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CALORIC COST OF MARTIAL ARTS TRAINING IN NOVICE PARTICIPANTS

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ABSTRACT

CALORIC COST OF MARTIAL ARTS TRAINING IN NOVICE PARTICIPANTS **Stephen C. Glass, Elizabeth A. Reeg, Jill L. Bierma**. **JEPonline**. 2002;5(4):29-34. To date no literature exists that accurately quantifies the caloric cost and cardiovascular strain of typical martial arts training drills. The purpose of this study was to examine the caloric cost of martial arts training in novice participants. Eighteen novice martial artists (9 men, 9 women age=19.7±1.9 yrs, Ht =174.8±11.1 cm, Mass=74.6±18.6 kg, Resting HR=79.9±10.3 beats/min, Resting SBP=120.8±11.8 mmHg, Resting DBP=76.3±8.4 mmHg, % fat=23.1±8.8) were given instructions as to proper technique for basic kicking and arm strike techniques. Subjects then completed 2 exercise bouts consisting of: 1. front kicks 2. butterfly stretch 3. forearm strikes 4. sit-ups 5. side-kicks 6. quadriceps stretch and 7. push-ups. Total time for the martial art activity was 7.6±0.9 min. All strikes were against a large padded target. Subjects were asked to pace themselves. During the activities subjects' VO_2, RER, VE as well as telemetry heart rate were measured. Results indicated substantial cardiopulmonary strain (HR=157.4±18.9 beats/min, % Max HR=78.5±9.2, VE=55.2±24.4 L/min, RER=1.1±0.1) as well as energy expenditure (mean VO_2=1.67±0.7 L/min; 8.1±3.5 Kcals/min). However there were large variations in caloric expenditure, indicating that martial arts provides a unique opportunity for both fit and unfit individuals to participate, while clients can self select the training intensity.

Key Words: Energy Expenditure, Martial Arts, Aerobic Exercise, Oxygen Uptake, Taekwondo

INTRODUCTION

Energy expenditure for the purpose of weight loss and cardiovascular health is best achieved by exercise that can be performed regularly, provides enjoyment, and also offers an enhanced quality of life. Health fitness facilities continually offer a variety of activities in order to provide new experiences for their clients. One of the more popular activities in recent years is the use of martial arts for fitness and health improvement. Training regimens that either train the client in traditional martial arts, or a combination of aerobic dance and martial arts training offer a unique combination of activities. Non-competitive, "Cardiokick" styles emphasize punching,

kicking pads as well as stretching and calisthenics. This form of training offers a variety of movement activities, skill development, and the potential for cardiovascular training.

Martial arts training has been a part of eastern society for thousands of years, while it has only been introduced to the United States in the last 60 years. Research related to martial arts training has shown a positive influence on anger suppression (4) as well as self-confidence and energy (17,20). Research related to martial arts training as a source of physical fitness improvement has only recently begun. Martial arts training can generally be broken into three parts. First is the basic training of callisthenic exercise, mixed with kicking and punching drills. Often a large pad is used to provide a target and reduce injury. Second, a pre-arranged sequence of movements called Kata (Japanese) or Poomse (Korean) are used to train the practitioner for balance, coordination, weight transfer and focus. These formal pattern movements generally last under one minute, with most completed in less than 30 s. Finally, practitioners are put into active sparring situations lasting 2-3 min in duration. These are high intensity, all out efforts.

Research in martial arts training and energy expenditure has focused primarily on the energy cost of performing Kata repeatedly. Zehr and Sale (24) examined the energy expenditure of 4 male black belt qualified subjects who completed the Seisan kata repeatedly for 10 min. The pace was varied from slow to fast. Their results showed that the Kata practice induced a relative intensity of 73-94% of their cycle ergometer VO_2max. Other studies have demonstrated heart rates between 113 and 184 beats/min for different Kata exercises and a caloric expenditure between 5 and 14.5 Kcals/min (3,7,9,19,21,23,24).

