Original Article

# No Differences in Energy Cost of a Predetermined Exercise among Young Overweight/Obese and Undernourished Individuals

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## Abstract

**Background:** Physical activity is an integral part of one's daily life. Obese (Ob) and undernourished (UN) persons are known to underperform physically as compared to normal weight (N) individuals. In this study, we have measured the energy spent to perform a prefixed exercise on treadmill walking and basal heart rate and blood pressure. Body mass index (BMI) and body fat of participating individuals were assessed. Fasting blood sugar and lipid profile were also evaluated. **Materials and Methods:** Eighty-three young individuals (male: 41; female: 42) of medical faculty, Universiti Sultan Zainal Abidin, who volunteered for the study, were recruited. The mean age of the individuals was 19.8 ± 0 years ($P < 1.08$). The individuals were grouped as N, UN/underweight, and overweight (Ow)/Ob based on BMI. **Results:** The results of the study revealed that there were no differences in the energy spent on performing the predetermined treadmill walking of 20 min duration among the three groups (a mean of 78 and 70 calories in all male and female subgroups, respectively). The distance covered by the males was 1.6 km while the females covered 1.4 km on treadmill walking in 20 min time. Basal blood pressure and heart rate and fasting blood sugar did not reveal any significant difference among the groups. However, total cholesterol and triglyceride levels were marginally higher in the Ow/Ob groups of male and female individuals as compared to other groups. **Conclusion:** Since the study individuals were very young and competitive by nature and possibly had no major metabolic disturbances, the differences in physical activity performances were not obvious. Possibly, such differences would become apparent only at later stages of life as age advances or when the intensity and duration of exercise are set at higher levels.

**Keywords:** *Body mass index, energy cost of exercise, obese, treadmill, undernourished/weight*

## Introduction

Physical activity is a vital part of human's everyday life. Physical fitness is important for effective, efficient, and purposeful completion of any physical activity performed which also includes different forms of exercise. It is commonly understood that work performance depends on both physical and mental abilities.

There are suggestions that body mass plays a pivotal role in exercise efficiency as estimated by oxygen consumption during the activity.[1] In some forms of physical activity (e.g., bicycle ergometer exercise), efficiency is considered to be independent of body mass. However, it is generally presumed that overweight (Ow) and obese (Ob) individuals physically perform with less efficiency mainly due to excess body mass as a result of increased body adiposity, more than the other morbid conditions associated with obesity.[2] Similarly, undernourished (UN)/underweight (UW) individuals also suffer from functional limitations due to smaller body size, particularly lesser skeletal muscle mass and energy stores.

We have previously reported that Ob individuals have low cardiac efficiency and hence low physical fitness scores in comparison with normal weight (N)/lean group or regularly exercising group as assessed by Harvard step test.[3,4] The Ob group either could not complete the exercise activity or took more time to recover to preexercise levels even if they completed the exercise.[3] Salvadori *et al.* also have a similar report published in 1999.[5]

It is well understood that the physiological responses are different in aerobic and anaerobic exercises and depend on the duration and intensity and nature/type of exercise performed. We, therefore, designed this study where the intensity is submaximal and the duration is moderate



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and does not allow the individuals to easy exhaustion. In the present study, we have primarily evaluated the calories spent on a prefixed treadmill walking exercise with a speed and duration (that was slightly different for the male and female individuals) to investigate the differences, if any, in the energy cost of exercise among N, underweight (UW), and Ow/Ob individuals.

## Materials and Methods

Age-matched, male (41) and female (42) students (mean age – 19.8 ± 0.8 years) ($P < 1.08$) of Universiti Sultan Zainal Abidin (UniSZA) medical faculty were recruited for the study as volunteers. The inclusion criteria were that the individuals should be healthy without any acute or chronic major cardiovascular or respiratory problems. Moreover, they should not have had any illness of any nature during the previous 2 weeks before they were subjected for experimental procedures. For the female individuals, those who were on their monthly menstrual cycle were avoided to perform the experiment. The individuals were on their normal diet and were not restricted. They were briefed about the aims and objectives of the study. Persons with any health problems were excluded from the study after a preliminary medical examination. The faculty research ethical committee approval was obtained before the start of the study. They were grouped as per the body mass index (BMI) classification for Asians[6] into N with a BMI of 18.5–22.9 who served as controls while individuals with a BMI of <18.5 formed the UW/UN group. Individuals with a BMI >23 were in Ow/Ob group.

