Original Article

Correlation between basal metabolic rate, visceral fat and insulin resistance among type 2 diabetes mellitus with peripheral neuropathy

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ABSTRACT

Background: Basal Metabolic Rate (BMR) means the amount of energy utilized by body in physical and psychological resting rate, after a night sleep, awake without any previous physical activity post meal (10 h after last meal) & neutral environment. In people with type 2 diabetes mellitus (T2DM) there is an increase in BMR which is said to be associated with the level of glycaemic control. So, the objective of the study was to find out the correlation between BMR, Insulin resistance and Visceral fat in T2DM with peripheral neuropathy.
Materials & methods: A total of 50 participants with T2DM with peripheral neuropathy were included. Age group of 30—75 years were selected for the study. Participants with a known history of neurological disease, locomotor disability, and pregnancy were excluded from the study. Demographic details of the participants like duration of diabetes mellitus, age, Fasting Blood Glucose, Fasting Insulin, HOMA-IR, Glycated Haemoglobin (HBA1c), Neuropathy and Blood pressure values were noted. We measured Basal Metabolic Rate (BMR) by using Mifflin-St Jeor predictive equation in T2DM with peripheral neuropathy.
Results: The mean age of the participants is 60.16 ± 10.62. The mean duration of T2DM 13.44 ± 11.92. In the present study we found a statistical significant correlation between BMR and HOMA IR (r = 0.913*; p = 0.000), BMR & Fasting blood sugar (FBS) (r = 0.281*; p = 0.048), BMR and Visceral fat (VF) (r = 0.332*; p = 0.018).
Conclusion: Basal metabolic rate is correlated to Homa-IR, visceral fat, fasting blood sugar and musculoskeletal mass among T2DM with peripheral neuropathy.

1. Introduction

Basal Metabolic Rate (BMR) or Basal Energy Expenditure (BEE) means the amount of energy utilized by a body in physical and psychological resting rate, after a night sleep, awake without any previous physical activity post meal (10 h after last meal) & neutral environment [1]. In recent years, a decrease in activity followed by a rise in sedentary behaviors and the degradation of eating habits have observed which can result to an increase in the risk of developing metabolic diseases such as diabetes mellitus [2].

In T2DM there will be elevated glucose levels in circulating blood, caused by impairment in glucose tolerance which leads to the development of Insulin Resistance (IR) [3]. It is known that a disproportionate accumulation of subcutaneous and abdominal fat contributes to the desensitization of insulin receptors that is characterized by an inhibited uptake of glucose within skeletal muscle,

and an impaired ability to suppress endogenous glucose production [4]. IR in diabetic individuals is associated with abnormal metabolic reactions in skeletal muscle, liver, and adipose tissue [5].

Measurement of BMR is essential in people with T2DM, as there is an increase in BMR which is said to be associated with the level of glycaemic control. In the Caucasian population, BMR is reported to increase by 6% [6,7]. The reason for the increase in BMR in T2DM is because of increase in oxidation level for carbohydrate metabolism, increase in neoglucogenesis and hepatic glucose output, acceleration in sympathetic activity, the decline in glycogen synthesis, increase in blood glucose levels and altered metabolic activities in the body [8—10]. The most significant independent predictor variables for BMR are weight, height, age, gender and free fat mass.1 BMR depends on the metabolic rate of organs and tissue as well as body mass [11].

Basal metabolic rate (BMR) accounts for approximately 60% of total daily energy expenditure, making it the most critical parameter for determining appropriate energy intake. Since it is difficult to measure BMR directly, indirect calorimetry or predictive equations have been used. Indirect calorimetry determines energy expenditure by measuring oxygen uptake (VO2), and carbon dioxide output (VCO2) [12]. Measurement of BMR requires much control before and during the testing like food, medication, physical activity, temperature and time of the day. These factors limit the use of indirect calorimetry [13,14]. Due to these limitations prediction equations were developed to determine basal metabolic rate using body height, weight, sex and other individual differences. Although the first prediction equation was computed in 1919 by Harris and Benedict [15] due to changes in lifestyle, new predictions such as Mifflin-St Jeor prediction equation was more accurate and routinely used in clinical practice and research. It is found to have 73.4% accurate in measuring the BMR compared against indirect calorimetry [16].