More recently, research has focused on training activities beyond Katas and Poomse. Pieter et al. (18) compared the cardiovascular responses of recreational practitioners performing taekwondo forms to more dynamic technique combinations. Subjects completed basic beginner patterns 15 times repeatedly with 45 s rest in between. They also completed two striking combinations (1. kicking only, 2. kicking and punching). Their results showed no differences in heart rate between the two forms (159 vs 158 beats/min), while the technique combinations elicited a significantly higher heart rate (Tech. 1 182.5 beats/min; Tech 2. 180.8 beats/min). Energy expenditure during non-contact boxing was examined by Bellinger et al. (2). Boxers expended an average of 11.2 Kcal/min and had a mean heart rate of 147 beats/min during a 50 min exercise bout. Imamura et al. (12,13) examined the differences in cardiovascular and metabolic responses bouts of repeated strikes (punches and kicks) as well as 2 min sparring matches. Their results showed that this type of dynamic martial arts training elicited a cardiac intensity between 66 and 70% of maximal heart rate during kicking and 53-58% during punching. Caloric expenditure averaged 8.1 Kcals/min. Blood lactate values did not exceed 2.5mmol/L, indicating a predominately aerobic exercise (12). Two min bouts of sparring elicited a near maximal effort throughout the trial, with subjects achieving 97% of heart rate max and an RPE of 19 (13).

Previous research has focused on the metabolic and cardiovascular response to specific training in martial arts. However, in the typical training of novice practitioners, repeated Katas are not performed as a form of aerobic training, and sparring is often held for students of higher ranking. Given the interest in martial arts and martial art-style training regimens, it is important to understand the typical response of novice practitioners to a training session. Typical training sessions include callisthenic exercise (pushups, sit-ups), striking drills, and stretching. Thus the cardiovascular and metabolic demand during a typical session may vary greatly. Whether a novice can expend adequate calories to benefit from training is not presently known. The purpose of this study was to determine the energy cost and cardiovascular responses to a typical sequence of martial arts training.

METHODS

Subjects

Eighteen non-martial arts trained individuals (9 men, 9 women) were recruited from the College population. Subjects were provided written instructions regarding the test procedures and provided signed consent in

accordance with the College's policy on testing human subjects. Subjects were asked to report to the laboratory on two separate occasions to complete the initial testing and orientation, followed by the activity testing.

Initial Testing and Orientation

Initial testing consisted of subjects' completion of a health history questionnaire, baseline physical testing, and technique orientation. Height and weight of subjects were measured using a Stadiometer (nearest cm) and a Health-o-meter scale (nearest 0.01 kg), respectively. Body density was determined from skinfolds (Lange calipers) using the three-site Jackson and Pollock equations for men and women (14,15). Body fat was calculated using the Siri equation (22). Resting blood pressure was measured with the subject seated using a standard stethoscope and sphygmomanometer and resting heart rate was measured by manual palpitation of the radial artery. Following the resting evaluation subjects were given instructions as to proper technique for basic kicking and arm strike techniques by an experienced black belt Tae Kwon Do instructor. Subjects practiced each leg and arm technique by striking a padded target. Technique orientation lasted 15-20 min.

Activity Testing

Subjects reported to the lab a minimum of 4 hours post prandial and were prepared for physiologic monitoring. Subjects were fitted with a telemetry heart rate monitor (Polar Electro Inc.) as well as a ventilatory mask (Vacumed) connected to a one-way breathing valve (Hans Rudolf). Oxygen uptake (VO_2) as well as VE and RER were measured and recorded every 15s using a Quinton Q-plex metabolic cart. The system was calibrated with known standards prior to each test.

Prior to beginning the activity session subjects warmed up by cycling on a stationary cycle ergometer (Monark) for 3-5 min. Immediately following the warm-up subjects began the martial art activity sequence. An investigator timed each activity and provided instruction regarding what was to be completed. Another investigator held tubing connecting the subject to the metabolic cart to ensure freedom of movement. All strikes were against a large padded target to minimize the possibility of injury and to allow solid contact.

