Diabetes & Metabolic Syndrome: Clinical Research & Reviews 13 (2019) 981–984

Contents lists available at ScienceDirect

Diabetes & Metabolic Syndrome: Clinical Research & Reviews

journal homepage: www.elsevier.com/locate/dsx

Original Article

Screening for basal metabolic rate and visceral fat among postmenopausal osteoporosis with type 2 diabetes mellitus

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ARTICLE INFO

Article history:
Received 4 December 2018
Accepted 14 January 2019

Keywords:
Basal metabolic rate
Type 2 diabetes mellitus
Postmenopausal osteoporosis

ABSTRACT

Background: In people with type 2 diabetes mellitus, there is an increase in basal metabolic rate (BMR) which is associated with level of glycaemic control. Women with postmenopausal osteoporosis have decreased BMR. The aim of the present study is to find the BMR using Meffin-St Jeor predictive equation in women with type 2 diabetes mellitus (T2DM) who have attained menopause with osteoporosis.
Materials & methods: 100 women who have attained menopause, who were diagnosed to have osteoporosis with type 2 diabetes mellitus were assessed for BMR using Meffin-St Jeor predictive equation. Detailed history of diabetes and menopause were obtained. Blood glucose value was measured using standard glucometers. Body composition for visceral fat (VF) was measured using bioelectrical impedance analysis. Level of physical activity of the participants was measured using global physical activity questionnaire (GPAQ).
Results: The median BMR of the participants was 1.075 (714, 1483.25). Statistically significant correlation was found between BMR and GPAQ ($r_s = 0.731$), BMR and VF ($r_s = 0.678$). However BMR was not correlated with FBS ($r_s = 0.083$) duration of diabetes ($r_s = -0.046$).
Conclusion: There is a decrease in BMR in women with T2DM with postmenopausal osteoporosis. BMR was significantly correlated with level of physical activity and visceral fat.

1. Background

Basal metabolic rate (BMR) or basal energy expenditure (BEE) means the amount of energy utilized by a body in physical and psychological resting state, i.e. after a night's sleep, being awake without any previous physical activity post meal (10 h after last meal) & neutral environment [1]. BMR depends on the metabolic rate of organs and tissue as well as body mass [2]. Studies have suggested that BMR is markedly decreased in aged people who follow a sedentary life style, which is at a rate of 1–2% per decade after 20 years of age [3]. Most of the research on BMR is done to develop treatment for obesity.

After attainment of menopause, there is a decrease in lean mass, increase in adipose tissue deposition in the body, female sexual hormones and resting energy expenditure. These changes in body composition is related to years ensued since menopause, rather than the age of the women [4]. Previous studies have also shown that during exercise in postmenopausal women there is a decrease in fat oxidation and energy expenditure [5]. It is noticed that reduction in physical activity, balance, increased risk of fall in postmenopausal state reduces the quality of life. Free energy expenditure, active energy expenditure and sleeping energy expenditure is decreased in middle aged women. The studies have also shown that there is decline in 24 h energy expenditure and spontaneous physical activity in postmenopausal women [6]. In postmenopausal osteoporosis, women are said to have decrease in BMR compared to non-osteoporotic counterpart [7].

In people with diabetes mellitus, there is an increase in BMR which is said to be associated with level of glycaemic control. In Caucasian population BMR is said to increase by 6% in diabetes [8]. The reason for increase in BMR in diabetes mellitus is because of

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https://doi.org/10.1016/j.dsx.2019.01.003
1871-4021/

increase in oxidation level for carbohydrate metabolism, increase in neoglucogenesis and hepatic glucose output, acceleration in sympathetic activity, decline in glycogen synthesis, increase in blood glucose levels and altered metabolic activities in the body [1].

While determining the daily energy needs, accurate measurement of BMR is very much important in clinical setting. Measurement of BMR using quantification of flow rate and gas concentration is expensive and time consuming. Measurement of BMR requires much control prior and during the testing like food, medication, physical activity, temperature and time of the day. These factors limit the usage of indirect calorimetry [1]. Reduction in fat free mass with the advanced age result in decreased basal metabolic rate [9]. Previous studies have shown that there is correlation between bone mineral density and basal metabolic rate in postmenopausal women [10].

