

# 24 Hour Total Energy Expenditure Calculation Using Android Application: “24 ARM-Activity Recall Method”

Mohan Kumar M, Vineet Kumar Pathak\*

Department of Community & Family Medicine, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India

\*Corresponding author: pathakvineet2089@gmail.com

Received July 19, 2019; Revised August 29, 2019; Accepted September 15, 2019

**Abstract** Malnutrition refers to deficiencies, excesses or imbalances in a person’s intake of energy and/or nutrients and can be the ground for both communicable and Non Communicable Diseases (NCDs). Nutrition is essential and Energy Expenditure (EE) assessment in an individual’s daily routine is the key to it as both under nutrition and over nutrition are detrimental. Currently, an individual is categorised as having sedentary behaviour or light/ moderate/ vigorous intensity activities based on the Metabolic Equivalents (METs) and duration of activity. MET values for the same are given for the activity as such but using this to classify an individual sedentary or moderate or a vigorous worker is not appropriate especially when duration of activity is less than 10 minutes. As there is no single effective tool available to calculate Total Energy Expenditure (TEE), we developed a simple android application based 24 hour Activity Recall Method abbreviated as “24 ARM” to calculate TEE along with its 3 components (Resting Energy Expenditure (REE), Activity Energy Expenditure (AEE) and Diet Induced Thermogenesis (DIT)) and results can be shared with other persons also.

**Keywords:** physical activity, energy expenditure, METs, resting energy expenditure, activity energy expenditure, Diet-Induced Thermogenesis

**Cite This Article:** Mohan M, Pathak VK, “24 Hour Total Energy Expenditure Calculation Using Android Application: ‘24 ARM-Activity Recall Method’.” *Journal of Physical Activity Research*, vol. 4, no. 2 (2019): 126-130. doi: 10.12691/jpar-4-2-8.

## 1. Introduction

Low and Middle Income Countries (LMIC) around the world suffer from a triple burden of disease: the backlog of common infections, malnutrition, the emerging challenges of Non-Communicable Diseases (NCDs), such as cancer, diabetes, heart disease, and mental illness. [1] Malnutrition refers to deficiencies, excesses or imbalances in a person’s intake of energy and/or nutrients and can be the ground for both communicable and NCDs. The term malnutrition covers 2 broad groups of conditions. One is ‘under nutrition’—which includes stunting (low height for age), wasting (low weight for height), underweight (low weight for age) and micronutrient deficiencies or insufficiencies leading to communicable diseases. The other is overweight, obesity and diet-related NCDs (such as heart disease, stroke, diabetes and cancer). [2]

**Table 1. Global & India’s Nutritional Status of Children aged ≤ 5years**

Nutritional Status of Children aged ≤ 5years	Global (in million)	India (%)
Stunted (height for age)	150.8 (22.2%)	38.4
Wasted (weight for height)	50.5 (7.5%)	21.0
Severely wasted (weight for height)	17 (2.4%)	7.5
Underweight (weight for age)	91.1 (13.5%)	35.7
Overweight	38.3 (5.6%)	19.3

In India, of children aged ≤ 5 years, 38.4% are stunted [3] (22.2% globally) [4], 21% children are wasted [3] (7.5% globally) [4], 7.5% severely wasted [3], 35.7% underweight [3] (13.5% globally) [5] and 19.3% overweight [6] (5.6% globally) [4].

Globally, the prevalence of overweight among adults (age ≥18) shows an increase from 35.7% in 2010 to 38.9% in 2016 (38.5% in men and 39.2% in women). Obesity prevalence in adults is also on the rise: from 11.2% in 2010 to 13.1% in 2016 (11.1% men and 15.1% women). The prevalence of women being underweight (BMI is less than 18.5 kg/m<sup>2</sup>) is 9.7%. [4]

**Table 2. Nutritional Status of Adults in India (age 15-49 years) [3]**

Nutritional Status of Adults in India (age 15-49 years)	Percentage
Women whose Body Mass Index (BMI) is below normal (BMI < 18.5 kg/m <sup>2</sup> )	22.9
Men whose Body Mass Index (BMI) is below normal (BMI < 18.5 kg/m <sup>2</sup> )	20.2
Women who are overweight or obese (BMI ≥ 25.0 kg/m <sup>2</sup> )	20.7
Men who are overweight or obese (BMI ≥ 25.0 kg/m <sup>2</sup> )	18.9

Nutrition is essential and Energy Expenditure (EE) assessment in an individual’s daily routine is the key to it as both under nutrition and over nutrition are detrimental. Currently, an individual is categorised as having sedentary behaviour or light/moderate/vigorous intensity activities based on the Metabolic Equivalents (METs) of the

activities he/she does for most part of the day and this classification is used to calculate their daily calorie requirement [7,8].

