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ENERGY EXPENDITURE OF CONTINUOUS AND INTERMITTENT EXERCISE IN COLLEGE-AGED MALES

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ABSTRACT

Darling JL, Linderman JK, Laubach LL. Energy expenditure of Continuous and Intermittent Exercise in College aged males. ***JEP****online* 2005;8(4):1-8. The primary purpose of this study was to compare energy expenditure during and following exercise for a 30 min continuous bout of running at 70 %VO_2max compared to three 10 min bouts of intermittent running at the same intensity. Twenty fit college-aged males (VO_2max 61.5±7.7 ml/kg/min) volunteered to participate. Energy expenditure was measured with indirect calorimetry at rest, during exercise and during recovery. The 30 min continuous bout of exercise included a 45 min recovery and each of the three10 min bouts included 15 min of recovery. Workload was adjusted during exercise to maintain oxygen consumption at 70 %VO_2max. Our results indicated total energy expenditure during 30 min of intermittent exercise and 45 min of recovery was slightly (15.2 Kcals), but significantly ($P<0.05$) greater than the collective energy expenditure for 30 continuous min of exercise and 45 min of recovery. Exercise alone resulted in 7 Kcal more energy expenditure during continuous exercise than intermittent exercise ($P<0.05$). During three 15 min bouts of recovery from the intermittent exercise, energy expenditure was 22.2 Kcal more than during 45 min of recovery from continuous recovery ($P<0.05$). From a practical standpoint and for purposes of total energy expenditure it is our finding that in young, healthy college-aged males the effects of intermittent bouts of moderate exercise result in the same energy expenditure as continuous exercise at the same intensity.

Key Words: Physical Activity, Accumulated Exercise, EPOC

INTRODUCTION

The present study was designed to estimate energy expenditure during 30 min of either continuous or intermittent treadmill running of moderate intensity, as well as assess energy expenditure during 45 min of recovery. The importance of regular physical activity to reduce risks associated with a sedentary lifestyle is well known. The Report of the Surgeon General (1) indicates that men and women of all ages benefit from a moderate amount of daily activity such as 30 min of brisk walking. Furthermore, it is recommended that every adult accumulate 30 min or more of moderate intensity physical activity on most, if not all, days of the week (1). More recently, it has been suggested that 20-60 min of aerobic activity, 3-5 days/week and at 50-85 % of maximum oxygen uptake reserve can develop or maintain cardiorespiratory fitness (2). An energy expenditure of 2,000 Kcals/week from physical activity has been suggested as the threshold that provides protection against cardiovascular disease (3). Additionally, it is suggested that this volume of exercise is equal in benefit whether it is continuous in nature, or through repeated bouts of intermittent exercise lasting a minimum of 10 min (2).

The effects of multiple short bouts of exercise versus one continuous bout were examined by Jakicic et al. (4) using obese, sedentary females in a randomized controlled trial over a 20 week duration. Exercise participation was self-reported and energy expenditure was estimated from Tri-Trac Accelerometers. Results indicated that there was no significant difference in estimated energy expenditure between the long bout group and short bout group. However, research investigating energy expenditure measured by indirect calorimetry comparing continuous and intermittent exercise is limited (5-11).

Previous work in our laboratory has indicated that energy expenditure from three 10 min bouts of brisk walking (70 %VO_2max) was equivalent to a single 30 min bout of walking at the same intensity (9). Based upon total energy expenditure from activity of this intensity and duration (~275 Kcals) our data indicate that daily intermittent bouts of exercise would provide the energy expenditure indicated to be of benefit to prevent cardiovascular disease (3). However, physical activity not only increases energy expenditure above resting levels during the exercise, but during the recovery period from exercise as well (12).

The mechanism for elevation in post-exercise metabolic rate or EPOC is not completely understood. It is known that metabolic rate rapidly drops for two to five min after exercise and then assumes a more gradual decline towards resting values (12). In addition, energy expenditure has been reported to return to resting values within an hour (13) or remain elevated 6 hrs following exercise (12). Because EPOC may affect the total energy expenditure associated with exercise, it is important to investigate possible differences in EPOC between continuous and intermittent exercise.

