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Original Research Article

Study of correlation between daily calorie intake (DCI) and body composition in type 2 DM patients using bioimpedance analysis as a screening tool

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ABSTRACT

Background: Evaluation of body composition (BC) represents a valuable screening tool to assess nutritional status among diabetic patients. The most commonly used methods to evaluate BC in the clinical practice are based on bicompartmental models such as dual energy X-ray absorptiometry (DXA) etc. Factors like daily caloric intake (DCI), percentage of total body water (%TBW), muscle mass and bone mass and the changes that occur in these components with age could be related to the development of type 2 diabetes mellitus (T2DM). The objective of the study is to use Bioimpedance Analysis (BIA) as a screening tool to assess the correlation between these parameters in type 2 diabetic patients.
Materilas and Methods: This study was conducted on 200 T2DM patients aged 25-45 years for a duration of 6 months in an urban out-patients clinic after obtaining proper informed consent and ethics committee approval. A multifrequency body composition monitor TANITA MC 980 was used to analyse muscle mass, bone mass and %TBW. The impedance readings were entered into medically researched formulae to calculate body composition. The results were correlated with DCI.
Results: The study results showed a strong correlation between DCI and muscle mass ($p<0.01$). Scatter diagram analysis showed that muscle mass has a significant correlation with DCI at $p<0.01$. No significant correlation was observed between bone mass, and metabolic age with DCI. Joint regression analysis by ANOVA showed a significant correlation between %TBW and muscle mass with DCI at $p<0.05$.
Conclusion: This study showed a strong correlation between DCI and increasing muscle mass and basal metabolic rate among diabetic patients. It also shows that BIA is a useful tool for clinical studies in assessing the correlation between DCI and body composition among type 2 diabetic patients.

1. Introduction

Type 2 diabetes mellitus (T2DM) is considered one of the severe, urgent and emerging health concern across the globe. It is estimated by the International Diabetes Federation (IDF) that the prevalence of T2DM among adults aged 20 – 79 years will significantly increase to 578 million (10.2%) by 2030.[1]

T2DM is often characterized by insulin resistance, hyperinsulinemia and disorder of carbohydrate metabolism. T2DM and obesity are metabolic disorders that closely corelated and often affect the body composition of diabetic patients. Measuring of body composition is considered crucial for assessing nutritional status, motor function, personal health and physical fitness of the diabetic patients. It is often measured by the ratio of fat to non-fat component in total body weight. Body composition consists of body mass index (BMI), fat mass and fat-free mass (FFM),

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percentage body fat (PBF), percentage of total body water (%TBW), muscle mass, and bone mass. The changes that occur in all or specific components of body composition due to age and nutritional status mostly complements the evolutionary characteristics of T2DM which further increases the risk of mortality and other health issues such as cardiovascular diseases, hypertension, dyslipidaemia, inflammatory diseases [(excessive release of interleukin-6 (IL-6)], metabolic syndrome (MetS), hyperuricemia and cardiometabolic risks.[2]

Body composition assessment is also an important tool to evaluate the nutritional status of diabetic patients. Daily calorie intake (DCI) is the sum of calories for basal metabolism, daily activities and diet induced thermogenesis. The recommended caloric intake of overweight diabetic patients (BMI ≥ 25 kg/m^2) and obese diabetic patients (BMI ≥ 30 kg/m^2) by American Diabetes Association (ADA) is 500-1000 less than the required to maintain ideal body weight. The European Association for the Study of Diabetes (EASD) suggests that the daily caloric intake should be decreased, and the energy expenditure increased among the overweight diabetic patients (BMI ≥ 25 kg/m^2), so that the BMI moves towards the recommended range (BMI, 18.5 - 25 kg/m^2).[3] Total calorie intake plays a key role in maintain the desired body composition among diabetic patients. DCI is determined by metabolic estimation which takes into consideration fat free mass, fat mass, age, sex, body size and energy expenditure. muscle, bone, water constitute fat free mass.[4]

Traditionally, the body composition is often measured by BMI which is an easy and convenient standard to measure obesity. However, studies have indicated that BMI is not an ideal screening tool to measure body composition due to its limitations such as – its inability to differentiate between muscle mass and fat mass and assess the extent of fat distribution in the body. Measuring the body fat percentage and skeletal muscle are essential among diabetic patients as these factors are closely corelated with the disease.[5]