Table 1. Training Sequence

Sequence	*Activity*
1	12 front kicks (each leg) against a pad
2	30s butterfly stretch
3	12 forearm strikes (each arm) against a pad
4	30s crunch sit-ups
5	12 rear leg sidekicks (each leg) against a pad
6	15s quadriceps stretch
7	30s pushups

subjects completed two cycles – see text

The martial arts technique sequences are shown in Table 1. Subjects completed the entire exercise bout two times (mean time = 7.6±0.9 min.). The intent of the sequence was to simulate the work-rest activities typically found in a martial arts class. Subjects were asked to pace themselves, yet make solid contact. Following the drills subjects were allowed to cool down on the cycle or by walking.

Table 2. Subject Characteristics (9 men, 9 women)

Variable	*Men*	*Women*
Age (yrs)	19.3±2.1	20.0±1.7
Height (cm)	182.9±7.4*	166.8±7.9
Mass (kg)	83.7±13.2*	65.6±19.3
Rest Heart Rate (b/min)	79.8±10.1	80.0±11.1
Rest Systolic Blood Pressure (mmHg)	123.2±2.9	118.4±16.5
Rest Diastolic Blood Pressure (mmHg)	80.4±3.0*	72.2±10.1
% Body Fat	27.3±8.9*	18.8±6.6

* = men significantly different from women ($p<0.05$)

Data Analyses

Since total caloric expenditure was the variable of interest, mean±SD data were computed across both exercise bouts for each variable. Total calories were computed using indirect calorimetry and the non-protein RER table (6). Since the exercise bouts consisted of non-steady state activity where RER frequently exceeded 1.0, a standard value of 5 Kcals/ L O_2 was used to

compute caloric expenditure. Differences between men and women were tested using independent means t-tests. Significance was set at $p<0.05$.

RESULTS

Subject characteristics comparisons between men and women are shown in Table 2. Men were taller, heavier and carried a significantly higher amount of body fat than women. In fact, mean percent body fat for the men placed them in the tenth percentile for body fat, while the women placed in the 70th percentile (1). Men also displayed significantly higher resting diastolic blood pressure as compared to women.

Table 3. Mean Data for Martial Art Activity

Variable	*Men*	*Women*
Heart Rate (beats/min)	160.0±14.7	154.8±22.9
% Maximal Heart Rate	79.7±7.3	77.3±11.1
VO_2 (L/min)	1.99±0.7	1.30±0.70
METS	6.6±1.6	6.0±3.0
RER	1.10±0.07	1.05±0.11
VE (L/min)	67.1±24.5*	43.3±8.5
Kcals/min	10.2±3.4*	6.0±2.1
Total Kcals	78.5±28.9*	43.4±15.8
Test Time (min)	7.8±0.8	7.3±1.0

*= men significantly different from women ($p<0.05$)

Mean exercise data for the martial art activity are presented in Table 3. Both groups exceeded 75% of their age predicted maximal heart rate for the exercise bouts. Both groups also exceeded 6 METS of intensity and an RER of 1.0. Men expended significantly greater kilocalories per minute as well as total caloric expenditure for the bout. Men also had a significantly greater ventilatory response to exercise.

A representative subject was chosen to demonstrate the typical changes in energy expenditure (Figure 1) and heart rate (Figure 2) across the exercise bout. Total caloric expenditure for men ranged from 31.5 Kcals to 115.3, while for women the range was 18.0 to 61.1 Kcals. Mean percent maximal heart rate for men ranged from 64.4% to 86.1%, while for women the range was 65.0% to 93.5%. All subjects completed the exercise bouts without any ill effects or undue fatigue.

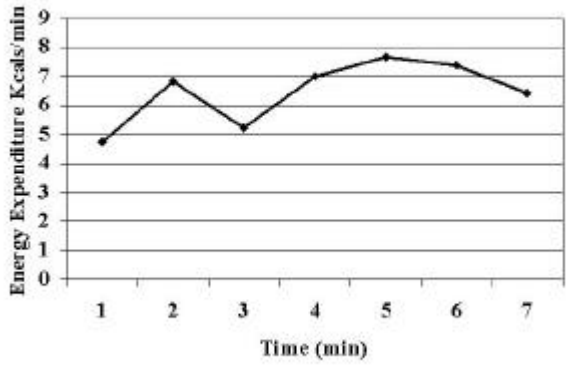

Figure 1: Caloric expenditure example across both exercise bouts in a representative subject.
Subject #15: Female, age=21, Height=172.7 cm, Weight=65.5 kg, % Fat=22.2