The respective MET values for sedentary behaviour, light intensity, moderate intensity and vigorous intensity activities are 1.0-1.5 METs, 1.6-2.9 METs, 3-5.9 METs, >6 METs respectively. [7,9,10] As these values are given for the activity as such, using this to classify an individual sedentary or moderate or a vigorous worker is not appropriate. This is because an individual doing Moderate to Vigorous Physical Activity (MVPA) in bouts less than 10 minutes but for more than 150 or 75 minutes in a week respectively should not be classified as sedentary. But according to definition to classify into moderate or vigorous, the activity bout should be a minimum of 10 minutes. [11] Despite this historical notion that physical activity needs to be performed for a minimum duration to elicit meaningful health benefits, there are evidences showing that sporadic and bouted MVPA are similarly associated with substantially reduced mortality. [12] This finding communicates future physical activity guidelines and can help clinical practitioner while advising individuals about the benefits of physical activity. Practitioners can promote either long single or multiple shorter episodes of activity in advising adults on how to progress toward 150 min/week of MVPA. [12] This flexibility also means that an individual's should be evaluated for 24 hour EE for accurate predictions.

The classification for adults being inactive, insufficiently active, active, and highly active based on the total duration of moderate or vigorous activity over a week is useful because these categories are related to how much health benefit a person obtains at a given level and how to become more active. [10] But this cannot be used to calculate the Energy Expenditure (EE) of an individual over a 24 hour period.

An individual's 24 hour EE is so important that it reflects the energy requirement per day of that individual. Conceiving a concept that estimates Total Energy Expenditure (TEE) of an individual reasonably close to the actual TEE is the need of the hour. Having a point of survey tool is pivotal.

## 2. Total Daily Energy Expenditure

Total Daily Energy Expenditure (TEE or TDEE) is comprised of Resting Energy Expenditure (REE), Activity Energy Expenditure (AEE) or Thermic Effect of Physical Activity (TEPA) and Thermic Effect of Food (TEF) also referred to as Diet-Induced Thermogenesis (DIT). [13]

$$\text{TEE} = \text{REE} + \text{AEE} + \text{DIT}.$$

Resting Energy Expenditure represents the largest proportion of TEE (60 to 75%). Activity Energy Expenditure accounts for 15 to 30% and Thermic Effect of Food for the remaining 10% of TEE [13,14].

## 3. Resting Energy Expenditure

REE represents the amount of energy expended by a fasted individual at rest in a thermo-neutral environment. Resting Metabolic Rate (RMR) is typically slightly higher than basal metabolic rate (BMR) that is measured under

strict conditions. Basal metabolic rate (BMR) is more precisely defined as the REE measured just after awakening in the morning [15]. There are more than a dozen formulas to estimate REE and notable ones are Harris-Benedict (HB) equation [16,17], Schofield equation [18], WHO/FAO/UNU [World Health Organization (WHO) equation] [19] and Mifflin-St Joer equation [18,20,21].

*Harris benedict equation:*

For women, REE (kcal/24hr)

$$655 + (9.6 \times \text{Body mass in kg}) \\ + (1.85 \times \text{Stature in cms}) - (4.7 \times \text{Age in years})$$

For men, REE (kcal/24hr)

$$66.0 + (13.7 \times \text{Body mass in kg}) \\ + (5.0 \times \text{Stature in cms}) - (6.8 \times \text{Age in years})$$

Harris benedict equation is applicable to all age groups with reasonably high percentage of accurate predictions across the range of BMI values. Various researchers like Hasson et al (2010) conducted a study [22] in 362 healthy participants to test the accuracy of four commonly used prediction equations: Harris-Benedict, Mifflin-St. Jeor, Owen and WHO/FAO/UNU equations. They found that Harris-Benedict equation was the most accurate, with 57.5% of predicted RMR values within  $\pm 10\%$  of measured RMR. The other significant findings are,

- HB equation is the most accurate for predicting RMR in both males and females
- HB equation is accurate for predicting RMR across all BMI groups
- HB and Owen equations accurately predicted RMR in older participants.

