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Energy Demand Assessment Between Exercising and Non-Exercising Young Female Collegiate During a Single Exercise Bout

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Abstract: Balancing energy requirement with energy availability during determination for any exercise is of importance to performance. This study was set up to evaluate the influence of regular exercise on energy demand for a given exercise bout among exercising and non-exercising young female College students from University of Lagos using the different energy determining equations available. Sixty volunteer young female students were grouped into two: exercising (Ex-Sub) and non-exercising (NonEx-Sub) subjects. Their heights, weights, ages were recorded, while their blood glucose and blood pressure levels, as well as heart rates were measured before and after the exercise. Two minutes warm-up on the cycle ergometer at 40 km/hr was allowed while gradually increasing the speed to 70km/hr lasting for five minutes. Using the Heart Rate and the estimated VO2max (VO_2) the energy demand was determined. The basal systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate were significantly lower in Ex-Sub compared with NonEx-Sub. Although, both ExSub and NonEx-Sub recorded a significantly lower SBP after exercise, Ex-Sub result before and after the exercise were significantly lower compared with that of NonEx-Sub. Both Ex-Sub and NonEx-Sub recorded a significant reduction in heart rate after the exercise. The basal and after exercise heart rate in Ex-Sub was significantly lower, while both the estimated VO_2max and energy demands were significantly higher in ExSub compared to NonEx-Sub. Regular exercise confers an advantage by modifying cardiovascular parameters with an added advantage on efficient and reduced energy utilization in the exercising subjects.

Key words: Exercise, Energy demand, Basal energy expenditure, blood pressure, VO_2max, Blood glucose level.

1.0 Introduction

The maintenance of body weight is regulated by the relationship between several processes, comprising of homoeostatic, environmental, and behavioural factors. In homoeostatic regulation, the hypothalamus has a central role in integrating signals regarding food intake, energy balance and body weight, whereas an obesogenic environment and behavioural patterns exert effects on the amount and type of food intake and physical activity. The roles of other environmental factors are also now being considered, including sleep debt and iatrogenic effects of medications. The physiological adaptations to weight loss unfortunately, favour weight regain. These changes include perturbations in the levels of circulating appetite-related hormones and energy homoeostasis, in addition to alterations in nutrient metabolism and subjective appetite.

To maintain weight loss, individuals must adhere to behaviours that counteract physiological adaptations and other factors favouring weight regain such as exercising [1].Exercise is a physical activity that maintains physical fitness and optimum health of an individual [2]. Exercise is prescribed and used as a therapy for obese individuals as well as for patients recovering from stroke [3]. As exercise is initiated and its intensity increases, there is increase in oxygen demand from the body in general, but primarily from the working muscles with a concomitant increase in heart rate [4]. A comprehension of the factors that affect energy balance is of key importance in understanding the regulation of body mass and the prescription of exercise for weight loss. Energy balance is determined by intake and output with adverse consequences of overweight or underweight whenever an imbalance is established.

Factors that have the capacity to affect energy balance may be linked to genetics which is inheritable, or it may be epigenetic which is dependent on environmental factors that can change the phenotype or the expression of the genetic makeup of an individual. Such factors are abundance of food supply, pregnancies that are conceived during famine but born into abundant food supply, lack of adequate exercise, a sedentary lifestyle which would tilt the energy balance towards obesity condition. Inadequate food supply on the other hand would tilt the energy balance towards energy deprived conditions. Exercise is thus prescribed for a healthy living but most importantly as a means of burning off excess energy stored in the body that may lead to obesity. The purpose of this study is to determine the energy expenditure and the changes to cardiovascular parameters in exercising and non-exercising young female adults during a single exercise bout on the cycle ergometer.

2.0 Materials and Methods

2.1 *Participants in the study:*

Thirty young, healthy female subjects (15 exercising and 15 non-exercising) took part in this study. They were screened using a questionnaire. The questionnaire contained information such as: age, weight, height, etc. Those who had been on a regular exercise for at least 6 months were considered as exercising, while those that do not participate in any regular exercise were chosen as the non-exercising subjects.

The inclusion criteria for the study were that the participants were females, between 16-24years of age, and they were students at the College of Medicine, University of Lagos. The exclusion criteria for the study were smoking, drinking and the use of any medications.

