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ORIGINAL ARTICLE

Exercise intensity and energy expenditure during a mini-trampoline rebounding exercise session in overweight women

Quantification de l'intensité de l'exercice et de la dépense énergétique pendant une session de minitrampoline chez des femmes en surpoids

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Mini-trampoline;
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Summary
Objectives. — The purpose of this study was to estimate the exercise intensity and energy expenditure during a mini-trampoline rebounding training session in a group of overweight women to assess whether such fitness activity meets the guidelines for exercise prescription in adults of the American College of Sports Medicine (ACSM) and whether it can be recommended for an overweight female population.
Equipment and methods. — To achieve the aims of our study, eighteen overweight women (36.7 ± 10.6 years, BMI: $26.8 \pm 1.6\,kg/m^2$), were enrolled. All the participants underwent a maximal cardiopulmonary exercise test and the main physiological variables were recorded. Afterwards, the subjects performed a mini-trampoline rebounding exercise session where

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exercise intensity and energy expenditure were measured with a heart rate monitor, a rating perceived exertion scale and a portable armband device, respectively. Successively, the physiological responses obtained from these two activities were compared.
Results. — The average heart rate throughout the mini-trampoline exercise session, lasting 46.1 ± 5.0 min, was 132.3 ± 7.7 bpm, corresponding to 72.2 ± 3.3% of that obtained in the preliminary maximal test. The estimated energy expenditure of participants to mini-trampoline rebounding exercise session was 6.9 ± 0.8 kcal/min, corresponding to a total of 317.3 ± 45.7 kcal for the duration of the entire session.
Conclusions. — Our results showed that mini-trampoline rebounding exercise is a vigorous physical activity, which can be identified as an effective way to achieve an optimal level of training, as indicated by the ACSM guidelines.
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MOTS CLÉS
Minitrampoline ;
Intensité d'exercice ;
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Femmes en surpoids ;
Système cardiovasculaire

Résumé
Objectifs. — Cette étude vise à évaluer l'intensité de l'exercice et la dépense énergétique pendant une session d'entraînement sur minitrampoline chez un groupe de femmes en surpoids, et à déterminer si cette activité physique est conforme avec les *guidelines for exercise prescription in adults* de l'American College of Sports Medicine (ACSM), et peut ainsi être recommandée pour une population de femmes en surpoids.
Sujets et méthodes. — Dix-huit femmes en surpoids (36,7 ± 10,6 ans, BMI : 26,8 ± 1,6 kg/m^2) ont été incluses dans cette étude. Toutes les participantes ont préalablement réalisé un test d'effort maximal dont toutes les principales variables physiologiques ont été enregistrées. Les sujets ont ensuite réalisé une séance de minitrampoline dont l'intensité et la dépense d'énergie ont été contrôlées avec un actimètre, une échelle d'intensité de l'effort perçu et un brassard portable. Les données physiologiques obtenues lors du premier et deuxième exercice ont été comparées.
Résultats. — La fréquence cardiaque moyenne pendant la session de minitrampoline, qui durait 46,1 ± 5,0 min, a été de 132,3 ± 7,7 battements par minute, ce qui correspond au 72,2 ± 3,3 % de la fréquence obtenue lors du test d'effort maximale initial. La dépense énergétique des participantes à la session de minitrampoline a été estimée à 6,9 ± 0,8 kcal/min, ce qui correspond an total de 317,3 ± 45,7 kcal pour la durée totale de la séance.
Conclusions. — Nos résultats montrent que l'exercice sur minitrampoline est une activité physique vigoureuse qui peut constituer un moyen efficace pour atteindre un niveau d'entraînement optimal conforme aux préconisations de l'ACSM.
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1. Introduction

Mini-trampoline rebounding exercise (MRE) is a long time known and very popular fitness workout. The first research in this field began in the 1980s with preliminary studies by Carter [1] and White [2]. In the first instance, the authors attempted to outline the characteristics of the rebound while describing the effects on the human body. Subsequently, other studies on rebound carried out by Bhattacharya et al. confirmed the beneficial effects of this particular training on the human body, especially in people exposed to absence of gravity [3].

Exercise on the mini-trampoline consists of a multicomponent approach which involves strength and balance training, physical fitness, body stability, coordination of muscle responses and spatial orientation [4—10].