In a study done by Lee et al in the year 2012 [23] among police officers doing shift works, of the various other predictive equations tested, Harris-Benedict equation was the most accurate and precise. Amirkalali et al conducted a study [20] to test the degree of agreement between measured REE by indirect calorimetry and predicted REE by HB and Mifflin-St Jeor equations. There was no statistically significant difference between the measured and predicted REE by both equations. But when the participants were categorised according to their sex, significant difference was found between the measured and predicted equivalent by Mifflin-St Jeor equation. In a study done by Jesus et al [18] in the year 2014 among 1726 patients being followed for malnutrition, eating disorder or obesity, above the age of 18 years, without acute diseases or chronic high-grade inflammatory diseases, HB equation accurately predicted the REE in 73% (Figure 1) participants with normal BMI (18.6 to 24.9 kg/m<sup>2</sup>). But the accurate prediction of REE was only 51.8% in the group with BMI ranging from 16 to 18.5 kg/m<sup>2</sup> and 39.3% in patients with BMI lesser than 16 kg/m<sup>2</sup>.

A major limitation in the use of Harris-Benedict equation for critically ill patients is that, it was derived from indirect calorimetry data of healthy volunteers. To correct for disease states and degrees of stress, the REE is multiplied by factors for better estimates of energy expenditure of critically ill patients. These factors range from 1.2 to 2.0. [24] Lower values of correction factors

(approximately 10%) in the calculation of energy needs to avoid overfeeding can also be done with the Harris-Benedict equations [25].

### 4. Activity Energy Expenditure

Activity energy expenditure (AEE) is the modifiable component of total energy expenditure (TEE) derived from all activities, both volitional and non-volitional. [26] As an individual has a daily routine of day to day activities, it can easily be translated in terms of ‘24 hour Activity Recall Method’ in which the person recalls the set of activities he does in a 24 hour day. By doing so we get the subjective set of activities for which the amount of calorie he/ she has to spend during the course of the day can be calculated. This will give us the Thermic Effect of Physical Activity (TEPA) or Activity Energy Expenditure (AEE).

The Compendium of Physical Activities (Compendium) 2011 [27,28] has received widespread acceptance as a resource to estimate and classify the energy cost of human physical activity (PA). The Compendium provides a five-digit coding scheme linking categories and types of PA with their respective MET intensity values. It provides a comprehensive list of PA and their associated MET values to facilitate the coding of self-reported behaviours obtained from PA questionnaires, logs, and records. Its use has since been expanded to include estimating the energy cost of individual PA for exercise and weight management programs.

The idea here is to make use of the list of physical activities and MET values to calculate an individual’s energy expenditure over a period of his/ her 24 hours. The MET values given in the Compendium for various physical activities can be modified in terms of Kilo Calories as, 1

MET equates to 3.5 mL/O<sub>2</sub>/kg/min-1 or 1 kcal/kg/h [13,15]. For instance consider a 60 kg man sleeping for 8 hours. The MET value for sleeping is 1.0. So, the energy expenditure will be 480 kcal/kg/hr (1 kcal x 60 kg x 8 hours). In this way the set of activities over a 24 hour period is recorded and the energy expended for the same is calculated.

### 5. Diet-induced Thermogenesis (DIT)

Diet induced thermogenesis (DIT) can be defined as the increase in energy expenditure above basal fasting level divided by the energy content of the food ingested and is commonly expressed as a percentage different for each nutrient. Reported DIT values for separate nutrients are 0 to 3% for fat, 5 to 10% for carbohydrate, 20 to 30% for protein, and 10 to 30% for alcohol. In healthy subjects with a mixed diet, DIT represents about 10% of the total amount of energy ingested over 24 hours. When a subject is in energy balance, where intake equals expenditure, DIT is 10% of daily energy expenditure [29]. Therefore, considering energy balance here the idea is to take 10% of the TEE (the sum of REE and AEE).

#### The way forward-Concept of 24 hour Activity Recall Method (24 ARM)

Though the importance of nutrition is widely recognized there is no single effective method of estimating the TEE of an individual so that the appropriate nutritional requirement are prescribed.

**Total Energy Expenditure**= Resting Energy Expenditure (REE) + Activity Energy Expenditure (AEE) + Diet Induced Thermogenesis (DIT)

REE to be calculated with Harris Benedict (HB) equation.