Brockman and co-workers (6) indicated that EPOC was significantly greater after a 10 min bout of intermittent high intensity (~90 %VO_2max) running when compared to a continuous bout of running at a more moderate intensity (~80 %VO_2max). At present it is unknown whether intermittent bouts of exercise may affect EPOC differently than the same duration of exercise when intensity is comparable. Therefore, the primary purpose of this study was to compare energy expenditure in a 30 min bout of continuous running at 70% of VO_2max with 45 min of recovery when compared to 30 min of intermittent running equally divided into three10 min bouts with 45 min of recovery equally divided into three 15 min periods. Secondary purposes of this study were to compare energy expenditure in the continuous and intermittent exercise only conditions and the continuous and intermittent recovery only conditions.

METHODS

Subjects

Twenty males 18-25 years of age volunteered to participate in the present investigation. Procedures used in this study were approved by the Institutional Review Board of the University of Dayton, and an informed consent and medical history were obtained from each subject prior to data collection. All subjects with a VO_2max equal to or greater than 43 mL/kg/min (50th percentile for physical fitness according to age and gender) were included in the study (14). Subjects had no apparent risk for cardiovascular disease and/or metabolic disorders.

VO_2max Testing

Subjects whose predicted VO_2max (15) was ≥43 mL/kg/min reported to the laboratory to complete a graded VO_2max test. VO_2max was determined using the following protocol: after a 5 min warm-up subjects selected a running speed ranging from 7-8 mi/hr at a 2 %grade. While speed remained constant, grade was increased 2 % every two min. Testing was terminated if the subject's heart rate did not increase with increased exercise intensity; subject experienced shortness of breath or labored breathing, light-headedness, confusion, nausea, ataxia, pallor, or cold and clammy skin; subject requested to stop; subject reached an RER value equal to or greater than 1.1; subject exhibited physical and verbal manifestations of severe fatigue; and/or testing equipment failed (14). For subsequent testing sessions, subjects were asked to fast overnight and consume no caffeine or alcohol for 24 hr preceding data collection.

Resting Energy Expenditure.

Following measurement of height and weight with an anthropometer and calibrated balance scale, respectively, resting energy expenditure was measured through indirect calorimetry (ParvoMedics TrueMax 2400; Sandy, UT). Subjects sat quietly in a chair for 10 min or until heart rate maintained a plateau for at least five min. This procedure was repeated for each of the continuous and intermittent exercise sessions. As described previously (9), energy expenditure was determined from the caloric equivalent of VO_2 (L/min) utilizing RER averaged every 30 s.

Procedure For The 30 Min Continuous Exercise Bout

After resting energy expenditure was determined, subjects ran at a workload corresponding to 70 %VO_2max. Workload was adjusted during exercise to maintain oxygen consumption representing 70 % VO_2max (6). At the conclusion of the 30 min exercise bout, VO_2 was measured during seated recovery at five min intervals for a period of 45 min.

Procedures For The Three 10 Min Bouts

Following estimation of resting energy expenditure subjects ran for 10 min and recovery VO_2 was measured for 15 min as described above. This protocol was repeated three times the same day, at intervals of no less than 3 hrs. During the intervals between testing subjects maintained normal diet and activity, but refrained from caffeine and alcohol.

Statistical Analyses

The statistical power of the study was set to detect a 50 Kcal difference between the continuous and intermittent running conditions with recovery. Using a paired t-test with $P=0.05$ significance level, 80 % power, and assuming a standard deviation of the difference of 50 Kcal, 19 participants were required. Differences in energy expenditure between continuous and intermittent exercise, recovery from exercise, as well as the combination of exercise and recovery were assessed with a paired t-test. Significance was set a $P<0.05$.

RESULTS

Subjects

The male participants (n=20) were 21±2 years of age, with a VO_2max of 61.5±7.7 mL/kg/min (Table 1).

Table 1. Descriptive characteristics of the subjects.

Variables	*Mean±SD*	*Range*
Age (yr)	21±2	18 - 25
Weight (kg)	73.2±8.7	58 - 90.5
Height (cm)	178.3±6.7	166 - 193
Body mass index (kg/m^2)	23±2.5	19 - 28
VO_2 (L/min)	4.5±0.7	2.69 - 6.54
VO_2 (ml/kg/min)	61.5±7.7	43 - 71

Continuous Exercise

During continuous exercise VO_2 increased from 0.36 L/min at rest to 3.1 L/min at the start of exercise. Subjects' VO_2 averaged approximately 3.2 L/min for the 30 min run. At five min post-exercise VO_2 dropped rapidly to 0.44 L/min and began a gradual decline for the remainder of the 40 min recovery period. Subjects' VO_2 at the last minute of recovery averaged 0.3 L/min (Figure 1).

