**Open Access** 



# An evaluation of basal metabolic rate among healthy individuals — a cross-sectional study

Natasha Verma<sup>1\*</sup>, S. Senthil Kumar<sup>1</sup> and Anjali Suresh<sup>1</sup>

# Abstract

**Background** The main source of daily energy requirement in Asian societies is basal metabolic rate (BMR). Even though the reason for this fluctuation is debatable, prior research have shown that BMR is highly varied in individuals. All studies concur that variation in fat-free mass (FFM) is important, although the effects of fat mass (FM), age, sex, and the hormones leptin, triiodothyronine (T3), and thyroxine (T4) are still unknown.

Objective The main objectives of the study are as follows:

• To evaluate the basal metabolic rate among healthy individuals

• To identify the risk factors on basal metabolic rate among healthy individuals

**Methodology** In total, 50 individuals were consecutively enrolled in the study during the entrepreneurship studio on 29th June 2022 held at Garden City University (GCU). The inclusion criteria were age between 18 and 50 years, both males and females, students and professors of GCU, and healthy individuals. The exclusion criteria were subjects who had overt metabolic and/or endocrine diseases (e.g., diabetes, hypothyroidism, hypertension, amenorrhea) and those taking any drug known to influence energy metabolism. The convenient samples of 50 subjects were taken from this study.

Outcome measures Basal metabolic rate (BMR) and body mass index (BMI).

**Results** The demographic data, height, weight, BMI, and BMR were recorded. The mean and standard deviation of age are  $25.81 \pm 8.71$  and  $23.95 \pm 6.67$  of males and females, respectively. The mean and standard deviation of height are  $1.68 \pm 0.68$  and  $1.63 \pm 0.07$ , respectively. The mean and standard deviation for weight are  $63.8 \pm 11.49$  and  $54.86 \pm 10.43$ , respectively. The mean and standard deviation of BMI are males and females which are  $22.3 \pm 3.22$  and  $20.47 \pm 3.62$ , respectively. The mean and standard deviation of BMR are males and females which are  $1552.41 \pm 127.3$  and  $1327.7 \pm 147.9$ .

**Conclusion** The energy used up while lying still at rest and being awake during the nocturnal postabsorptive state is known as the basal metabolic rate (BMR). The values can be used as a reference for comparison with the normative values, and cardiorespiratory endurance training can be included in the rehabilitation program.

Keywords Body composition, Health, Hormones, Metabolism, Obesity

\*Correspondence:

Natasha Verma

vnatasha345@gmail.com

<sup>1</sup> Department of Physiotherapy, School of Health Sciences, Garden City University, Bengaluru, Karnataka, India



# Introduction

Over the past few decades, obesity has become more prevalent, and this is mostly due to an imbalance between energy intake and energy expenditure (EE) [1, 2]. Numerous and intricate factors, including genes, environment,

© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

and their interactions, affect this delicate balance. But the goal of weight management techniques is to pinpoint and alter the quantity of energy consumed and introduced in order to return to normal body weight (BW) [3]. A widely used model of human nutrition states that daily energy expenditure can be broken down into three categories: thermic effect of food; thermic metabolic rate (BMR) extrapolated to 24 h, which accounts for about 25% of daily energy expenditure (DEE); and thermic effect of physical activity, which accounts for about 65% of DEE in sedentary subjects. Due to its large contribution to DEE, particularly in obese individuals, BMR has frequently been the focus of studies on the causes of and therapies for obesity [4].

The total energy expenditure (EE) of the body's tissues and organs while fasting, at rest, and under thermoneutral conditions can be thought of as BMR [5]. The size and metabolism of the tissues and organs control it. Gender, age, physical activity, nutritional status, and body composition as determined by the fat mass and fat-free mass are only a few of the variables that affect BMR in general. Age, gender, height, weight, and body composition are the primary determinants of BMR. After taking into consideration body composition, BMR is strongly influenced by gender, with men having a higher BMR than women [5]. Additionally, BMR decreases dramatically with age in inactive individuals at a rate of 1–2% every decade after the age of 20. Due to this decrease in EE, the ability to control energy balance is expected to get worse with age. There have been various studies on the topic of whether EE reduces with age and whether females have lower EE than males, while the literature is divided on this subject regarding normal persons [6].

