Tabata Interval Exercise: Energy Expenditure and Post-Exercise Responses

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Abstract

PURPOSE: Tabata training, named for its developer Dr. Izumi Tabata who studied this form of conditioning at the National Institute of Fitness and Sports in Tokyo, involves a movement or modality such as squat jumps, stair running or cycling done for 20 seconds at max effort with 10 seconds rest for 8 total cycles. The Tabata researches found that this protocol produced significant improves in $VO_{2\ max}$ following a period of training. However, no published data are available regarding the energy cost of the Tabata method. The purpose of this study was to measure the energy cost of a Tabata protocol and determine the energy expenditure following a Tabata bout.
METHODS: 15 participants, 12 women and 3 men (mean age, 24.9 yr) who were physically active or involved in university athletics participated in the study and provided informed consent. The study protocol was as follows: Pre-exercise VO_2 was measured for 30 minutes (Parvomedics metabolic system) while the subjects rested in a supine position on an athletic training table. Subjects then completed a Tabata bout executing 8 cycles of body-weight squat jumps with max effort while being measured continuously for VO_2. Following exercise, the subjects' VO_2 was further recorded as per the pre-exercise conditions.
RESULTS: Mean pre-exercise VO_2 was 3.7 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$. For the Tabata bout VO_2 was 38.4 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ with an average peak VO_2 of 48.2 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ during various 20 second max effort periods. Mean peak RER recovery values were 1.54. At 10, 20 and 30 minutes post-exercise, mean VO_2 was 12.5, 6.4 and 4.1 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$, respectively. All time-ordered post-exercise VO_2 values were significantly higher than pre-exercise (ANOVA, p. 0.05). Using the 5 $kcal{\cdot}min^{-1}$ equivalent for every 1 L of O_2 consumed, kcal cost for the Tabata protocol was 13.4 $kcal^{-1}min^{-1}$ (standardized to 70 kg wt). Additionally, the kcal expenditure incurred 30 minutes post exercise was double that for the 30 minute pre-exercise period: 80.5 kcals versus 39 kcals, respectively.
CONCLUSIONS: This data shows that a bout of Tabata exercise using body-weight squat jumps produced a marked VO_2 equivalent to 11.0 METs and a VO_2 that had not fallen to pre-exercise 30 minutes post exercise. Thus, the intensity of Tabata's appears viable as an interval training method particularly for athletes and the higher-fit.

Introduction

Various forms of interval training, sometimes referred to as high intensity interval training or HIIT, have become increasingly popular in both athletic conditioning and mainstream fitness arenas. Traditional HIIT protocols are generally comprised of "Effort" and "Recovery" ratios such as 1:3 where 15 seconds of all-out supramaximal exercise effort is followed by a recovery or rest interval three times the length of the effort period such as 45 seconds. Common HIIT modalities, particularly in athletic conditioning include running and sprinting, cycle ergometry and plyometrics.

In contrast, Dr. Izumi Tabata from the National Institute of Fitness and Sports in Tokyo, studied an "Effort-Recovery" protocol using cycle ergometers comprised of 20 seconds supramaximal effort (i.e. 170% of VO_{2max}) followed by 10 seconds of recovery. This form of interval training was found to elicit significant improvements in VO_{2max} which were comparable to substantially longer training durations of steady-state sub-maximal exercise.

However, little is know about the energy cost of Tabata interval training including post-exercise oxygen uptake responses. Therefore, the purpose of this study was to measure the energy cost of the Tabata format using body weight squat jumps at an al-out effort and to also measure post exercise oxygen uptake responses for comparison to resting oxygen uptake.

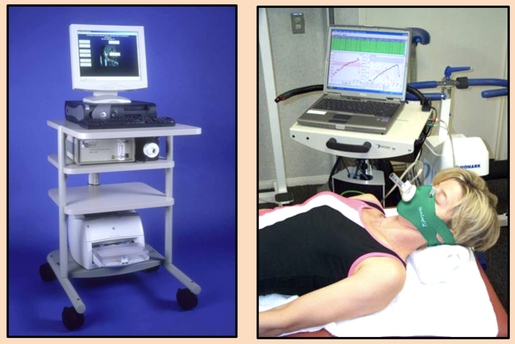
Methods

The subjects were 15 physically active women (n = 12) and men (n = 3) with a mean age, 24.9 yr. After receiving a detailed explanation of the investigation, the study participants were screened for health history and provided informed consent as prescribed by the American College of Sports Medicine and the Institutional Review Board for Human Subject Research at Auburn University Montgomery. During the experimental trials, the subjects reported to the exercise laboratory and were measured for height and weight. Height was measured to the nearest 0.5 cm and weight to the nearest 0.01 kg.