Even though T2DM prevalence is very high and patients have been screened for diabetes mellitus related complications, there is a lack of literature regarding the correlation between basal metabolic rate and IR. Therefore, the objective of the study was to find out the correlation between BMR, IR and Visceral fat in T2DM with peripheral neuropathy.

2. Methods

2.1. Study setting and design

A total of 50 participants with T2DM with peripheral neuropathy were recruited from the Diabetic foot clinic, Centre for Diabetic Foot Care and Research & Department of General Medicine, Kasturba Hospital in Manipal, Karnataka, India, using a purposive sampling method.

2.2. Ethics approval

After the approval from the Institutional ethics committee study was initiated. Detailed information about the study was given and informed consent obtained from all the participants who were willing to take part in the study.

2.3. Inclusion and exclusion criteria

Participants with a known case of T2DM with neuropathy between the age group of 30—75 years were selected for the study. Participants with a known history of neurological disease, locomotor disability, and pregnancy were excluded from the study.

2.4. Anthropometric measurement

Demographic details of the participants like duration of diabetes mellitus, age, Fasting Blood Glucose, Fasting Insulin, HOMA-IR, Glycated Haemoglobin (HBA1c) and blood pressure values were noted. Height and weight were measured by using wall-mounted stadiometer and digital weighing scale. Body mass index (BMI) and Fat analysis were performed using Bioimpedance Analyser (BIA) (Omron HBF-701 Karada scan). It consists of subcutaneous fat, skeletal muscle mass, visceral fat and total body fat measurement.

2.4.1. Procedure
2.4.1.1. BMR measurement. In the present study, we calculated the Basal Metabolic Rate (BMR) by using the Mifflin-St Jeor predictive equation in T2DM. MD Mifflin and St Jeor proposed it. The ADA (American Dietetic Association) published a comparison of various equations.19 The Mifflin-St Jeor was found to be the most accurate. This predictive equation is separate for both Men and Women.

2.4.1.2. Men. $10 \times$ weight (kg) $+ 6.25 \times$ height (cm) $- 5 \times$ age (y) $+ 5$.

2.4.1.3. Women. $10 \times$ weight (kg) $+ 6.25 \times$ height (cm) $- 5 \times$ age (y) $- 161$.

2.4.1.4. Neuropathy assessment. The test for presence the of peripheral neuropathy (sensory and motor) was confirmed using 10 g Monofilament test, Biothesiometer (Vibration Pressure Threshold).

2.5. Data analysis

Statistical Package analyzed the data obtained from the study for the Social Sciences (SPSS) version 16. The descriptive statistical test was used to analyze the demographic characteristics. Spearman's correlation test was used to find the correlation between IR, BMR, visceral fat, subcutaneous fat and musculoskeletal fat. The statistical significance level is set at P value is ≤ 0.05.

3. Results

A total of 50 participants screened with T2DM along IR were included in the study. Demographic details of study participants are given in Table 1. The mean age of the participants is 60.16 ± 10.62. The mean duration of T2DM 13.44 ± 11.92. The body composition measurements are reported in Table 2. In the present study we found a statistical significant correlation (Table 3) between BMR and HOMA IR (r = 0.913*; p = 0.000) (Fig. 1), BMR & Fasting blood sugar (FBS) (r = 0.281*; p = 0.048), (Fig. 2), BMR and BMI(r = 0.390*; p = 0.05) (Fig. 3), BMR and Visceral fat (VF) (r = 0.332*; p = 0.018), (Fig. 4), BMR and Waist circumference (WC) (r = 0.412*; p = 0.003), BMR and Hip circumference (HC) (r = 0.406*; p = 0.003), BMR and musculoskeletal mass (r = −0.358*; p = 0.011), BMR and height (r = 0.527*; p = 0.000), BMR and weight (r = 0.489*, p = 0.000). Co-morbidities associated with type 2 diabetes mellitus were eye complications 19 (37.3%) like cataract and retinopathy, hypertension 23 (46.2%) and

Table 1
Demographic characteristics of the study participants.