Dual-energy X-Ray absorptiometry, magnetic resonance imaging (MRI) and densitometry are other advanced screening tools that are widely used in developed countries to assess body fat, lean soft tissue mass, bone mineral content and bone mineral density. However, these methods are proven to be inconvenient, costly, require expensive specialized equipment and include minimal radiation exposure.[6,7] In contrast, bioelectric impedance analysis (BIA) is relatively simple, quick, low cost, non-invasive method which gives reliable, reproducible measurements of body composition in epidemiological studies. BIA quantifies fat free mass, body fat and %TBW in both normal and obese individuals. BIA has gained high patient acceptability over the years due to its advantages and the fact that it does not pose any health risks to the patients.[8]

Among diabetic patients DCI, nutritional status, body composition, and physical activity are often strongly associated with diabetes control.[9] Hence, determining thTe relationship between the DCI and body composition among T2DM patients is essential considering various background factors in diabetic patients and may prove to be of reasonable clinic-investigative significance.

2. Materials and Methods

The study was performed on 200 T2DM patients aged 25 – 45 years at a diabetes clinic in Mumbai. All participants who visited the out-patient ward and fulfil the inclusion criteria and were willing to give informed consent were included in the study. The study was conducted after obtaining ethic committee approval. The exclusion criteria included pregnant women, patients with pacemaker or any other cardiac implants, post exercise, post alcohol ingestion, amputees, skin diseases of hand or feet and those who were not willing to give informed consent for the study.

The test was performed between 9-11 a.m., 2 hours after breakfast, after normal bladder and bowel clearance and alcohol abstinence within 24 hrs of obtaining readings. A multifrequency body composition monitor TANITA MC 980 was used to analyse muscle mass, bone mass and %TBW. Tanita scan has two footpad electrodes incorporated into a precise electronic scale. Safe low level electrical signals pass through body when subject stands on the scales with electrodes in contact with soles and fingers of outstretched hands. Tanita Scan Unit is turned on and personal data number is selected. Height and weight of subject is recorded and entered. The study subjects were normal in weight with a BMI of <25 kg/m^2. Press SET to confirm. When 0.0 is displayed on screen, instruct to hold hand electrode while standing on footpad and readings are recorded which included metabolic age in years, percentage of total body water, muscle mass, and bone mass. Unit is then switched off.

The impedance readings were entered into medically researched formulae to calculate body composition. The results were correlated with DCI. The DCI was calculated by patient's recall of food items consumed during the previous day and then adding up total calories consumed during the day. The relationship between DCI, %TBW content, muscle mass and bone mass were studied by using Karl Pearson Coefficient and relationship between %TBW content and DCI and bone mass and DCI were studied by Scatter Diagram.

The precautions undertaken during the study include - Soles and heels should be in contact with electrode with straight knees and all fingers to be in contact with electrodes, arms should be extended with elbows not touching the body.

3. Results

Out of the 200 T2DM patients enrolled for the study, 110 (55%) were males and 90 (45%) were females. The Table 1 below shows the descriptive statistics of the study population.

Table 1: The descriptive statistics of thestudy population.

Category	Mean	SD
Age (years)	55.34	12.10
Metabolic Age (years)	58.28	15.51
Total Body Water (%)	46.09	6.22
Muscle Mass (%)	43.43	7.75
Bone Mass (%)	2.74	2.35
DCI (kcal)	2227.04	438.64

An analysis by Scatter diagram showed no significant correlation between %TBW content and DCI (Figure 1). This shows that increase and decrease in DCI has no impact on the %TBW among the study population.

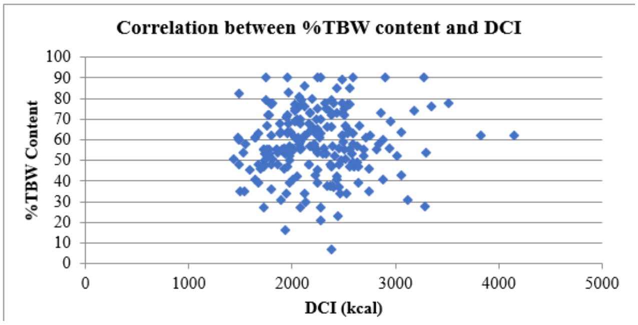

Fig. 1: Correlation between %TBW content and DCI by scatter diagram.

An analysis by Scatter diagram showed no significant correlation between bone mass (%) and DCI (Figure 2). This shows that increase and decrease in DCI has no impact on the bone mass among the study population.