AEE to be calculated with the MET values given in Compendium of physical activities 2011.

DIT to be calculated as 10% of REE+AEE.

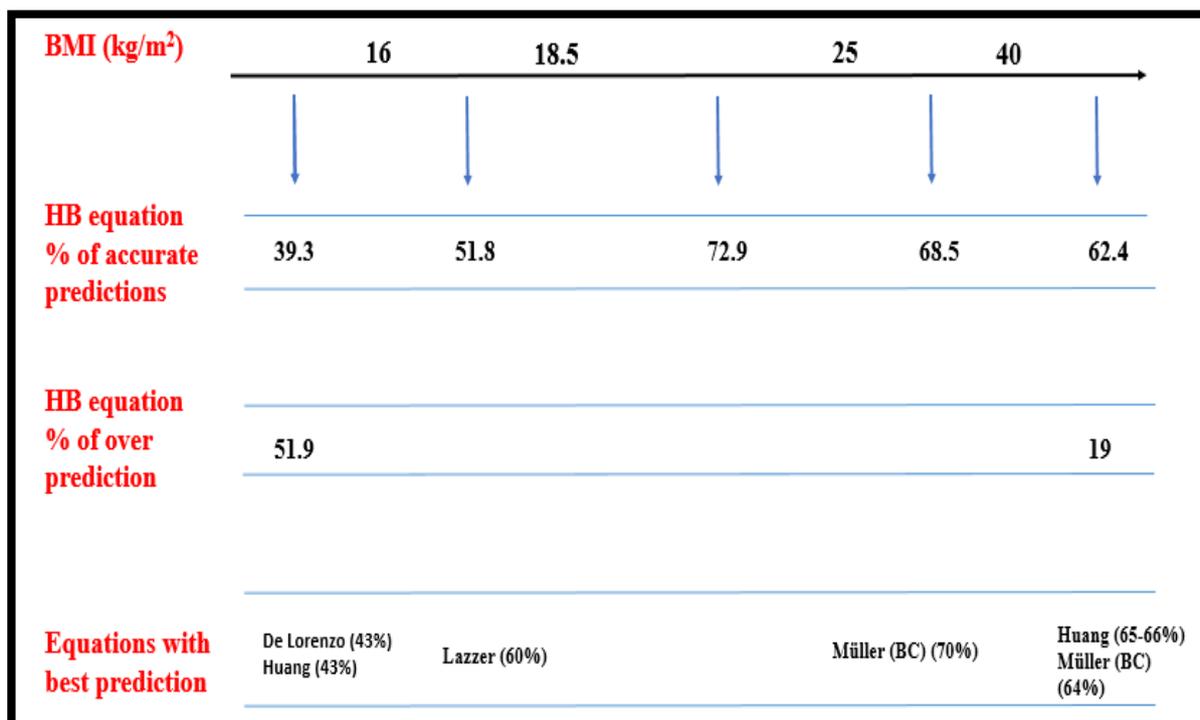


Figure 1. Percentage of accurate predictions by Original Harris Benedict equation