The Harris-Benedict formula, and many online calculators, predicts BMR based on height, weight, age, and sex and is accurate to within 10% in 90% of persons with BMIs between 18.5 and 45 kg/m<sup>2</sup>. Contrary to popular belief, muscle only makes up 25% of RMR but can account for 80–90% of energy expenditure during exercise. With only 3 kcal/kg of body fat consumed daily, adipose tissue is a modest contributor to daily energy expenditure. BMR will always be significantly higher than the reported food consumption if it is determined using a trustworthy device [7].

The present study aims to assess the BMR of healthy individuals at Garden City University, Bengaluru, and to identify the risk factors on basal metabolic rate among healthy individuals.

# Objectives of the study

To evaluate the basal metabolic rate among healthy individuals

 To identify the risk factors on basal metabolic rate among healthy individuals

#### Methodology

In total, 50 individuals were consecutively enrolled in the study during the entrepreneurship studio held at Garden City University. The inclusion criteria were age between 18 and 50 years, both males and females, students and professors of Garden City University, and healthy individuals. The exclusion criteria were subjects who had overt metabolic and/or endocrine diseases (e.g., diabetes, hypothyroidism, hypertension, amenorrhea) and those taking any drug known to influence energy metabolism.

This study is a cross-sectional study. It has been estimated that 50 subjects are included with 95% confidence and a margin of error of 5%, a population proportion of 6.5%, and a population size of 100.

A convenient sample of 50 subjects was recruited for this study. The potential participants were contacted and explained step by step about the study, the participation information, and the consent sheet. The patients were then screened for inclusion criteria requirements and also checked for any exclusion criteria. Those fulfilling the inclusion criteria were requested to participate in the study, and informed consent was taken. All participant's doubts and concerns were addressed following which consent form. Those who did not agree to participate in the study or those who did not meet the inclusion criteria were excluded from the study.

Fifty samples of subjects were from the entrepreneurship studio GCU. Anthropometry was done by measuring weight in kilogram (kg) and height with a stadiometer, and body mass index (BMI) was calculated according to the formula kg/m<sup>2</sup>. BMR was calculated by a BMR calculator and Mifflin-St Jeor equation [8–12]. This BMR formula is as follows: BMR (kcal/day)=10×weight (kg)+6.25×height (cm) — 5×age (y)+s (kcal/day).

## Results

The demographic data, height, weight, BMI, and BMR were recorded by SPSS software. The mean and standard deviation of age are  $25.81\pm8.71$  and  $23.95\pm6.67$  of males and females respectively (Table 1). The mean and standard deviation of height are  $1.68\pm0.68$  and  $1.63\pm0.07$ 

Та	b	le	1	Socioc	lemo	grap	hic	data
----	---	----	---	--------	------	------	-----	------

S. no	Gender	Age		
		Mean	SD	
1	Male	25.81	8.71	
2	Female	23.95	6.67	

respectively (Table 2). The mean and standard deviationfor weight are  $63.8\pm11.49$  and  $54.86\pm10.43$  respectively (Table 2). The mean and standard deviation of BMI are males and females are  $22.3\pm3.22$  and  $20.47\pm3.62$ respectively (Table 3). The mean and standard deviation of BMR are males and females are  $1552.41\pm127.3$  and  $1327.7\pm147.9$  (Table 4). The graphical representation of the age between Male and Female is shown by Fig. 1. The graphical representation of the Height and Weight between Male and female is shown by Fig. 2. The graphical representation of the Body mass index is shown by Fig. 3. The graphical representation of the Basal Metabolic Rate is shown by Fig. 4 respectively.

#### Discussion

We evaluated the characteristics of participants, i.e., age, height, weight, BMI, and BMR in 50 healthy individuals. Gender was a major predictor of BMR in healthy individuals. In line with other research on obese children and teenagers, the greater BMR of our male patients can be mostly attributed to their higher fat-free mass (FFM) in comparison to females. FFM,

Table 2 Height and weight for both gender

S.no	Gender	Height		Weight	
		Mean	SD	Mean	SD
1	Male	1.68	0.68	63.8	11.49
2	Female	1.63	0.07	54.86	10.43

Table 3 Body mass index

S. no	Gender	BMI value		
		Mean	SD	
1	Male	22.3	3.22	
2	Female	20.47	3.62	

#### Table 4 Basal metabolic rate

S. no	Gender	BMR value		
		Mean	SD	
1	Male	1552.41	127.3	
2	Female	1327.7	147.9	

the body's metabolically active component, accounted for only around 60% of the variation in BMR in children and adolescents, indicating that BMR is influenced by other factors [13–15]. Particularly, despite accounting for FFM, gender remained a significant multivariable predictor of BMR in children and adolescents, which may be related to greater percentages of skeletal glycolytic fibers, higher Na+/K+ATPase activity, and altered hormonal state [3].