S.No	Demographic data (n = 50)	Mean ± SD
1	Age in years	60.16 ± 10.62
2	Duration of Type 2 Diabetes Mellitus in years	13.44 ± 11.92
3	Waist circumference in cm	92.81 ± 11.49
4	Hip circumference in cm	99.62 ± 9.42

Table 2
Demographic parameters of the study participants.

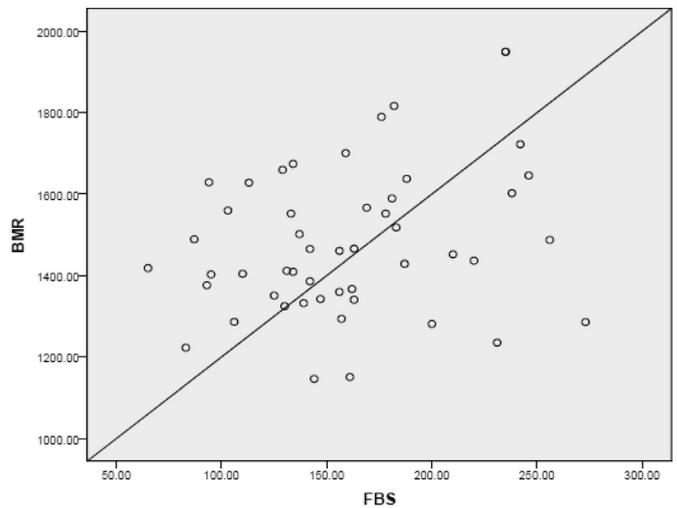| S.No	Demographic parameters (n = 50)	Mean ± SD
1	Height in cm	166.73 ± 9.46
2	Weight in kg	68.50 ± 13.88
3	Body Mass Index (BMI) in kg/m^2	25.22 ± 3.48
4	Total fat (%)	27.32 ± 6.59
5	Visceral fat (%)	11.62 ± 6.13
6	Subcutaneous fat (%)	19.98 ± 5.30
7	Musculoskeletal mass (%)	24.89 ± 6.42
8	Basal Metabolic Rate (BMR)	1481.11 ± 183.51
9	Systolic blood pressure in mm of Hg	140.40 ± 20.66
10	Diastolic blood pressure in mm of Hg	79.74 ± 10.19
11	Fasting Blood sugar in mg/dl	160.46 ± 49.92
12	Fasting Insulin in mIU/l	19.69 ± 18.63
13	Postprandial blood sugar in mg/dl	222.38 ± 67.45
14	Homa-IR	7.37 ± 6.90
15	Glycated haemoglobin (HbA1c) in %	8.18 ± 1.68
16	Vibration pressure threshold in volts	39.65 ± 10.57

Table 3
Correlation between basal metabolic rate (BMR), visceral fat, musculoskeletal mass, fasting blood sugar, body mass index (BMI) and Homa-IR.

Parameters	Mean ± SD	r value	p value
Visceral fat	11.62 ± 6.13	.332[a]	0.018[a]
Musculoskeletal mass	24.89 ± 6.42	-.358[a]	0.011[a]
Fasting Blood sugar	160.46 ± 49.92	.281[a]	0.048[a]
Body Mass Index (BMI)	25.22 ± 3.48	0.390[a]	0.05[a]
Homa-IR	7.37 ± 6.90	.913[a]	0.000[a]

[a] Correlation is significant at the 0.05 level (2-tailed).