Due to the multiple effects of rebounding on motion patterns, several recent studies were undertaken focusing on the usage of mini-trampoline. Some of these were tailored to evaluate its effect on improving athletes' performance [11,12] while others investigated the role of MRE training in improving balance ability and movement coordination [13—15]. Besides, studies on the use of MRE protocols in special populations are increasing, with the aim to highlight its usefulness in medical rehabilitation treatment and its positive psychological effects [14—18].

Despite the spread and interest in MRE as a fitness workout, only a few studies dating back to 1990s examined the exercise intensity (ExI) during an MRE session [2,4,8]. Indeed, little is known about the energy expenditure (EE) in the context of MRE, especially if measured in overweight and obese subjects, whose attendance of gym fitness classes has been continuously increasing in the last decade [19]. Conversely, the assessment of EE and ExI would be particularly useful to clarify whether MRE can improve the overall health status of people who perform this specific exercise. In addition, such approach could reveal whether the MRE is an effective activity for those individuals, such as overweight women, who have a particular need to follow specific exercise prescription guidelines as recommended by the American College of Sport Medicine (ACSM) [20,21].

Starting a program of physical training is particularly encouraged in individuals with a higher cardiovascular risk profile, where the exercise is acknowledged as a key point

of primary prevention. This is the case of peri-menopausal women, in whom the rapid depletion of ovarian estrogens is linked to the onset of cardiovascular risk factors or to their greater expression, if already present [22]. Among these risk factors, weight gain and redistribution of body fat in an android shape become prevalent [22].

Based on these premises, the present study was aimed at assessing the ExI through the analysis of heart rate (HR), the EE, in kcal and metabolic equivalent (MET), and the ratings of perceived exertion (RPE) during a session of MRE in a group of overweight women free of cardiovascular diseases.

2. Materials and Methods

2.1. Participants

Eighteen overweight women (36.7 ± 10.6 years, BMI: 26.8 ± 1.6 kg/m^2), who had ceased any practice of physical activity for more than one year prior to the present study were recruited from the database of a gym located in the hinterland area of Cagliari, Sardinia.

Inclusion criteria were: age between 25 and 55 years, BMI between 25 and 29.9 kg/m^2 and sedentary lifestyle. Exclusion criteria were: the presence of other risk factors, except overweight, cardiovascular diseases and major systemic illnesses that could seriously reduce their ability to participate in the study. The study was approved by our institutional review board and conducted under the strict supervision of our Cardiovascular Disease Unit. Written informed consent was obtained from all participants before enrollment, in accordance with the Declaration of Helsinki for Human Research of 1964 (last amended in 2000). Subjects' characteristics are reported in Table 1.

Table 1 Anthropometric profile and cardiopulmonary exercise test data.

Variables (n = 18)	M ± SD
Anthropometric profile	
Age (years)	36.7 ± 10.6
Height (cm)	162 ± 0.0
Weight (kg)	68.5 ± 6.4
BMI (kg/m^2)	26.8 ± 1.6
WC (cm)	78.9 ± 5.2
HC (cm)	105.5 ± 3.8
WHR	0.7 ± 0.0
Cardiopulmonary exercise test	
RHR at rest (bpm)	75.3 ± 6.2
SBP at rest (mmHg)	128 ± 7.7
DBP at rest (mmHg)	71 ± 4.5
HR max (bpm)	183.3 ± 10.6
SBP max (mmHg)	147.5 ± 2.6
DBP max (mmHg)	78 ± 6.9
VO2 max (l/min)	1.0 ± 0.2
VO2 max (ml/kg/min)	15.4 ± 2.6
VO2 max predicted (l/min)	1.8 ± 2
VO2 max (% of predicted)	57.6 ± 13.3
AT (l/min)	6.6 ± 1.6
AT (%)	44.1 ± 7.3
Work (watt)	104 ± 21.1

Note: data are expressed as the mean ± SD. BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-hip ratio; RHR: resting heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; VO2 max: maximum oxygen uptake expressed in absolute and indexed for body weight; VO2 max predicted: maximum oxygen uptake predicted by Wasserman's equation; AT: anaerobic threshold; AT %: anaerobic threshold in percentage compared to the VO2 max; Work: maximum work.

2.2. Anthropometric profile and cardiopulmonary exercise test

Body weight (kg) and height (cm) were measured by standardized anthropometric procedures [23]. The body mass index (BMI) was also calculated (kg/m^2). Waist circumference (WC), hip circumference (HC) and the waist-hip ratio (WHR) were assessed by linear meter (to the nearest centimeter).