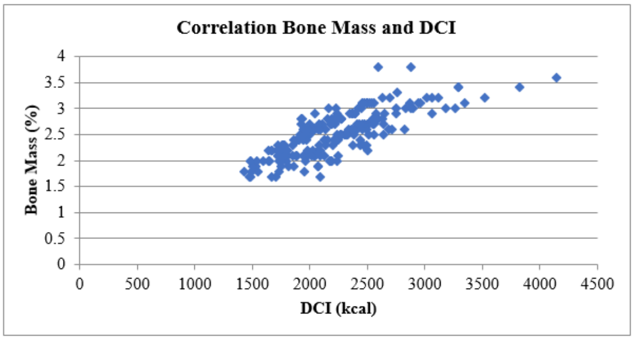

Fig. 2: Correlation between bone mass and DCI by scatter diagram.

An analysis by Scatter diagram showed strong correlation between muscle mass (%) and DCI ($p<0.01$) (Figure 3). The normal ranges for muscle mass in this study group is 62-73.5% for women and 73-86% for men. The mean muscle mass in this study is 43.

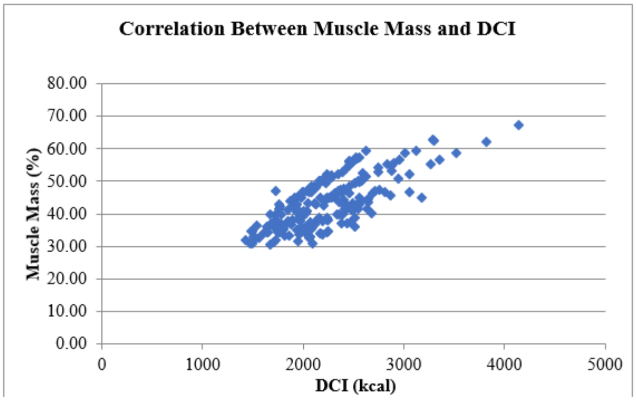

Fig. 3: Correlation between muscle mass (%) and DCI by scatter diagram.

Joint regression analysis by ANOVA showed that %TBW and muscle mass (%) have a significant correlation with DCI at $p<0.05$. No correlation was observed between DCI and metabolic age. Multiple correlation between DCI and other variables is not significant.

4. Discussion

The study has not shown any significant corelation between bone mass, and metabolic age with DCI. This study shows significant correlation between %TBW and DCI at $p<0.05$. Studies show that %TBW content reduces with aging and that could be attributed to decrease in fat free mass.[10] BIA estimates %TBW content but its estimation of fat free mass depends on the hydration status. Significant alteration in body hydration, cutaneous disease and amputations affect impedance measurements. Lukaski et al. emphasizes that dehydration increases resistance by 40 ohms which results in 5 kg underestimation of fat free mass.[11] Androutsos et al. showed increased impedance 1 hour after eating heavy meal. In contrast, investigators report that food intake before test decreases impedance value by 3% and results in overestimation of fat free mass by 1.5 kg. Due to conflicting observations, overnight fast is recommended before measurements.

The DCI refers to the daily caloric requirements to maintain weight based on the basal metabolic rate (BMR) of the patient. As per the Recommended Daily Allowances (RDA) and Estimated Average Requirements for Indians, 2020 by National Institute of Nutrition (NIN) and Indian Council of Medical Research (ICMR),[12] the average DCI for men and women who are moderately active is 2710 and 2130 calories, respectively and for those who have a sedentary lifestyle is 2110 calories for men and 1160 calories for women. The subjects selected for this study

Table 2: Correlation between DCI and metabolic age (years), %TBW, muscle mass (%) and bone mass (%).

ANOVA					
Category	**df**	**SS**	**MS**	**F**	**Significance F**
Regression	5	27554218.78	5510844	82.28548	9.97E-48
Residual	212	14198116.93	66972.25		
Total	217	41752335.71			
Category	Coefficients	Standard Error	t Stat	P-value	
Intercept	164.728	546.973	0.301	0.764	
Metabolic age (years)	-1.642	1.547	-1.061	0.290	
%TBW	-51.144	11.104	-4.606	0.000	
Muscle mass (%)	74.390	11.035	6.741	0.000	
Bone mass (%)	12.990	8.228	1.579	0.116	
Ratio	1148.799	448.957	2.559	0.011	

were taking + 5 % calories to the RDA. The BMR represents an estimate of calories burned while resting and is measured in kilojoules per kilogram of body weight. In this study, DCI shows a strong correlation with muscle mass. The normal ranges for muscle mass in this study group is 62-73.5% for women and 73-86% for men. The mean muscle mass in this study is 43.43 showing that there is a decrease compared to the normal reference range. The T2DM is associated with loss of skeletal muscle mass.[13] The decrease in muscle mass could explain the decrease in BMR and fat oxidation which occurs with aging.[14] This shifts the balance between energy intake and expenditure leading to obesity. In this study the metabolic age of the population is more than the chronological age showing a decrease in the basal metabolic rate. Loss in muscle mass is also offset by increase in intraabdominal fat and redistribution of fat thereby maintaining the same body weight. Only few studies have examined effect of T2DM on muscle mass.[15]