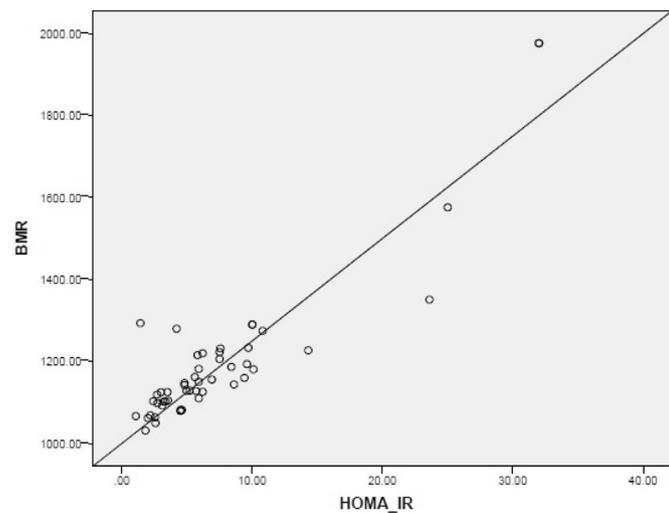Fig. 2. Scatter plot correlation between BMR and Fasting blood sugar.

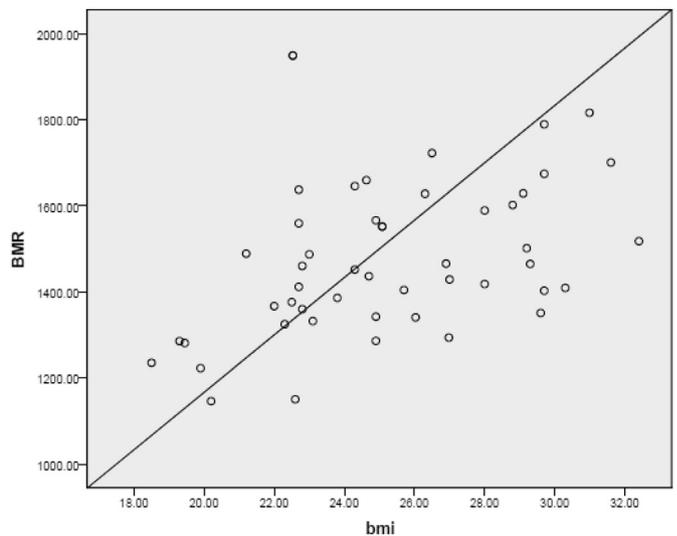Fig. 3. Scatter plot correlation between BMR and BMI.

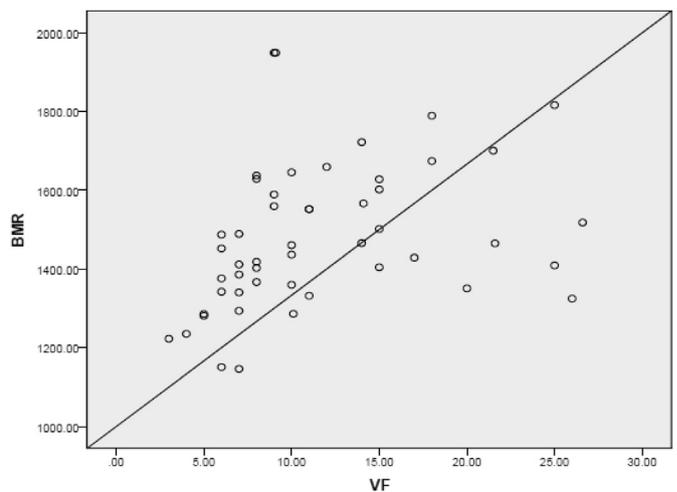Fig. 1. Scatter plot correlation between BMR and Homa-IR.

Fig. 4. Scatter plot correlation between BMR and Visceral fat.

cardiac complications 14 (27.5%) were reported.