Due to these limitations, prediction equations were developed to determine basal metabolic rate using body height, weight, sex and other individual differences. The first predictions equation was developed by Harris and Benedict in 1919 [11]. Harris Benedict Equation was considered to overestimate BMR by 6% for male and 13% for females [12]. Hence in the present study, Meffin-St Jeor prediction equation was used. Meffin-St Jeor prediction equation was found to be 73.4% accurate in measuring the BMR compared to indirect calorimetry [13].

The purpose of the current study is to find the BMR using Meffin-St Jeor predictive equation in women with type 2 diabetes mellitus (T2DM) who have attained menopause with osteoporosis.

2. Methods

The study was initiated after obtaining ethical clearance from the institutional ethics committee. Participants were explained the purpose of the study in local language and written informed consent of the participants who were willing to take part in the study was taken. The study was conducted in Kasturba Hospital Manipal, Karnataka, India. The study was conducted between February 2017 to February 2018. Using random method sampling, 100 postmenopausal osteoporosis women with type 2 diabetes mellitus were included in the study. Inclusion criteria for the study was women who have been menopausal at least since a year and those who were on medication or insulin for the management of T2DM. Participants were excluded if they were smokers, febrile, with the signs of acute or chronic infection, history of thyroid dysfunction.

Demographic details of the participants like duration of menopause and diabetes mellitus, age, random and fasting blood glucose and blood pressure values were noted. Height and weight of the participants were measured using standard height scale and calibrated weight scale. Body composition (Visceral fat, subcutaneous fat and skeletal muscle fat) of the participants was measured using Omron HBF-701 Karada scan body composition monitor. Precaution was taken while measuring body composition to avoid errors. The measurement was taken only if atleast the participant had not performed any vigorous activities, after drinking alcohol, large amount of water or after a meal (about 2 h).

Fasting blood glucose levels were measured using calibrated Accu-chek performa nano glucometer. Blood pressure of the participants were measured in sitting position with back resting onto chair, feet flat on the ground and elbow is placed on a table in resting position. Omron HEM-7120 automatic blood pressure monitor was used. Level of physical activity of the participants was assessed using global physical activity questionnaire (GPAQ), which is reported as MET.MIN.WK^{-1}.

The data obtained from the study were analysed using Statistical Package for the Social Sciences (SPSS) version 16. Descriptive statistical test was done to analyse the demographic characteristics. Spearman's correlation test was used to find the correlation between level of physical activity, BMR, visceral fat, subcutaneous fat and musculoskeletal fat. Statistical significance level was set at P value is ≤ 0.05.

3. Results

A total of 100 participants with T2DM who have attained menopause and diagnosed to have osteoporosis were included in the study. Demographic details of study participants is given in Table 1. The mean age of the study participants was 59.3 ± 6.5. The mean duration of T2DM and menopause was 6.05 ± 4.8 and 11.35 ± 7.5 years respectively. The average FBS value was 140.9 ± 38.9. Average blood pressure systolic and diastolic value was 144.6 ± 22.2 and 86 ± 13.3 respectively (Table 1).

The body composition measurements were calculated. The average height, weight and body mass index (BMI) of the participants was 152.7 ± 6.1, 59 ± 11.8, 25.1 ± 4.1 respectively. The body fat percentage measured using bioelectrical impedance analysis method showed an average total fat (TF) of 31.6 ± 8.4, visceral fat (VF) 9.4 ± 4.3, subcutaneous fat (SF) 31.3 ± 4.4, musculoskeletal mass 21.7 ± 1.9 (Table 2).

The median BMR of the participants was 1.075 (714, 1483.25). On further analysis it was found that statistically significant correlation was found between BMR and GPAQ ($r_s = 0.731$) (Fig. 1), BMR and VF ($r_s = 0.678$) (Fig. 2), BMR and duration of menopause ($r_s = 0.02$). However, no statistically significant correlation was found between BMR and RBS ($r_s = 0.120$), BMR and FBS ($r_s = 0.083$) and BMR and duration of diabetes ($r_s = -0.046$).