2.2. Ethical Approval

All subjects were properly briefed about the procedures and purpose of the study and informed consent forms were signed by all willing participants. Samples from participants were not used for any other purpose other than that specified in the proposal. The participants or subjects with high blood pressure and fasting blood glucose levels were advised to seek for medical assistance from health care givers at the Lagos University Teaching Hospital (LUTH). The research procedures adopted in this study were approved by the Health Research Committee of Lagos University Teaching Hospital (ADM/DCST/HREC/VOL.XVI/APP/404) and were in accordance with the international standards in medical research and Helsinki declaration of 1975 as revised in 2013 [5]

2.3 Procedure for exercise administration and data collection

Prior to the day of the study, participants were properly briefed about the study, its significance, data to be collected, and what the data will be used for. Screening was carried on the willing participants using the inclusion and exclusion criteria as highlighted above. They were also asked to fill the questionnaires provided which contained questions on lifestyle and health status. The volunteers that met the requirements were recruited for the final study after they filled an informed consent form. The volunteers were also asked to fast overnight (12 hours) prior to the day of the exercise. On the day of the exercise, the height, weight, blood pressure, and resting heart rate were measured before the exercise. A drop of blood was drawn from the thumb to measure the fasting blood glucose before and after the exercise using ACCU-CHEK Active (Model GC, Roche Diagnostics Gmbh, 68298 Mannheim, Germany). The exercise took place at the Human laboratory of the Department of Physiology at the College of Medicine, University of Lagos. The cycle ergometer was used for the exercise starting with a warm-up session at a speed of 60km/hr for 2 minutes, after which the speed was gradually increased until the speed got to 70 km/hr and was maintained for another 5 minutes.

2.4 Blood pressure, Heart rate and blood glucose measurement

The blood pressure, blood glucose, and the heart-rate parameters were measured before and immediately after the exercise. The blood pressure and the heart-rate values were measured using the standardized OMRON automated blood pressure machine (OMRON M2 Basic (HEM-7116-E8-V), OMRON Healthcare Co., Ltd. The whole fasting blood glucose level was measured with the aid of a pre-calibrated glucometer (ACCU-CHEK Active [Model GC], Roche Diagnostics Gmbh, 68298 Mannheim, Germany). One or two drops of the blood samples obtained from the finger after pricking with a sterile lancet was placed on the luminescence area of the glucometer for reading. Care was taken to clean off the first few drops of blood from the finger with a blotting paper.

2.5 VO_2max and Basal Energy Expenditure (BEE) determination

VO_2max which is the maximum amount of oxygen the body can process to produce energy during maximal exhaustive exercise [6, 7] was calculated according to the theory proposed by Hill and Lupton in 1923 [8], using the formula $VO_2max = 15.3(MHR/RHR)$, where MHR is the maximum heart rate (beats/minute) and RHR is the resting heart rate (beats/minute). Basal Metabolic Rate (BMR) which is synonymous with Basal Energy Expenditure (BEE) in this study was estimated according to Harris Benedict equation [9], Mifflin *et al*., formula [10] and Schofield *et al*., [11].Results using the three above formulae were compared.

2.6 Statistical Analysis

Results were presented as means ± SEM. Data analysis between two study groups was carried out using the independent sample t-test. One-way analysis of variance (ANOVA) was used to compare variables in three groups. Statistical significance was set at $p \leq 0.05$ for the independent sample t-test and ANOVA test. Bar charts were used for graphical illustration.

3.0 Results

There was no significant difference in the anthropometry of the participants in the Ex-Sub and NonEx-Subgroups (Figure 1).Before exercise, the recorded heart rate of the Ex-Sub was significantly lower than the NonEx-Sub(Figure 2). After exercise, the heart rate of the Ex-Sub was still significantly lower than that of the NonEx-Sub. Also in Figure 2, the two groups recorded a decrease in diastolic blood pressure and an increase in the systolic blood pressure.

There was no significant difference between the fasting blood glucose level before and after the exercise in both Ex-Sub and NonEx-Sub. There was also no significant difference between the glucose uptake in the Ex-Sub and the NonEx-Sub within the duration of the exercise in this study. The oxygen consumption and energy demand were significantly higher in the Ex-Sub than in the NonEx-Sub. Both ExSub and NonEx-Sub recorded a significantly lowered SBP after exercise. The systolic blood pressure levels from the Ex-Sub before and after the exercise were significantly lower compared with that of NonEx-Sub. Both Ex-Sub and NonEx-Sub recorded a significant reduction in heart rate after the exercise. The heart rate before and after exercise in Ex-Sub was significantly lower compared to NonEx-Sub. The estimated VO_2max, energy demand and Basal energy expenditure (BEE) were all significantly higher in ExSub compared to NonEx-Sub (Figure 3).