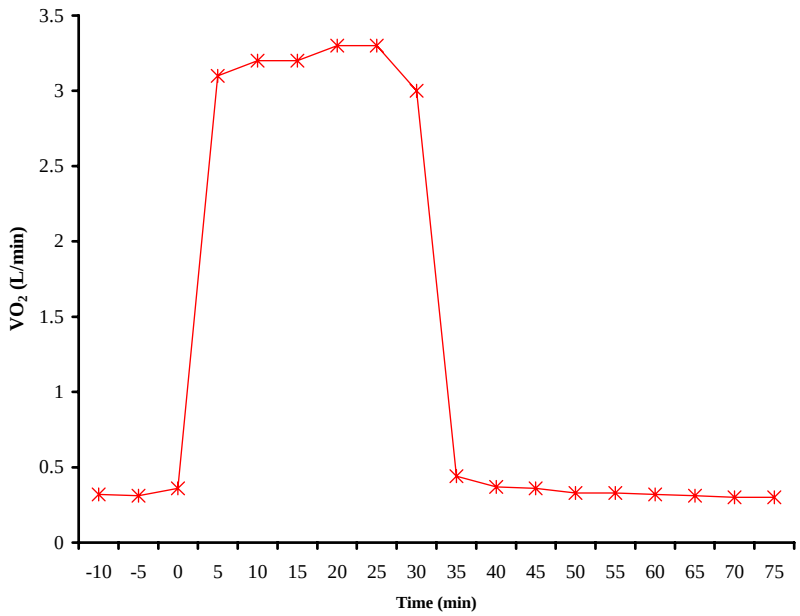

Figure 1. Mean data for oxygen consumption (L/min) for continuous exercise during rest, exercise, and 45 min of recovery. Error bars have been eliminated for clarity.

Intermittent Exercise

During intermittent bouts of exercise VO_2 increased from 0.35 L/min at rest to 3.2 L/min at steady state. Subjects' VO_2 averaged approximately 3.2 L/min during each of the 10 min runs. At five min post exercise VO_2 dropped rapidly to 0.4 L/min and began a more gradual decline to 0.33 L/min for the remainder of the 15 min recovery period (Figure 2). The time course of the relationship between VO_2 and recovery from exercise was the same for continuous and intermittent exercise (Figure 3).

Energy Expenditure

Energy expenditure (mean ± SD) during continuous and intermittent exercise, including rest and recovery is illustrated in Figure 4. Subjects expended more energy during 30 min of continuous exercise than during 30 min three 10-min runs (469±67 vs. 462±67 Kcal, continuous vs. intermittent, respectively, P>0.05). During recovery from exercise subjects expended more energy following intermittent exercise, than following continuous exercise (105±13 vs. 83±9 Kcal, intermittent vs. continuous, respectively, P>0.05). The total energy expenditure for the combination of exercise and recovery was significantly greater with intermittent bouts of exercise (567±72 vs. 551±80 kcal, intermittent vs. continuous, respectively, P>0.05).