As the individuals arrived at the laboratory, they were made to relax and to be comfortable for a few minutes. The following investigations were carried out before the treadmill exercise began. A baseline evaluation of body composition was done using an automated body composition analyzer (model SM N-40) that works on the principle of bioelectric impedance. It provided information on body weight, BMI, body fat, fat-free mass, skeletal muscle mass, and body water levels. However, body fat and BMI were essential variables for the present study. Blood pressure measurement was done as per standard procedures using a mercury sphygmomanometer. Blood analysis for sugar and lipids was carried out according to standard procedures using the biochemical auto-analyzer in the faculty laboratory (Olympus AU400). The exercise protocol included treadmill walking for 20 min (predetermined task, i.e., a fixed duration and gradient of the treadmill) at different speeds each for a specified duration. At the end of the exercise, the calories spent for the exercise, heart rate, and the distance covered were recorded and stored in the computerized treadmill. The treadmill walking protocol is as follows that we had used in the faculty for another project.

### Treadmill protocol for males

| Exercise duration | 1 min | 4 min | 10 min | 4 min | 1 min |
|---|---|---|---|---|---|
| Time on screen | 20 | 19 | 15 | 5 | 1 |
| Speed on screen (km/h) | 2 | 4 | 6 | 4 | 2 |

### Treadmill protocol for females

| Exercise duration | 1 min | 3 min | 3 min | 6 min | 3 min | 3 min | 1 min |
|---|---|---|---|---|---|---|---|
| Time on screen | 20 | 19 | 16 | 13 | 7 | 4 | 1 |
| Speed on screen (km/h) | 2 | 4 | 4.5 | 5 | 4.5 | 4 | 2 |

In brief, the total duration of treadmill exercise of 20 min was set first and then the individual was asked to walk on the treadmill for 1 min at a speed of 2 km/h after which the speed was changed to 4 km/h for 3 min exercise. The same procedure was followed till the individuals completed the 20 min exercise at different speeds of varying duration as shown in the treadmill exercise protocol tables above. A small difference in the speed and duration for female individuals was observed due to the convenience of the participants.

The data were analyzed using SPSS software version 17.0 (SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc.2008.). One-way ANOVA was employed for comparison of results among the groups, and descriptive analysis was done for comparing mean values. $P < 0.05$ was considered statistically significant.

## Results

Based on the BMI, the number of individuals in each group was as follows: male; normal – 11, UW/UN – 6, Ow – 13, and Ob – 11. Similarly, the number of individuals in the female category was normal – 14, UW/UN – 7, Ow – 13, and Ob – 8. Body fat percentage in different group of individuals increased in accordance with the BMI. It rose from 10% in the UN to 35% in the Ob males. And, the range was from 27% in the UW to 43% in the female Ob. The resting/basal blood pressure and heart rate were within the normal range. Further details are shown in Table 1. The results of the fasting blood sugar and lipid profile are shown in Table 2. These measurements were done to make sure that the individuals in our study did not have any serious metabolic abnormalities.

The distance covered by treadmill walking was 1.6 km and 1.4 km by the male and female individuals, respectively. The energy cost of the exercise was 78.0 ± 1.2 calories for male and 70.0 ± 0.9 calories for female subgroups. These values were statistically insignificant.

## Discussion

Obesity is on the rise and it becomes important in the face of its serious health problems as it is associated with metabolic changes resulting in altered blood lipid and sugar profile, altered cardiovascular hemodynamics, and

**Table 1: Body mass index, body fat percentage, resting blood pressure and heart rate of male and female individuals in different subgroups of the study**

| Group (*n*) | BMI | Body fat percentage | BP (mmHg) | HR/min |
|---|---|---|---|---|
| Male | | | | |
| Normal (11) | 21.0±2.3 | 17.3±4.3 | 125/78±6/9 | 80±8 |
| UW (6) | 16.4±2.0* | 10.5±5.2* | 127/79±12/8 | 76±6 |
| OW (13) | 25.4±3.2* | 26.3±4.8* | 128/82±9/6 | 77±9 |
| Ob (11) | 32.7±4.3* | 35.8±6.4* | 134/78±10/7 | 74±8 |
| Female | | | | |
| Normal (14) | 20.8±1.8 | 35.6±5.6 | 112/71±10/9 | 82±9 |
| UW (6) | 16.9±2.0* | 26.9±4.8* | 113/70±6/6 | 86±10 |
| OW (13) | 24.5±1.9* | 37.0±5.0* | 117/72±8/7 | 83±7 |
| Ob (8) | 29.5±2.5* | 43.1±3.8* | 122/83±8/7 | 86±8 |

*$P$<0.05. UW=Underweight, OW=Overweight, Ob=Obese, *n*=Number of individuals, BMI=Body mass index, BP=Blood pressure, HR=Heart rate