4. Discussion

To the best of our knowledge, this is the first study conducted in India to report about the basal metabolic rate in postmenopausal osteoporosis with T2DM. In T2DM measuring of energy expenditure is very important in scientific research, healthy body weight maintenance, diet recommendation and exercise training. In developing countries like India, due to unaffordability and non-availability of expensive instruments to measure BMR, it can be measured easily using standard prediction equations. In the current study we used Meffin-St Jeor predictive equation.

In our study, the median BMR of the participants was found to be 1.075 (714, 1483.25). Due to loss of ovarian function after the attainment of menopause there will be decrease in resting metabolic rate, physical activity energy expenditure and abdominal adipose tissue accumulation. Previous study has also shown that basal metabolic rate and diabetese state are also correlated with bone turnover [14]. This energy dysregulation may result in obesity, increased visceral fat, impaired blood glucose levels in the postmenopausal years [15].

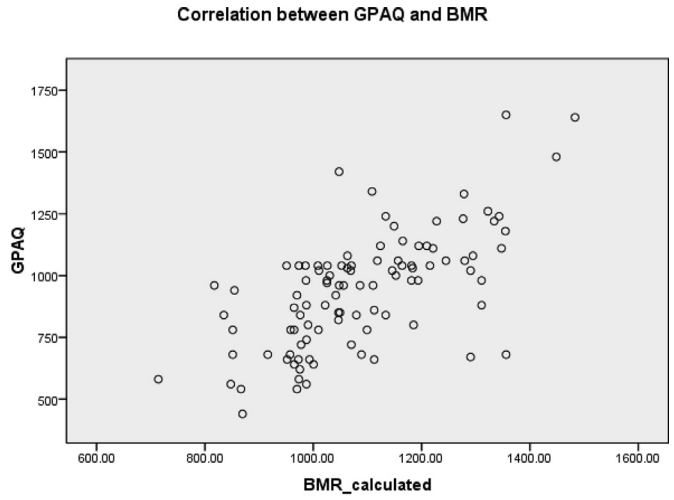
A positive correlation was found between BMR and physical activity level. This suggests that increase in skeletal muscle mass and reduction in fat mass in these participants with better physical

Table 1
Demographic details of the study participants.

SL No	Demographics	Mean ± SD
1	Age (Years)	59.3 ± 6.5
2	RBS (mg/dl)	199.7 ± 63.8
3	FBS (mg/dl)	140.9 ± 38.9
4	Systolic blood pressure (mmHg)	144.6 ± 22.2
5	Diastolic blood pressure (mmHg)	86 ± 13.3
6	Duration of T2DM (years)	6.05 ± 4.8
7	Duration of menopause (years)	11.35 ± 7.5

Table 2
Body composition of the study participants.

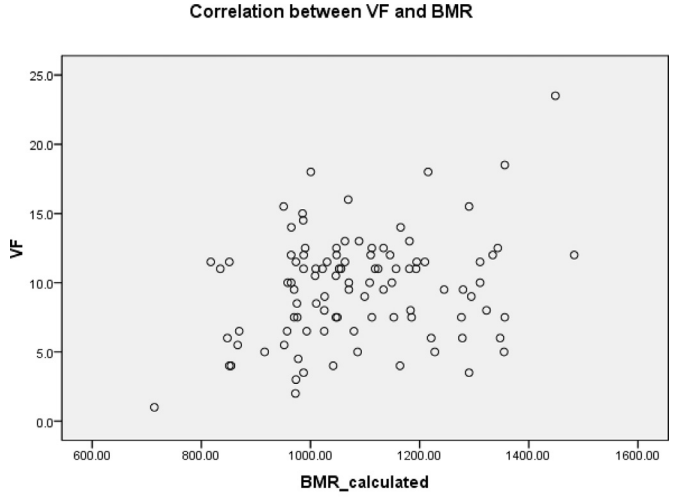
SL No	Demographics	Mean ± SD
1	Height (cms)	152.7 ± 6.1
2	Weight (kgs)	59 ± 11.8
3	BMI	25.1 ± 4.1
4	Total fat (%)	31.6 ± 8.4
5	Visceral fat (%)	9.4 ± 4.3
6	Subcutaneous fat (%)	31.3 ± 4.4
7	Musculoskeletal mass (%)	21.7 ± 1.9



GPAQ: Global physical activity questionnaire

BMR: Basal Metabolic rate

Fig. 1. Scatter plot explaining correlation between GPAQ and BMR. GPAQ: Global physical activity questionnaire. BMR: Basal Metabolic rate.