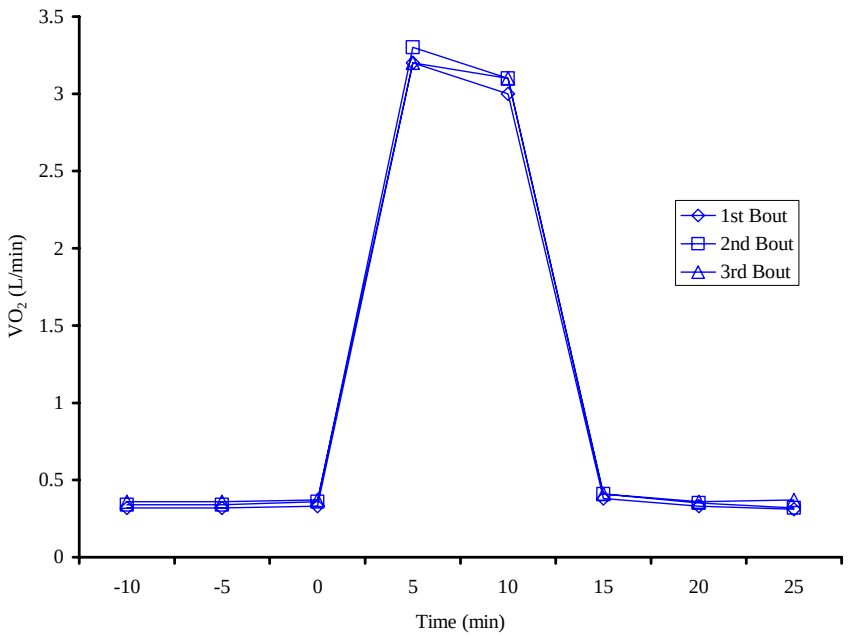

Figure 2. Oxygen consumption (L/min) for intermittent exercise at rest, exercise and 15 min of recovery. Values are means. Standard error bars have been eliminated for clarity.

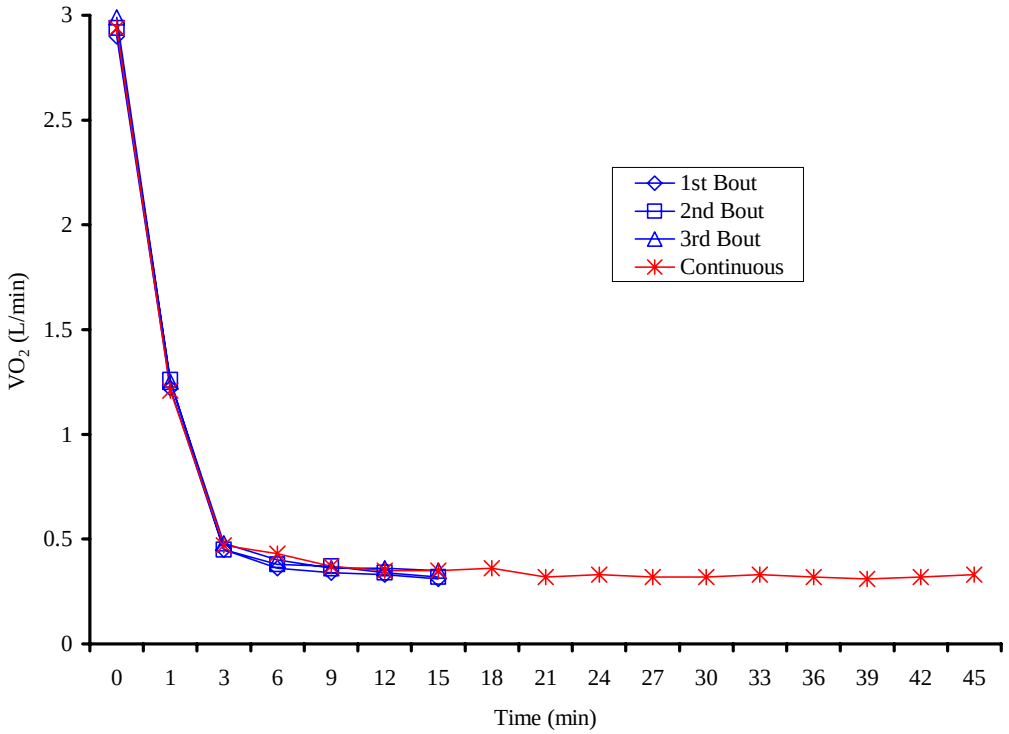

Figure 3. Oxygen consumption (L/min) following exercise for continuous and intermittent conditions. Values are means. Standard error bars have been eliminated for clarity.

DISCUSSION

The primary purpose of this investigation was to assess total energy expenditure from exercise as well as EPOC during a single bout of moderate intensity exercise (70 %VO_2max), when compared to the same duration of exercise equally divided into three 10 min bouts throughout the day. Recent indications suggest that accumulated exercise to be equally beneficial for cardiovascular health as continuous exercise (1,2). However, given the importance of weekly energy expenditure on cardiovascular health (3), it is important to understand whether intermittent bouts of exercise have the same effect on total energy expenditure when including recovery from exercise.