5. Conclusion

This study showed a strong correlation between DCI and increasing muscle mass and basal metabolic rate among diabetic patients. It also shows that BIA is a useful tool for clinical studies in assessing the correlation between DCI and body composition among T2DM. Body fat composition by BIA is gaining acceptance in nutrition, haemodialysis, gerontology and sports medicine and can be useful to general practitioners, nutritionists and cardiologists as results are immediately available and reproducible with <1% error on repeated measurements.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Lin CL, Yu NC, Wu HC. Association of Body Composition with Type 2 Diabetes: A Retrospective Chart Review Study. *Int J Environ Res Public Health*. 2021;18(9):4421. doi:10.3390/ijerph18094421.
2. Baltadjiev AG, Baltadjiev GA. Assessment of body composition of male patients with type 2 diabetes by bioelectrical impedance analysis. . *Folia Med (Plovdiv)*. 2011;53(3):52–7. doi:10.2478/v10153-011-0057-y..
3. Masuda K, Aoki K, Kawaguchi J, Yamakawa T, Matsuba I, Terauchi Y. Effect of Caloric Intake 25 or 30 kcal/kg/day on the Glycemic Control in Obese Patients With Type 2 Diabetes. *J Clin Med Res*. 2013;5(5):368–75. doi:10.4021/jocmr1488w..
4. Mosso C, Halabi V, Ortiz T, Hodgson M. Dietary intake, body composition, and physical activity among young patients with type 1 diabetes mellitus. *J Pediatr Endocrinol Metab*. 2004;7(8):895–902. doi:10.1515/jpem-2014-0334..
5. Han TS, Al-Gindan Y, Govan L, Hankey C, Lean M. Associations of BMI, waist circumference, body fat, and skeletal muscle with type 2 diabetes in adults. *Acta Diabetol*. 1998;56(8):947–54. doi:10.1007/s00592-019-01328-3..
6. Valsamakis G, Chetty R, Anwar A. Association of simple anthropometric measures of obesity with visceral fat and the metabolic subjects. *Diabet Med*. 2004;21:1339.
7. Womersly J. A Comparison of skinfold method with extent of overweight and various weight-height relationships in the assessment of obesity. *Br J Nutr*. 1977;38:271–84.
8. Kyle U. Bioelectrical impedance analysis-part I:review of principles and methods. *Clin Nutr*. 2004;23:1226–43.
9. Tsui EY. Bioelectral Impedance Analysis (BIA) using bipolar foot electrodes in the assessment of body composition in Type 2 diabetes mellitus. *Diabet Med Feb*. 1998;15(2):125–8.
10. Schoeller DA. Changes in total body water with age. *Am J Clin Nutr* . 1989;50(5):1176–81. doi:10.1093/ajcn/50.5.1176.
11. Lukaski HC, Bolonchuk W, Hall C, Siders W. Validation of tetrapolar bioelectric impedance method to assess human body composition. *J Appl Physiol* . 1986;60:1327–32.
12. Nutrition Requirements for Indians. A short report of the expert group. NIN and ICMR. 2020. Available from: https://www.im4change.org /upload/files/RDA_short_report%281%29.pdf. Accessed on: 05 July 2022.
13. Ben D, Caldow MK, Tara C. Brennan-Speranza, Melisssa Sbaraglia,George Jerums et al. Muscle atrophy in patients with Type 2 Diabetes Mellitus: roles of inflammatory pathways, physical activity and exercise. *Exerc Immunol Rev* . 2016;22:94–109.
14. St-Onge MP, Gallagher D. Body composition changes with aging: the cause or the result of alterations in metabolic rate and macronutrient oxidation? *Nutrition*. 2010;26(2):152–5.
15. Kim KS, Park K, Kim MJ, Kim SK, Cho Y, Park S. Type 2 diabetes is associated with low muscle mass in older adults:. *Geriatr Gerontol Int*. 2014;14(1):115–21.

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