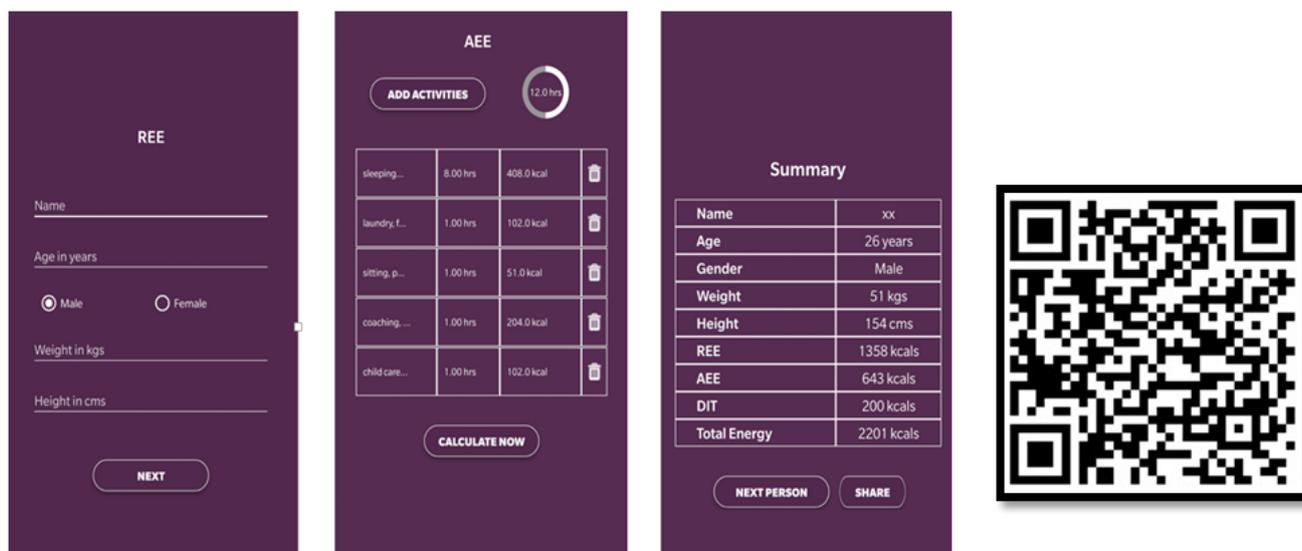


Figure 2.

These formulas independently are in use for various purposes but combining these three gives us the 24 hour energy expenditure of an individual. An android mobile application (currently in beta version) has been developed using this concept to estimate the Total Energy Expenditure (TEE) of an individual which can be used in field surveys, clinics and hospitals. The EE thus calculated can be used as a substitute for Calorie requirement of that individual.

#### About 24 ARM

24 hour Activity Recall Method abbreviated 24 ARM is a simple way to calculate the average energy spent in a day. It considers all 3 components energy is spent and so is considered to give values close to true values, being valid and reliable.

#### Using 24 ARM

1. Resting Energy Expenditure (REE) is calculated using age (in years), weight (in kilograms), and height (in cms). It is equivalent to Basal Metabolic Rate (BMR).
2. Activity Energy Expenditure (AEE) is calculated with the list of activities a particular person does over a 24 hour period. Activities and duration are obtained by 24 hour recall method.
3. The summary tells us the Total Energy Expenditure (TEE) along with its 3 components which can be shared with other persons also.