Age and BMR had an inverse association in every prediction model. By using a BMR-prediction model based on seven organ/tissue components [16, 17], Gallagher et al. first addressed the age-related fall in BMR in subjects of normal weight [18, 19] Wang et al. later demonstrated that the reduced BMR seen in elderly persons may be due to a decline in both the mass and the cellular percentage of organs and tissues. Other variables might help predict BMR in highly healthy people. BMR may also be affected by ponderal history, hereditary characteristics including physical activity level, variations in organ mass and metabolic rate, and hormonal condition. Further research is necessary to see whether the inclusion of these variables can increase the precision of predicting BMR in healthy individuals.

The primary BMR predictors for adults were examined in the current study. The anthropometric (height, gender, and age)-based prediction equation was used. Thus, anthropometric or body composition measurements can be used to estimate BMR in healthy individuals with the same level of accuracy. Clearly, since anthropometric equations are based on frequent measurements, they are simpler to apply in clinical practice [3].

Daily calorie needs based on activity level were also referred to the patients based on the following activities like a sedentary or little exercise, exercise 1–3 times/ week, exercise 4–5 times/week, daily exercise or intense exercise 3–4 times/week, intense exercise 6–7 times/ week, and very intense exercise daily or a physical job with calories of 1926, 2207, 2351, 2488, 2769, and 3050, respectively [20, 21].

Exercise 15–30 min of elevated heart rate activity, intense exercise: 45-120 min of elevated heart rate activity, and very intense exercise: 2 + h of elevated heart rate activity were taught to the subjects to all 50 subjects [22–25].

# Conclusion

The energy used up while lying still at rest and being awake during the nocturnal postabsorptive state is known as the basal metabolic rate (BMR). The values can be used as a reference for comparison with the normative values, and cardiorespiratory endurance can be included in the rehabilitation program.



Fig. 1 Age between male and female



Fig. 2 Height and weight between male and female



Fig. 3 Body mass index

# BMR Value



Fig. 4 Basal metabolic rate

#### Abbreviations

BMR	Basal metabolic rate
BMI	Body mass index
BW	Body weight
EE	Energy expenditure
FM	Fat mass
FFM	Fat-free mass
RMR	Resting metabolic rate

#### Acknowledgements

We are grateful to the participants for their cooperation and to our final year MPT student Ms. Srima Das of Garden City University in the collection of data. I thank Dr. Anjali Suresh, Head of Physiotherapy Department, at Garden City University, for the constant support and guidance. I extend my gratitude to all my colleagues for all the encouragement and support provided during my study.

# Authors' contributions

All authors discussed the results and commented on the manuscript. NV, SK, and AS contributed to the design and implementation of the research, the analysis of the results, and the writing of the manuscript.

#### Funding

Not applicable.

#### Availability of data and materials

Not applicable.

#### Declarations

**Consent for publication** Not applicable.

#### **Competing interests**

The authors declare that they have no competing interests.