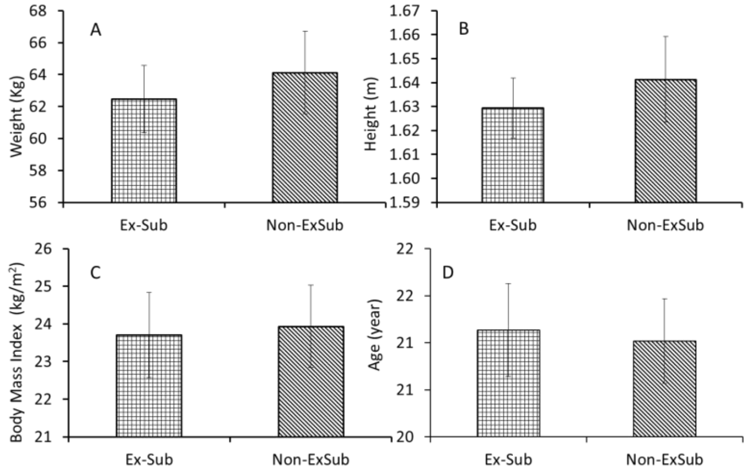

Fig 1: Anthropometry of exercising (Ex-Sub) and non-exercising (Non-ExSub) participants in this study showing body weight, height body mass index and age

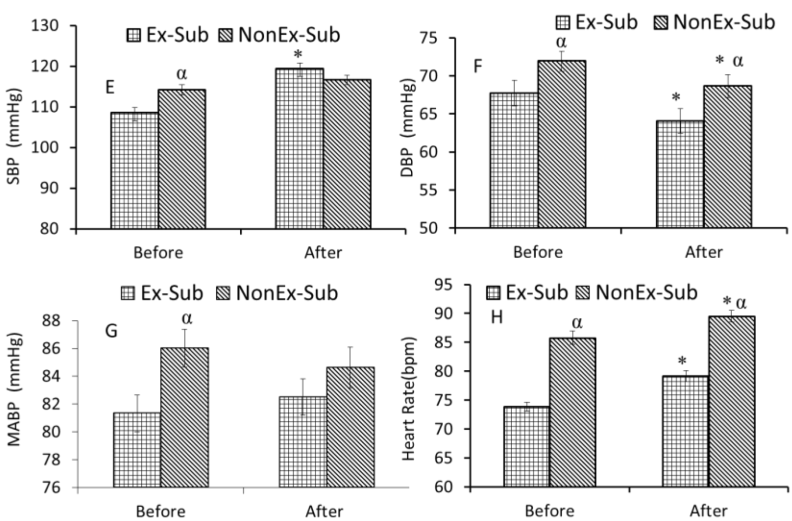

Fig 2: Blood pressure parameters of exercising (Ex-Sub) and non-exercising (Non-ExSub) participants during the exercise regimen. Plate E; Systolic blood pressure (SBP), Plate F; Diastolic blood pressure (DBP), Plate G; Mean arterial blood pressure (MABP), Plate H; Heart rate

* Significantly different compared with before

α Significantly different compared with result from exercising subject (Ex-Sub)

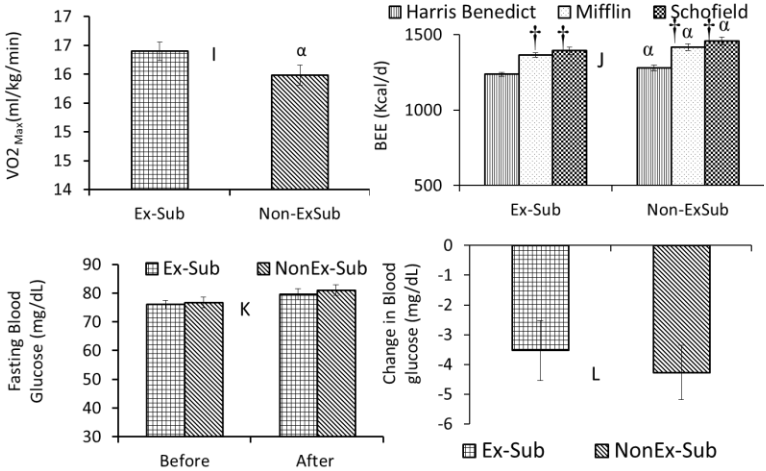

Fig 3: Oxygen consumption (VO_2) (plate I), Basal Energy Expenditure "BEE" (plate J), Fasting M, blood glucose level (plate K) and change in blood glucose (plate L) during the exercise regimen in exercising (Ex-Sub) and non-exercising (Non-ExSub) female volunteers

α; Significantly different compared with result from exercising subject (Ex-Sub).

†; Significantly different when result from Harris Benedict is compared with result from Mifflin equation or Schofield equation.