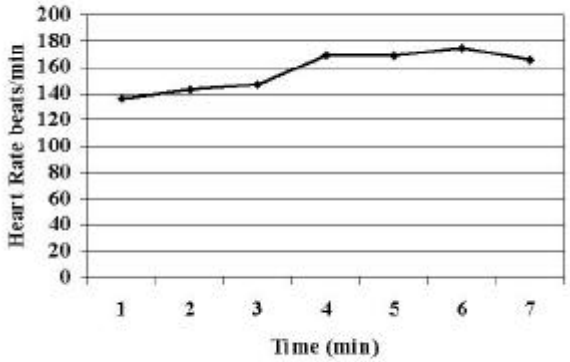

Figure 2: Heart rate response across both exercise bouts for subject #15 to the martial arts training sequences. 75% age predicted max HR=150 beats/min; 85% age predicted max HR=170 beats/min.

DISCUSSION

Martial arts and modern aerobic dance kickboxing are popular throughout the world. Advantages to this form of training include the improvement of balance, coordination, muscular endurance and cardiovascular fitness. The data from the present study show that novice individuals performing a combination of martial arts drill activity and callisthenic exercises are able to exercise at an intensity exceeding 6 METS. This can result in significant caloric expenditure, and subsequently is an effective adjunct to other calorie expending exercises. In fact, the average MET expenditure for the martial arts activity was equivalent to activities such as wrestling, fencing, boxing, bicycling at 10-11.9 mi/hr, aerobics and selected walk/job intensities (10).

By its very nature, martial arts is a discontinuous type exercise. This means that the exerciser must often engage in fairly intense levels of exercise, followed by periods of reduced activity or rest. The work intervals are typically brief (i.e. 30-60 s exercise followed by 30-60 s reduced activity), so that a reasonably consistent level of metabolic intensity can be maintained. Subjects in the present study completed a common sequence of martial arts activity, including punching, kicking, calisthenics, and stretching exercises. These novice subjects were able to expend between 2.3 and 14.1 Kcals/min, with a mean of 8.1 Kcals/min. Given a typical martial arts class of 60 min in duration, these subjects could expend an average of 480 Kcals/session, far exceeding the goal of 300 Kcals/session set by the American College of Sports Medicine (1).

Mean RER for the exercise session averaged 1.07, with 16 of the 20 subjects exceeding 1.0. This is not unexpected due to the interval type nature of the training. Bellinger et al. (2) showed that during a 60 min boxing session RER frequently exceeded 1.0. Subject self-regulation during martial arts activity may ultimately be a combination of cardiovascular endurance, as well as their ability to recover from short term, high intensity activity. While blood lactate was not measured in the present study, previous studies have shown blood lactate values up to 3.0 mmol/L (2,7,11). As subjects improve their recovery ability, they will be able to increase their training intensity during the punching and kicking activity, and thus provide a more strenuous cardiovascular and calorie expending workout. Research has shown that individuals are capable of self-selecting appropriate training intensities for inducing adequate cardiovascular conditioning (5,8). The subjects in the present study were not evaluated for aerobic capacity, but the wide range of total kilocalories expended in a single session for men (31-115 Kcals) and women (18-61 Kcals) indicate large differences in effort. Thus martial arts training provides an excellent training activity for a wide range of fitness levels. As individuals become more fit, they will naturally adjust their training intensity to maintain the conditioning benefits of the activity.

In conclusion, the present study demonstrated the effectiveness of a simulated martial arts exercise regimen for caloric expenditure and cardiovascular conditioning. The nature of martial arts training is interval, but self-regulation of intensity is possible, thus both fit and unfit individuals can benefit from this form of exercise. Martial arts training is of sufficient intensity for many individuals to expend the 300 Kcals/session, as recommended by the American College of Sports Medicine.

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