After admission to the study, all women underwent an integrated maximal cardiopulmonary exercise test (CPExT) on an electrically braked stationary cycle ergometer (Medical Graphics Corporation, Minneapolis; USA-Breeze Software, integrated with the XScribe 5, Mortara Instrument Europe Srl) [20,24,25]. Heart rate and rhythm were continuously monitored with a 12-lead ECG, recorded every 30 seconds, both during exercise and for a post-exercise recovery period of 10 minutes. Arterial blood pressure was ascertained by the standard technique with a sphygmomanometer cuff placed on the participant's left arm. A ramp protocol with an exercise regimen of a 4 min warm-up at 10 W at a pedal speed of 60—65 rpm was applied, in order to record the main physiological variables. Breath-by-breath VO2, carbon dioxide production (VCO2), minute ventilation (VE) and maximum effort (watt) were measured. VO2 max and the consumption of oxygen at the anaerobic threshold were expressed as absolute values, standardized by body weight and as a percentage compared to the above mentioned values, according to the Wasserman's formula [25]. Anaerobic threshold was calculated by two independent skilled operators using the V-Slope method [25].

2.3. Mini-trampoline rebounding exercise session monitoring

The session consisted of approximately 50 minutes of MRE (46.1 ± 5.0 min), preceded by a 5-minute warm-up and followed by a 5-minute cool-down. All women were beginners to the MRE, so it was decided to perform the monitoring session after one week of familiarization sessions.

The training was carried out with the use of eighteen individual mini-trampolines with the following characteristics: diameter 115 cm, height 27 cm, weight 13 kg, dimensions of the spring 105/3.2 mm, number of feet 8. Participants were trained and supervised by a professional trainer specialized in both exercise prescription for special populations (Adapted Physical Activity Master Degree Course) and MRE (Rebgym Basic Trainer). The room temperature was between 19° and 23 °C, at a < 60% relative humidity. Each participant wore a radio-telemetric heart rate monitor (Polar Team 2 Pro, Polar Electro Oy, Kempele, Finland) which registered

the heart rate pattern continuously during the entire MRE session [26]. Data resulting from the CPExT were included in the calculation of the Polar Team 2 software and used to obtain the ExI.

The EE was estimated during the MRE by the SenseWear Pro3 Armband (SWA; BodyMedia, Pittsburgh, PA). The SWA is a multisensory activity monitor. The device provides estimation of EE during physical and free living activities through a biaxial accelerometer, the galvanic skin response and the body heat loss. The SWA was worn by the participants on the upper right arm during the whole MRE session, without causing any discomfort. The EE was estimated using a proper algorithm that incorporates the subject's height, weight, age and sex, which were introduced prior to the analysis of data. The minute-by-minute values were reported in either kilocalories (kcal) or MET.

The SWA is a validated device, already used to assess EE, both at rest and during low-moderate and high-intensity physical activity in healthy people, obese individuals and patients with chronic diseases [27—31].

RPE during the MRE session was quantified by the Borg's method, a 15-point RPE scale ranging from 6 to 20 (20—100% effort) [32], previously shown to strongly correlate with HR [33]: one RPE point is considered approximately as 10 beats/minute (bpm). The Borg's scale was explained to each participant before the exercise session (Fig. 1).

2.4. Statistical Analysis

Descriptive statistics are reported as the mean ± SD or percentage frequency for all the eighteen women. Differences in means of the variables of resting heart rate assessed prior to the CPExT and before carrying out the MRE session were tested by the analysis of variance (ANOVA). The analyses were carried out using InStat (GraphPad Software, Inc.) with statistical significance set for P value < 05.

3. Results

All the examined women exhibited an anthropometric profile of overweight (weight: 68.5 ± 6.4 kg; BMI: 26.8 ± 1.6 kg/m^2; WC: 78.9 ± 5.2 cm; HC: 105.5 ± 3.8 cm; WHR: 0.7 ± 0.0) (Table 1). None of the participants was under pharmacologic treatment during the whole study.

Table 1 shows the modifications of cardiovascular and metabolic parameters during maximal CPExT. HR and systolic (SBP) and diastolic (DBP) blood pressure were within normal limits in resting conditions at baseline and normally increased during exercise [25]. At the end of the CPExT effort, maximal HR was 183.3 ± 10.6 bpm, with SBP and DBP values being 147.5 ± 2.6 mmHg and 78 ± 6.9 mmHg, respectively.