Received: 7 December 2022 Accepted: 20 June 2023 Published online: 19 July 2023

#### References

- Berger NA. Obesity and cancer pathogenesis. Ann NY Acad Sci. 2014;1311:57–76. https://doi.org/10.1111/nyas.12416.
- Vivek Anand, Devi Sendhil, E. Rajasekar. Estimating the metabolic rate and associated physiological response for Indian subjects through climate chamber experiments. Build Environ. 2022;207:108466. Part B, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2021.108466.
- Lazzer S, Bedogni G, Lafortuna CL, Marazzi N, Busti C, Galli R, De Col A, Agosti F, Sartorio A. Relationship between basal metabolic rate, gender, age, and body composition in 8,780 white obese subjects. Obesity (Silver Spring). 2010;18(1):71–8. https://doi.org/10.1038/oby.2009.162. Epub 2009 May 28 PMID: 19478787.
- Goran M. Energy metabolism and obesity. Med Clin North Am. 2000;84(2):347–62. https://doi.org/10.1016/s0025-7125(05)70225-x. PMID: 10793646.
- Wang Z, Heshka S, Wang J, Gallagher D, Deurenberg P, Chen Z, Heymsfield SB. Metabolically active portion of fat-free mass: a cellular body composition level modeling analysis. Am J Physiol Endocrinol Metab. 2007;292(1):E49-53. https://doi.org/10.1152/ajpendo.00485.2005. Epub 2006 Aug 1. PMID: 16882929; PMCID: PMC2723740.
- Frankenfield D, Hise M, Malone A, Russell M, Gradwell E, Compher C. Prediction of resting metabolic rate in critically ill adult patients: results of a systematic review of the evidence. J Am Diet Assoc. 2007;107(9):1552–61.
- Martin-Rincon M, Perez-Valera M, Morales-Alamo D, Perez-Suarez I,Dorado C, Gonzalez-Henriquez JJ, et al. Resting Energy Expenditure and Body Composition in Overweight Men and Women Living in a Temperate Climate. J Clin Med. 2020;9(1):203. https://doi.org/10.3390/jcm9010203.
- Cacciari E, Milani S, Balsamo A, et al. Italian cross-sectional growth charts for height, weight and BMI (6–20 y). Eur J Clin Nutr. 2002;56:171–80.
- Wang Z, Heshka S, Heymsfield SB, Shen W, Gallagher D. A cellular-level approach to predicting resting energy expenditure across the adult years. Am J Clin Nutr. 2005;81:799–806.
- Klausen B, Toubro S, Astrup A. Age and sex effects on energy expenditure. Am J Clin Nutr. 1997;65(4):895–907.
- 11. Weststrate JA. Resting metabolic rate and diet-induced thermogenesis: a methodological reappraisal. Am J Clin Nutr. 1993;58(5):592–601.
- Raurich Puigdevall JM, Ibanez JJ. Energy expenditure at rest: indirect calorimetry vs the Fick principle. Nutr Hosp. 1998;13(6):303–8.
- Korth O, Bosy-Westphal A, Zschoche P, Gluer CC, Heller M, Muller MJ. Influence of methods used in body composition analysis on the prediction of resting energy expenditure. Eur J Clin Nutr. 2007;61(5):582–9.

- Strain GW, Wang J, Gagner M, Pomp A, Inabnet WB, Heymsfield SB. Bioimpedance for severe obesity comparing research methods for total body water and resting energy expenditure. Obesity. 2008;16(8):1953–6.
- Papazoglou D, Augello G, Tagliaferri M, et al. Evaluation of a multisensor armband in estimating energy expenditure in obese individuals. Obesity (Silver Spring). 2006;14(12):2217–23.
- Wilms B, Schmid SM, Ernst B, Thurnheer M, Mueller MJ, Schultes B. Poor prediction of resting energy expenditure in obese women by established equations. Metabolism. 2010;59(8):1181–9. https://doi.org/10.1016/j. metabol.2009.11.011.
- Gallagher D, Belmonte D, Deurenberg P, et al. Organ-tissue mass measurement allows modeling of REE and metabolically active tissue mass. Am J Physiol. 1998;275:E249–58.
- Gallagher D, Allen A, Wang Z, Heymsfield SB, Krasnow N. Smaller organ tissue mass in the elderly fails to explain lower resting metabolic rate. Ann N Y Acad Sci. 2000;904:449–55.
- Wang Z, Heshka S, Wang J, et al. Metabolically active portion of fat-free mass: a cellular body composition level modeling analysis. Am J Physiol Endocrinol Metab. 2007;292:E49–53.
- Trumbo P, Schlicker S, Yates AA, Poos M. Food and Nutrition Board of the Institute of Medicine, The National Academies. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. J Am Diet Assoc. 2002;102(11):1621–30. https://doi. org/10.1016/s0002-8223(02)90346-9. Erratum in: J Am Diet Assoc. 2003;103(5):563.
- Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc. 1993;25(1):71–80.
- 22. Jakicic JM, Marcus M, Gallagher KI, et al. Evaluation of the SenseWear Pro Armband to assess energy expenditure during exercise. Med Sci Sports Exerc. 2004;36(5):897–904.
- Corder K, van Sluijs EM, Wright A, Whincup P, Wareham NJ, Ekelund U. Is it possible to assess free-living physical activity and energy expenditure in young people by self-report? Am J Clin Nutr. 2009;89(3):862–70.
- Alves VG, da Rocha EE, Gonzalez MC, Da Fonseca RB, Silva MH, Chiesa CA. Assessement of resting energy expenditure of obese patients: comparison of indirect calorimetry with formulae. Clin Nutr. 2009;28(3):299–304.
- Weijs PJ. Validity of predictive equations for resting energy expenditure in US and Dutch overweight and obese class I and II adults aged 18–65 y. Am J Clin Nutr. 2008;88(4):959–70.

#### **Publisher's Note**

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Submit your manuscript to a SpringerOpen<sup>®</sup> journal and benefit from:

- Convenient online submission
- ► Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at > springeropen.com