4.0 Discussion of Findings

Previous studies have shown the advantages that engagement in regular exercise has on blood pressure, mental and physical fitness [2]. However, the processes of measuring energy expenditure for the different types of exercises remain a difficult task. The present study further confirmed that engaging in regular exercise confers some advantages as we recorded a lower blood pressure (SBP, DBP and Heart rate) in participants involved in regular exercise compared with the counterpart on sedentary lifestyle. Physical activity level (PAL) has been graded into sedentary or light activity lifestyle (1.40-1.69), active or moderately active lifestyle (1.70-199) and vigorous or vigorously active lifestyle (2.00-2.40) (13). The recorded basal SBP, DBP and heart rate were significantly lower in Ex-Sub compared with that of NonEx-Sub. Similarly, the reduction recorded in SBP and the HR after the exercise bout in Ex-Sub was significantly lower compared with what was recorded in NonEx-Sub buttressing the reported beneficial effects of regular exercise on blood pressure levels. This result is consistent with the report of Hattiwale *et al.*, [12] on heart rate in individuals involved with regular exercise compared with people with sedentary lifestyles. The lower resting HR in the Ex-Sub has been attributed to an increase in the parasympathetic activity with a minor decrease in sympathetic discharge [13]. Also, changes in the intrinsic mechanisms acting on the sinus node and alterations in the autonomic nervous system control of the heart have been reported to contribute to this recorded phenomenon [14].

Furthermore, the structural modifications to the heart musculature including the left ventricular hypertrophy [15, 16, 17,18], left ventricular end-diastolic volume [19], augmentation of the baroreflex sensitivity in the Ex-Sub [20] and greater capacity of reflex cardiovascular modulation in Ex-Sub [21] than with individuals living sedentary lifestyles have been explained to contribute to the reduced blood pressure and heart rate as recorded in the Ex-Sub. Thus, the results of this study showed that the differences can be validly attributed to differences in the physical activity or aerobic fitness status between the groups and not their physical characteristics as previously recorded by other authors [22].

Both the fasting whole blood glucose level and the amount of glucose uptake during the single bout of exercise carried out by both the Ex-Sub and the NonEx-Sub in this study were not significantly different. Previous reports have also shown that blood glucose level remains unchanged during moderate-intensity exercise of short duration due to an equal rise in hepatic glucose production [23]. Comparing the three methods used in assessing basal energy expenditure showed that the results obtained with the Harris Benedict equation was significantly lowered compared with that of the Mifflin *et al*., [10] and Schofield *et al*., [11] equations. This may have arisen due to the various deficiencies noticed with Harris Benedict and Mifflin equations which were corrected in the Schofield equation. The BMR results obtained with the Schofield equation was within the range adopted by the report of FAO/WHO/UNN expert consultation on Human Energy Requirements [24], which was significantly higher than those obtained using the equations from Harris Benedict [9], Mifflin and others [10].

The basal energy expenditure (BEE) which is the daily energy needed to sustain cell metabolism and associated life processes is known to be positively correlated with body size and composition and is easily predicted from age, sex, and height [9]. Although previous authors have doubted the relationship between exercise and BEE [10], this study has shown that involvement in regular exercise will significantly increase the BEE compared with sedentary lifestyle. It thus appears that apart from the reported antioxidant booster of exercise reported in young female adults [25], regular exercise confers also some form of efficiency on energy utilization with increase in VO_2max and combustion of energy for any given task. The above can thus explain why physical activities the target of behavioural interventional changes have been to tackle the problem of weight gain [26,27].

Furthermore, exercise induced energy deficit or its prevention of positive energy balance during the exercise period and immediately after, depends on its energy cost, its ability to modify post-exercise energy metabolism, and the post-exercise compensation in energy intake [28]. Thus, an increase in oxygen consumption will generate a corresponding increase in energy expenditure as the oxygen consumed is utilized in the production of ATP; the currency of energy as seen in the Ex-Sub in this study. The VO_2max result in this study showed a significantly increased VO_2max in the Ex-Sub compared with the result from the NonEx-Sub corroborated reports of other studies [29]. Other reports have shown that in determining efficiency and performance during sprinting exercise and competition, individuals with higher VO_2max stand a better chance of good performance and winning [30]. Although, VO_2max is not the only predicting factor for performance but exercise trainers and physical fitness experts are always interested in some higher values for athletes because of the importance to energy demand for exercise performance. Similar improvement in VO_2max was recorded in perennial asthma patients taken through two weeks of exercise training compared with those without the training [31].

Conclusions

In conclusion, regular exercise confers some efficiency on energy utilization in exercising female subjects with a corresponding energy output despite no significant difference in glucose uptake compared to individuals living sedentary lifestyles.

Conflict of Interest

The authors declared no conflict of interest.

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