value	u/p value			
Normal vs CED1	0.53	371/0.45	398/0.74	416/0.95	404/0.80
Normal vs CED2	1.00	147/0.04	205/0.44	183/0.23	231/0.85
Normal vs CED3	1.00	339/0.50	259/0.05	323/0.36	278/0.10

Normal (BMI 18.25), CED1 (BMI 17-18.9), CED2 (BMI 16-16.99), CED3 (BMI<16). Data expressed as mean median (Range) as appropriate. Mann Whitney and ANOVA was performed as a test of significance. TG= triglyceride, HDL= high density lipoprotein, LDL= low density lipoprotein.

Table VI: SGPT, Serum Creatinine and Total protein among the study subjects

BMI classes	SGPT(u/dl)	Serum Creatinine (mg/dl)	Total protein(gm/dl)
Normal BMI	36.55±22.46	1.04±.16	7.65±0.57
CED1	28.81±15.92	1.12±.15	7.62±0.75
CED2	24.58±19.69	1.12±.11	7.56±0.79
CED3	15.52±5.60	1.14±.14	7.28±0.61
P value			
Normal vs CED1	0.73	0.39	1.00
Normal vs CED2	0.30	0.66	1.00
Normal vs CED3	<0.001	0.11	0.36

Normal(BMI18.5-25),CED1(BMI17-18.49), CED2(BMI16-16.99), CED3(BMI<16). ANOVA (Bonferroni) was performed as a test of significance. SGPT= serum glutamate pyruvate transferase.

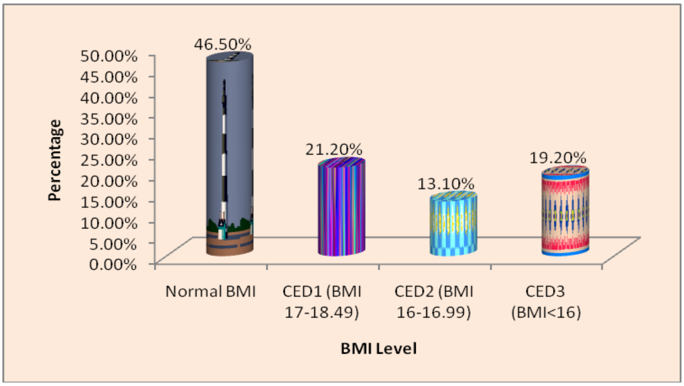

Figure 1: Distribution of the study subjects based on BMI

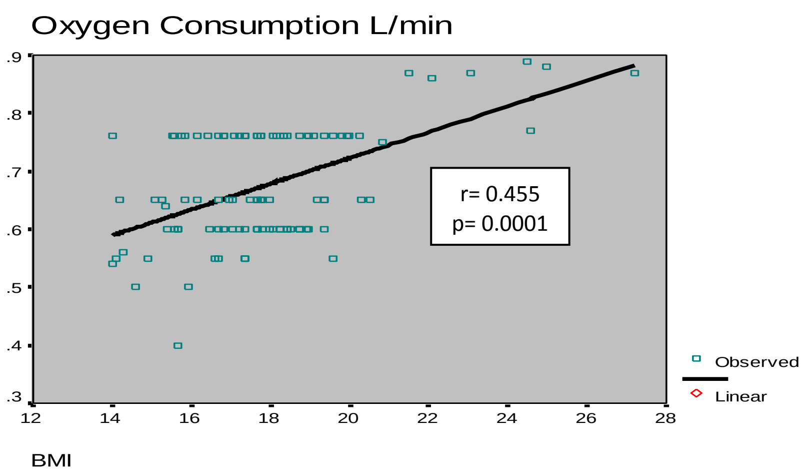

Figure-2: Relationship between BMI and oxygen consumption

Taslima Khatun: Career researcher in the field of Nutrition and also did my graduation, MSc in Food and Nutrition & MPhil degree in Nutrition and Food Science from Dhaka University. Working as a Sr Lecturer in the Dept of Community Nutrition, Bangladesh University of Health Sciences (BUHS) which is a leading Post-graduate institute of the country and sister organization of BIRDEM (the WHO Collaborating Center on Diabetes) which aims to create a Center of Excellence in medical education and research in the country. You will be happy to know that public health has been given the highest importance in this Institute. I published four (4) papers in internationally reputed journals and four (4) others in locally reputed journals. Completed project entitled "Assessment of Integrated Food and Nutrition Security Project (IFNSP) of Plan Bangladesh.

Mosaraf Hossain*:* working as an Assistant Professor in the Department of Biochemistry and Molecular Biology at the University of Chittagong, Chittagong-4331, Bangladesh and PhD Student (Pathology) School of Medicine, Clinical Science Institute National University of Ireland (NUI), Galway, Ireland. Published six (6) papers in internationally reputed journals and four (4) others in locally reputed journals.

Quamrun Nahar: Working as a Senior Research Officer, Dept of Biochemistry and Cell Biology at BIRDEM. Complete PhD in Nutrition from Dhaka University. Career researcher in the field of Nutrition and diet & NCDs at different age group Bangladeshi population. Huge publications have done in this relevant field in national and international journals.