All of the subjects were instructed on the squat jump Tabata protocol and allowed to practice in the days preceding the trails when oxygen consumption was measured. A Parvomedics True-One open-circuit spirometry gas analysis system was used to determined oxygen uptake and the respiratory exchange ratio (RER). The gas analyzers were calibrated prior to each test with gases verified by gas chromatography.

The oxygen uptake protocol was comprised of three stages:
Pre-exercise VO_2 was measured for 30 minutes while the subjects rested in a supine position on an athletic training table. Subjects then completed a Tabata bout executing 8 cycles of body-weight squat jumps with maximal (all-out) effort while being measured continuously for VO_2. Following exercise, the subjects' VO_2 was further recorded as (per the pre-exercise conditions) for 30 minutes.

Parvomedics Metabolic Cart – Pre Exercise Oxygen Consumption



Body Weight "TABATA" Squat Jumps

Statistical Analysis

Means were calculated for each of the descriptive variables (see Table 1). Time-ordered VO_2 responses were compared with an ANOVA (p. 0.05) to detect any differences between pre, exercise, and post-exercise values. In addition, kilo-calorie expenditure was determined via a 5 $kcal{\cdot}min^{-1}$ equivalent for every 1 L of O_2 consumed and is further reported based on a standardized body weight of 70 kg.

Table 1. Descriptive Characteristics of Subjects (mean)

Variable	15 Subjects
Age (yr)	24.9
Height (cm)	168.2
Weight (kg)	67.3

Results

All study participants completed the data collection trials successfully with no adverse events. The mean energy cost values ranged from 3.7 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ during the 30 minute pre-exercise period to peak value of 48.2 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ during the Tabata protocol (see Table 2). At 30 minutes post exercise, the mean VO_2 was 4.1 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ which was (still) significantly higher than the pre-exercise VO_2. The mean peak RER value measured during the early post-exercise period was 1.54.

Table 3 shows the caloric expenditure values. The mean per-minute energy cost was notably high at 13.4 $kcal^{-1}{\cdot}min^{-1}$. Thus, the total energy cost of the 4-minute "Tabata" bout was approximately 54 kcals. Further, the total energy expended during the 30 minute recovery was twice that of the energy expended during the 30 minute pre-exercise period yielding a gross energy cost of 134.1 kcals.

Table 2. Time-Ordered VO_2 Values (mean)*

Pre-Exercise VO_2	3.7 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$
Tabata VO_2	38.4 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$
Peak Tabata VO_2	48.2 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$
Post-Exercise VO_2 10 min.	12.5 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$
Post-Exercise VO_2 20 min.	6.4 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$
Post-Exercise VO_2 30 min.	4.1 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$

**All VO_2 values significantly greater than pre-exercise VO_2 (p. 0.05)*

Table 3. Kilocalorie Expenditure (mean)*

Pre-Exercise - 30 minutes	39.0 $kcal^{-1}$
Tabata Exercise - per minute	13.4 $kcal^{-1}{\cdot}min^{-1}$
Post-Exercise - 30 minutes	80.5 $kcal^{-1}$

**Note. Total energy expenditure accumulated during post-exercise period was double pre-exercise period*

Conclusions

The results of this study show that a bout of Tabata exercise using body-weight squat jumps produced a marked VO_2 equivalent to 11.0 METs, a mean kcal expenditure of 53.6, and a VO_2 that had not fallen to pre-exercise 30 minutes post exercise. Thus, the intensity of a Tabata interval exercise bout using squat jumps appears viable as an interval training method particularly for athletes and the higher-fit.

Future research aimed at determining the energy cost of a Tabata protocol with additional exercise modalities such as sprinting or other plyometric maneuvers may also prove valuable.
In addition, the time period required for oxygen uptake to reach pre-exercise levels following Tabata interval training has yet to be determined.

Reference

Tabata I, Nishimura K, Kouzaki M, *et al.* (1996). "Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO_2max". *Med Sci Sports Exerc* **28** (10): 1327–30.

Note. The research published by Nishimura Tabata was conducted with speed skaters who performed supramaximal bouts of the 20 sec:10 sec interval protocol (with 8 repeats) using cycle ergometers.

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