BMR: Basal Metabolic rate

VF: Visceral fat

Fig. 2. Scatter plot explaining correlation between visceral fat and BMR. BMR: Basal Metabolic rate. VF: Visceral fat.

activity might result in increased BMR. Physical activity and exercise in found to have a positive effect on BMR and fat free mass [16]. This suggests that, women after the attainment of the menopause should exercise or maintain a good physical activity to maintain a better metabolic rate.

Our study has shown that, body composition (VF) was correlated to BMR. 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 different rate in different organs [17]. The body organs account for 60%–70% of BMR in adults. Whereas on the other hand musculoskeletal fat accounts for 20%–30% of RMR [18]. In our study we found that BMR increases with increased visceral fat. This increase in metabolic rate could be due to special metabolic characteristics of visceral adipose tissue. Visceral adipose tissue contain an increased blood flow, more response to norepinephrine, a decreased sensitivity to antilypolitic action of insulin, increased sympathetic nervous system activity. This might results in various metabolic complications in postmenopausal women with T2DM [19]. The studies also suggests that increase in skeletal muscle mass also increases the basal metabolic rate [20,21].

No correlation was found between BMR and FBS values as well as duration of diabetes mellitus in the current study. Our study results are in agreement with the study conducted by Alawad et al., 2013. In their study they found that there was no correlation between FBS and BMR, however they found that there was a lower metabolic rate among participants with normal glycated haemoglobin levels in T2DM. This suggests that blood glucose control has a long term effect on BMR than the short term effect [22] BMR depends on the glycaemic control rather than the duration of diabetes mellitus.

In the study, a negative correlation was found between BMR and duration of menopause. This could be due to decline in BMR with advanced age and energy expenditure caused during physical activity. And this is in turn due to alteration in fat deposition, hormonal changes, altered metabolism, decrease in skeletal muscle mass, increase in deposition of adipose tissue as duration of menopause progress [4–7].

Previous studies have shown that with advanced age there will be increase in fat mass in the body and a decrease in bone mineral density, basal metabolic rate and lean mass [23–25]. Previous studies have demonstrated a higher median BMR value 1354 (1159, 1554) in postmenopausal women without T2DM [26]. Although previous studies suggested that with uncontrolled T2DM there is increased BMR, our study has shown a decrease in median BMR in postmenopausal women with T2DM and could be because of a decreased physical activity level and compliance to exercises.

This study suggests that a structured exercise protocol should be taught such that it promotes an increase in physical activity in activities of daily living. Adherence to exercise should be encouraged in postmenopausal osteoporosis with type 2 diabetes mellitus. Measurement of BMR should be done by clinician to prescribe exercise and diet in this population. Future studies can be done with a larger sample size and advanced equipments.

5. Conclusion

In postmenopausal osteoporosis with T2DM there in decrease in basal metabolic rate and it is correlated to visceral fat, duration of menopause and level of physical activity. No correlation was found between basal metabolic rate and duration of diabetes mellitus, RBS and FBS value.

Author contributions

Conception and design: G.S., A.G.M.; Data analysis and interpretation of data: G.S., A.G.M., A.B.K., M.H.H.; Statistical analysis & interpretation: G.S., S.K.A.; Language editing: A.B.K.

Conflicts of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Acknowledgment

We thank World Diabetes Foundation “Diabetic footcare stepping Ahead project” WDF 15-941, Centre for diabetic footcare research for their support. We would also like to thank Manipal Academy of Higher Education for approving study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2019.01.003.

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