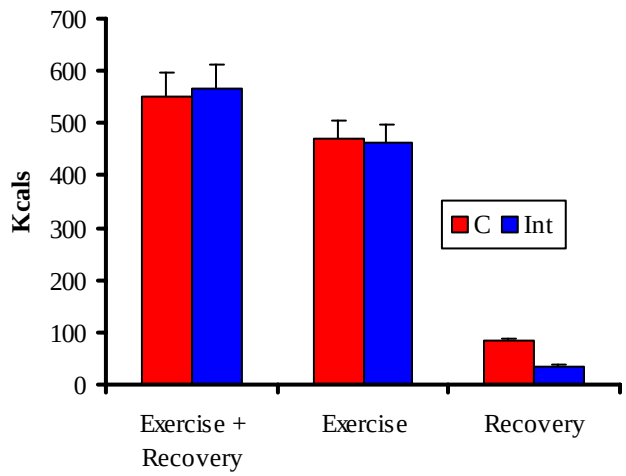

Figure 4. Energy expenditure (Kcals) during continuous (C) and intermittent (Int) exercise conditions. Values are mean ± SD. ; P < 0.05 exercise + recovery; P > 0.05, exercise only; P < 0.05 recovery only.

Estimated energy expenditure using accelerometers indicates that energy expenditure during 30 min of brisk continuous walking to be significantly greater than energy expenditure during intermittent walking conditions (8). Fulton et al. (8) reported that energy expenditure for 30 min bouts of walking to be ~14 Kcal higher than three 10 min bouts of walking in 30 female subjects ~44 years of age. Similarly, the present study indicates a small (~7 Kcals) but significantly greater energy expenditure from continuous exercise (Figure 4). Previous research from our laboratory compared 30 min of continuous and intermittent exercise in unfit males ~44 years of age (9). These results indicate that 30 continuous min and three 10 min walking bouts at the same intensity level (70 %VO_2max) resulted in identical exercise energy expenditures using indirect calorimetry. Collectively, past and present research indicates that energy expenditure for 30 min of exercise was very similar between a continuous bout of exercise and an accumulation of intermittent bouts of exercise. This similarity in exercising energy expenditure was consistent across a fairly broad range of age, gender, and fitness levels. However, intermittent exercise has been shown to increase energy expenditure during recovery from exercise, which may increase total energy expenditure associated with exercise (6,16)

In the present investigation, energy expenditure during recovery was ~22 Kcals higher during three 15 min periods of measurement, when compared to one 45 min period of measurement (Figure 4). In addition, our data indicate that subjects had recovered to resting levels of energy expenditure within ~15 min of cessation of continuous exercise (Figure 1) and ~10 minutes following cessation of intermittent exercise (Figure 2), indicating no additional EPOC beyond these time periods. In the present investigation the difference in post-exercise energy expenditure at the point where VO_2 returned to resting levels was ~25 kcals greater for the three bouts of intermittent exercise, when compared to continuous exercise. Therefore, the difference in post-exercise energy expenditure remains similar whether calculated as a return to resting levels or measured for an equivalent period of time. In a similar investigation Almuzaini and co-workers (16) measured EPOC after one 30 min bout of exercise at 70 %VO_2max and after two 15 min bouts of exercise at the same intensity in young males ~23 years of age. During 40 min of recovery from exercise these investigators reported energy expenditure to be ~11 Kcals greater following intermittent exercise. Following more prolonged

bouts of exercise (13) or more intense exercise (6) EPOC has been reported to be much higher than in the present investigation. However the present investigation, as well as other similar investigations (8,9,16) have been designed to investigate exercise intensity and duration that is consistent with the recommendations put forth by the U.S. Surgeon General (1).

Collectively past and present results from our laboratory as well as other similar investigations indicate that intermittent bouts of moderate exercise result in the same energy expenditure as continuous exercise in young apparently healthy individuals (16) as well as middle aged men and women (7,9). The small but statistically significant increase in energy expenditure during recovery from three exercise bouts is consistent with previous investigations (16) but may be of little practical significance with respect to total energy expenditure associated with exercise. However, Jakicic et al. (4) investigated whether prescribing exercise in short-bouts versus one long-bout per day would enhance exercise adherence and weight loss in overweight adult females. These authors indicate that short-bouts of exercise may enhance exercise adherence by increasing total bouts of exercise as well as total min involved in exercise over many weeks. Therefore, although past and present investigations indicate that energy expenditure is similar between short-bouts of exercise and one long-bout of exercise, it is possible that shorter bouts of exercise may be more beneficial from a practical approach to weight control or weight loss if an individual engages in more total min of exercise throughout many weeks or months.