4. Discussion

To the best of our knowledge, this is the first study conducted in India which reported about Basal Metabolic Rate (BMR) with IR & VF among T2DM with peripheral neuropathy. In the current study, we found a correlation between BMR with Homa-IR and BMI which are by an earlier study done by Shogo et al. 2017 [12].

Our results are consistent with the previous findings in that measured BMR was significantly correlated with FBS, HbA1c, and PPBS. A possible reason could be due to the influence of hyperglycemia on the BMR of diabetic patients. Patients with T2DM have

a higher BMR than non-diabetic people [17]. There is no scientific evidence indicating how the presence of diabetes mellitus may influence basal metabolism. The reason for this increase in BMR is not yet well established, although the physiological mechanisms responsible for the increased BMR in T2DM remain unclear, they are thought to be associated with increased protein turnover, elevated plasma concentrations of free fatty acids in fasting increased gluconeogenesis, glycogenolysis and hyperglucagonemia in patients with T2DM, which is known to be an energy-consuming metabolic pathway and increased sympathetic system activity [18–21], Consoli et al. observed that the increased gluconeogenesis rises BMR by more than 50% in subjects with T2DM. Miyake et al. reported that obese Japanese people with T2DM have a higher BMR than obese Japanese people without T2DM and that the fasting glucose level might be a significant determinant of this increase [18].

In this study, a significant correlation in BMR was found with relation to IR, fasting blood sugar, BMI, visceral fat and musculoskeletal mass, waist and hip circumference, height and weight by using Mifflin-St Jeor predictive equation. Our study has shown that body composition was correlated to BMR, which could be due to an increase in the development of body mass. BMR decreases with 2–3% per decade after 50 years of age.1 The body composition contains fat mass (FM) and fat-free mass (FFM). FFM means organs of the body, which is shown to have metabolism at a different rate in different organs [22–24]. The body organs account for 60%–70% of resting metabolic rate (RMR) in adults. Whereas on the other hand accounts for 20%–30% of RMR [25,26]. In the present study, we found that BMR increases with increased visceral fat. This increase in metabolic rate could be because of the unique metabolic characteristics of the visceral adipose tissue. Visceral adipose tissue contains an increased blood flow, more response to norepinephrine, a decreased sensitivity to the antilipolytic action of insulin, increased sympathetic nervous system activity. Earlier studies evidence have suggested a role for visceral fat (VF) accumulation in the pathogenesis of insulin resistance. Thus, VF excess has been associated with 1) decreased sensitivity of glucose uptake to insulin stimulation as measured by the euglycemic insulin clamp technique, 2) reduced rate of free fatty acids (FFA) reesterification, and 3) increased resistance of lipolysis to the inhibitory effect of insulin in both visceral and peripheral adipocytes [27]. The studies also suggest that an increase in skeletal muscle mass also increases the basal metabolic rate [28].

5. Conclusion

The basal metabolic rate is correlated with Homa-IR, visceral fat, fasting blood sugar and musculoskeletal mass among T2DM with peripheral neuropathy.

5.1. Implications for clinical practice

In clinical practice, measurement of energy expenditure is time-consuming and expensive. However, despite many other predictive equations, Mifflin-St Jeor prediction equation is accurate, quick and can be routinely used in clinical practice for individuals to estimate the BMR and also, can be included in lifestyle modifications in weight loss management in obesity and glycaemic control in type 2 diabetes mellitus.

5.2. New knowledge added by this study

- In recent years, a decrease in activity followed by a rise in sedentary behaviors and the degradation of eating habits have

observed which can result to an increase in the risk of developing metabolic diseases such as diabetes mellitus.
- To the best of our knowledge, this is the first study conducted in India which reported about Basal Metabolic Rate (BMR) with IR & VF among T2DM with peripheral neuropathy.

Conflicts of interest

The authors declare that there is no potential conflict of interest.

Acknowledgment

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2018.10.005.

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