## References

- [1] Frenk J, Gómez-Dantés O. The Triple Burden: Disease in Developing Nations. *Harv Int Rev*. 2011; 33(3): 36-40.
- [2] Malnutrition. Available from: <https://www.who.int/news-room/fact-sheets/detail/malnutrition> [Last accessed on 19/8/2019].
- [3] International Institute for Population Sciences (IIPS) and ICF. 2017. National Family Health Survey (NFHS-4), 2015-16: India. Mumbai: IIPS. 2017; 1-666.
- [4] WHO. The Burden of Malnutrition. *Glob Nutr Rep*. 2018. Available from: <https://www.who.int/nutrition/globalnutritionreport/en/> (Last accessed on 19/8/2019).
- [5] Prevalence of underweight, weight for age (% of children under 5) | Data. Available from: <https://data.worldbank.org/indicator/sh.sta.maln.zs?end=2017&start=2017&type=points&view=bar> (Last accessed on 19/8/2019).
- [6] Ranjani H, Mehreen T, Pradeepa R, Anjana R, Garg R, Anand K, et al. Epidemiology of childhood overweight & obesity in India: A systematic review. *Indian J Med Res*. 2016; 143(2): 160..
- [7] González K, Fuentes J, Márquez JL. Physical Inactivity, Sedentary Behavior and Chronic Diseases. *Korean J Fam Med*. 2017; 38(3): 111.
- [8] Dietary guidelines for Indians-A Manual. National Institute of Nutrition. 2011; 2: 89-117. 2017; 1 to 139. Available from: <http://ninindia.org/DietaryGuidelinesforNINwebsite.pdf> (Last accessed on 19/8/2019).
- [9] Dencker M, Andersen LB. Accelerometer-measured daily physical activity related to aerobic fitness in children and adolescents. *J Sports Sci*. 2011; 29(9): 887-95.
- [10] Physical Activity Guidelines for Americans 2014. Available from: <https://jamanetwork.com/journals/jama/fullarticle/2712935> (Last accessed on 19/8/2019).
- [11] WHO | Physical Activity and Adults. WHO. 2015. Available from: [https://www.who.int/dietphysicalactivity/factsheet\\_adults/en/](https://www.who.int/dietphysicalactivity/factsheet_adults/en/) (last accessed on 19/8/2019).
- [12] Saint-Maurice PF, Troiano RP, Matthews CE, Kraus WE. Moderate-to-Vigorous Physical Activity and All-Cause Mortality: Do Bouts Matter? *J Am Heart Assoc*. 2018 Mar 20; 7(6).
- [13] McArdle, W. D., Katch, F. I., & Katch, V. L. Exercise physiology: Energy, nutrition, and human performance. Philadelphia: Lippincott Williams & Wilkins 2001.
- [14] Bijlani, R. L., & Manjunatha, S. Understanding Medical Physiology: A Textbook for Medical Students. 4th edition New Delhi :: Jaypee Brothers Medical Publishers (2011).
- [15] Hills AP, Mokhtar N, Byrne NM. Assessment of Physical Activity and Energy Expenditure: An Overview of Objective Measures. *Front Nutr*. 2014; 1(June): 1-16.
- [16] Boothby W.M., and Sandiford I. A comparison of the du bois and the harris and benedict normal standards for the estimation of the basal metabolic rate. *J.biol.chem.*, 1922, liv, 783.
- [17] Boothby W.M. and Sandiford I. Summary of the basal metabolism data on 8,614 subjects with especial reference to the normal standards for the estimation of the basal metabolic rate. *Jbiolchem* 1922.
- [18] Jesús P, Achamrah N, Grigioni S, Charles J, Rimbart A, Folope V, et al. Validity of predictive equations for resting energy expenditure according to the body mass index in a population of 1726 patients followed in a Nutrition Unit. *Clin Nutr*. 2015; 34(3): 529-35.
- [19] Energy and protein requirements. Report of a joint FAO/WHO/UNU Expert Consultation. Vol. 724, World Health Organization technical report series. 1985. p. 1-206.
- [20] Amirkalali B, Hosseini S, Heshmat R, Larjani B. Comparison of Harris Benedict and Mifflin-ST Jeor equations with indirect calorimetry in evaluating resting energy expenditure. *Indian J Med Sci*. 2008 Jul; 62(7): 283-90.
- [21] M. D. Mifflin, S. T. St Jeor and L. A. Hill, "A New Predictive Equation for Resting Energy Expenditure in Healthy Individuals," *American Journal of Clinical Nutrition*, Vol. 51, No. 2, 1990, pp. 241-247.

- [22] Hasson RE, Howe CA, Jones BL, Freedson PS. Accuracy of four resting metabolic rate prediction equations: Effects of sex, body mass index, age, and race/ethnicity. *J Sci Med Sport*. 2011 Jul; 14(4): 344-51.
- [23] Lee SH, Kim EK. Accuracy of Predictive Equations for Resting Metabolic Rates and Daily Energy Expenditures of Police Officials Doing Shift Work by Type of Work. 2012; 66-77.
- [24] Resting Energy Expenditure - an overview | ScienceDirect Topics [Internet]. [cited 2019 Jun 6]. Available from: <https://www.sciencedirect.com/topics/neuroscience/resting-energy-expenditure>.
- [25] Japur CC, Penaforte FRO, Chiarello PG, Monteiro JP, Vieira MNM, Basile-filho A. Harris-Benedict equation for critically ill patients: Are there differences with indirect calorimetry? *J Crit Care*. 2009; 24(4): 628. e1-628. e5.
- [26] Neilson HK, Robson PJ, Friedenreich CM, Csizmadia I. Estimating activity energy expenditure: how valid are physical activity questionnaires? *Am J Clin Nutr*. 2008 Feb 1; 87(2): 279-91.
- [27] Ainsworth Be, Haskell Wl, Herrmann Sd, Meckes N, Bassett Dr, Tudor-Locke C, et al. 2011. Compendium of Physical Activities. *Med Sci Sports Exerc*. 2011; 43(8): 1575-81.
- [28] Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR, Tudor-Locke C, et al. 2011 compendium of physical activities: A second update of codes and MET values. *Med Sci Sports Exerc*. 2011; 43(8): 1575-81.
- [29] Westerterp KR. Nutrition & Metabolism Diet induced thermogenesis. 2004; 5: 1-5. Available from: <https://nutritionandmetabolism.biomedcentral.com/articles/10.1186/1743-7075-1-5> (Last accessed on 19/8/2019).



© The Author(s) 2019. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).