In the present investigation we did not control for diet in either exercise condition. Participants were asked to refrain from eating or drinking before attending the morning exercise sessions, and to refrain from alcohol and caffeine ingestion throughout the day during measurement of the three 10 min bouts of exercise. However, neither resting VO_2 (Figures 1 and 2), nor the recovery kinetics of VO_2 (Figure 4) were markedly different between continuous and intermittent exercise. Therefore, in healthy young males the lack of further dietary restrictions would likely not have affected exercising VO_2 or EPOC, nor the estimates of energy expenditure derived from these values.

CONCLUSIONS

In summary, the college-aged men who participated in this study expended more energy during intermittent running and recovery than during continuous running and recovery. However, this difference of 15 Kcal ($P<0.05$) may be of little or no consequence to the exercise practitioner. It appears that for healthy college aged males 30 min of moderate exercise, whether in a single bout or accumulated, has an equivalent effect on energy expenditure. Future investigators are needed to assess whether accumulate bouts of moderate exercise has a similar effect in sedentary or obese populations of men and women.

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REFERENCES

1. U.S. Department of Health and Human Services. **Physical Activity and Health: A Report of the Surgeon General**. Atlanta, GA: U.S. Department of Health and Human Services. Centers for Disease and Control and Prevention. Natl Center for Chronic Disease Prevention and Health Promotion, S/N no. 017-023-00196-5, 1996.
2. American College of Sports Medicine. Position Stand: the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. ***Med Sci Sports Exerc*** 1998;30:975-991.
3. American Heart Association Medical Scientific Statements. Statement on Exercise: Benefits and recommendations for physical activity programs for all Americans. ***Circulation*** 1992;86:340.
4. Jakicic, J. M., R. R. Wing, B. A. Butler, and R. J. Robertson. Prescribing exercise in multiple short bouts versus one continuous bout: Effects on adherence, cardiorespiratory fitness, and weight loss in overweight women. ***Int J Obes*** 1995;19:893-901.
5. Blair, S. N., and J. C. Connelly. How much physical activity should we do? The case for moderate amounts and intensities of physical activity. ***Res Q Exerc Sport*** 1996;67:193-205.
6. Brockman, L., K. Berg, and R. Latin. Oxygen uptake during recovery from intense intermittent running and prolonged walking. ***J Sports Med Phys Fitness*** 1993;33:330-336.
7. Fulton, J. E., L. C. Masse, and C. J. Caspersen. Response: how big is big? Only time will tell (Letter). ***Med Sci Sports Exerc*** 2001;33:1061.
8. Fulton, J. E., L. C. Masse, S. R. Tortolero, et al. Field evaluation of energy expenditure from continuous and intermittent walking in women. ***Med Sci Sports Exerc*** 2001;33:163-170.
9. Peterson, M.J., D.R. Palmer, and L.L. Laubach. Comparison of caloric expernditure in intermittent and continuous walking bouts. ***J Strength Cond Res*** 2004;18:373-376.
10. Thomas, D. Q., H. L. Lewis, S. T. McCaw, and M. J. Adams. The effects of continuous and discontinuous walking on physiologic response in college-age subjects. ***J Strength Cond Res*** 2001, 15:264-265.
11. Wood, R. H., and M. A. Welsch. Energy expenditure study makes erroneous inferences and recommendation (Letter). ***Med Sci Sports Exerc*** 2001;33:1060-1061.
12. Brehm, B. A. and B. Gutin. Recovery energy expenditure for steady state exercise in runners and nonexercisers. ***Med Sci Sports Exerc*** 1986;18:205-210.
13. Quinn, T. J., N. B. Vroman, and R. Kertzer. Postexercise oxygen consumption in trained females: Effect of exercise duration. ***Med Sci Sports Exerc*** 1994;26:908-913.
14. American College of Sports Medicine. **ACSM's Guidelines for Exercise Testing and Prescription**, 6th Ed. Philadelphia: Lippincott Williams & Wilkins, 2000.
15. Ebbeling, C. B., A. Ward, E. M. Puleo, J. Widrick and J. M. Rippe. Development of a single-stage submaximal treadmill walking test. ***Med Sci Sports Exerc*** 1991;23:966-973.
16. Almuzaini, K. S., J. A. Potteiger, and S. B. Green. Effects of split exercise sessions on excess postexercise oxygen consumption and resting metabolic rate. ***Can J Appl Physiol*** 1998;23:433-443.