**Table 2: Lipid profile of male and female individuals among different subgroups of the study (units of expression = mmol/L)**

| Group (*n*) | FBS | TCh | TGL | HDL | LDL |
|---|---|---|---|---|---|
| Male | | | | | |
| Normal (7) | 4.73±0.4 | 4.94±0.2 | 0.77±0.02 | 1.29±0.02 | 3.48±0.3 |
| UW (7) | 4.95±0.2 | 4.45±0.3 | 0.84±0.05 | 1.24±0.02 | 3.04±0.4 |
| OW (7) | 4.90±0.3 | 5.34±0.3 | 1.51±0.06 | 1.16±0.01 | 3.88±0.2 |
| Ob (7) | 4.95±0.2 | 5.32±0.2 | 1.93±0.03 | 1.13±0.01 | 3.81±0.5 |
| Female | | | | | |
| Normal (6) | 4.70±0.1 | 4.60±0.3 | 0.80±0.02 | 1.46±0.2 | 2.96±0.3 |
| UW (5) | 4.92±0.3 | 4.94±0.2 | 0.76±0.04 | 1.50±0.01 | 3.30±0.3 |
| OW (5) | 5.07±0.2 | 5.26±0.5 | 1.00±0.03 | 1.42±0.02 | 3.64±0.4 |
| Ob (4) | 5.10±0.3 | 5.10±0.2 | 0.67±0.01 | 1.42±0.02 | 3.32±0.2 |

UW=Underweight, OW=Overweight, Ob=Obese, *n*=Number of individuals, FBS=Fasting blood sugar, TCh=Total cholesterol, TGL=Triglyceride, HDL=High-density lipoprotein, LDL=Low-density lipoprotein

respiratory functions.[7-9] Such changes may be responsible for the lower physical activity performance in the Ob individuals. On the other hand, lower energy levels (fat) and lesser skeletal muscle mass may be the cause of decreased ability in activity of the UN persons. It is ironical that the Ob have large stores of energy in the form of triglycerides but still not efficient in the work performance. The reasons given are that they have heavier body mass. However, there may be other metabolic causes that have not been evaluated in detail.

The results of the present study revealed that there were no major differences in terms of energy spent on performing the predetermined treadmill exercise among the groups despite differences in BMI and body fat percentage. Other variables studied also did not reveal any significant differences except that the total cholesterol levels were slightly higher (insignificant) in the Ob group as compared to other groups both in male and female individuals, and triglycerides were marginally higher in all groups as per the reference values. Since the study individuals were very young and competitive by nature and no metabolic changes were obviously evident, the physical activity performance was not different among the subgroups both in males and females. Possibly, such differences would be picked up in such individuals only at later stages of life. One explanation for why Ob persons do not use that much more energy could be that, as a person becomes Ob, he/she learns to walk in a way that reduces the mechanical work required to lift, lower, accelerate, and decelerate his/her center of mass. This may be one possibility in our individuals too. Whether Ob walkers also minimize the mechanical work of walking in a similar way becomes interesting to look at. However, other studies[10-12] have shown that the calculated mechanical work did not explain the greater metabolic cost of walking for Ob adolescents or in other words did not find any differences in the mechanical work.

One another study from Shetty's group has suggested that there was no difference in the physical activity performance in the UN individuals as compared to normal controls while performing a real-life situation activity such as load transportation on head or hands by construction work laborers.[13] On the other hand, Zurairie *et al*. have shown that the UN young individuals had a better work performance than the Ob individuals and the normal controls.[3] In that study, probably, thinner body size of the UW individuals was an advantage to perform the step test for a longer period of time than the Ob individuals. According to experts in biomechanics, such feats of efficient work capacity both in Ob and UW individuals are accomplished by more skillful exchange of kinetic and gravitational potential energy so as to avoid the need for additional mechanical work.[14]

It should be borne in mind that certain distinctions are made with regard to exercise performance of Ob individuals in the execution of short and intense efforts; the work performance/efficiency is primarily reduced by the disproportionate amount of fat tissue. Whereas activities such as bicycle ergometer exercise or walking performance is limited in Ob individuals principally due to the higher metabolic energy required to move the heavier body. During exercise on a bicycle, the body weight is supported almost completely whereas treadmill walking is substantially influenced by the whole weight of the body of exercising individuals.[15]

## Conclusion

Therefore, it appears that age and body weight may be important factors that would influence the work capacity of an individual. The differences in results among various studies may be explained by different forms of exercises and conditions used in each study. However, the biomechanics of walking exercise in the Ob is very

interesting, and further studies in this area could throw more light to our understanding of such phenomenon.

However, the importance of the study may be that, once the physiological mechanisms of functional limitations in Ob or Ow individuals during exercise are evident, it could be used as an important marker in planning physical activity and rehabilitation protocols to improve work efficiency. The results of the study also lead one to consider to investigate further whether yogic training can alter the work efficiency of individuals as it is known to influence the cardiorespiratory functions through autonomic system.

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### Conflicts of interest

There are no conflicts of interest.

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