The enrolled subjects showed a low aerobic capacity (VO2 max: 15.4 ± 2.6 ml/kg/min) but executed an appropriate work rate (104 ± 21.1 watt) [25].

Prior to the start of the MRE session, HR values and blood pressure levels at rest were re-measured and no significant difference between the two registrations was found (P = n. s). Then, all women completed the MRE session without reporting any clinical problem (Table 1).

Figure 1 Example of mini-trampoline rebounding exercise session.

The HR, recorded by radio-telemetry technique during the MRE session which lasted 46.1 ± 5.0 min, was 132.3 ± 7.7 bpm (range: 75—177 bpm), corresponding to 72.2 ± 3.3% (range: 41—96%) of the HR max obtained in the preliminary CPExT.

The estimated EE, evaluated during every minute MRE by SWA registration, was 6.9 ± 0.8 kcal/min, corresponding to a total of 317.3 ± 45.7 kcal for the entire duration of the MRE session (46.1 ± 5.0 min). On the other hand, the EE during MRE was 5.2 ± 1.1 MET/min.

Finally, mean RPE, according to the Borg's rating scale, was 13.2 ± 1.3 (range: 12—15). The average physiologic responses to the MRE session are reported in Table 2.

4. Discussion

The present study provides original information about the exercise intensity and energy required by the MRE addressed to the specific target population of overweight women. Our results indicate that the MRE: (i) is a form of vigorous physical activity (72.2 ± 3.3%) and (ii) requires the cardiovascular system to work at levels which impose a moderate-to-high EE and is considered to be adequate to the physiological requirements (5.2 ± 1.1 METs/min) [20,21].

Table 2 Average physiologic responses to the MRE session.

Variables ($n = 18$)	M ± SD (range)
Exercise intensity (ExI)	
Workout Time (min)	46.1 ± 5.0
Average HR during MRE session (bpm)	132.3 ± 7.7 (75–177)
% of HR max in CPExT	72.2 ± 3.3% (41–96%)
Energy expenditure (EE)	
MET/min during MRE session	5.2 ± 1.1
kcal/min	6.9 ± 0.8
kcal (46.1 ± 5.0 min)	317.3 ± 45.7
RPE at the end of MRE session	13.2 ± 1.3 (12–15)

Note: data are expressed as the mean ± SD, percentage (%) and range. HR: heart rate; VO2: oxygen uptake expressed in absolute and indexed for body weight; AT: anaerobic threshold; MET: metabolic equivalent (1 MET is defined as the energy to lie/sit quietly, it is equivalent to a metabolic rate of consuming 3.5 ml O2/kg/minute); RPE: Borg's rating of perceived exertion scale.

Indeed, according to the guidelines for exercise testing and prescription of the ACSM, individuals should perform exercise between 64–94% of HR max or at 40–85% of VO2 max to improve cardiovascular fitness [20,21]. Accordingly, overweight women enrolled in this study achieved an energy cost that, in line with the above guidelines, appears adequate to increase the aerobic capacity and induce training effects. On the other hand, in agreement with previous studies investigating its beneficial effects on balance ability and movement coordination [13–15], the MRE is likely to prove as an excellent workout activity for those overweight people, who, more than others, are at high risk of joint and muscle injuries during physical activities [34–36].

Our data confirm and extend those from previous studies that evaluated the exercise intensity of MRE [4]. Tomassoni et al. showed an ExI between 75–80% of the HR max in 10 young women (18–28 years) [6]; likewise, Gerberich et al. found that a 12-week MRE program in 10 adult women (18–40 years) resulted in an ExI between 70–85% of the HR max [8]. In addition, our study integrates these evaluations with the use of a RPE scale, resulting in a self-reported 13.2 ± 1.3 score, which is considered an appropriate value for a workout activity [33].

To the best of our knowledge and to date, no study was aimed so far at measuring EE during a MRE session. The reason for this lack of information may be related to the fact that previous researches on the MRE were conducted when portable and appropriate devices for the assessment of the EE during physical activities were not available yet.

By the use of the SWA, a practical, comfortable and easy-to-wear device, we were able to assess and measure the adequate level of EE guaranteed by MRE activities (5.2 ± 1.1 MET/min with a total of 317.3 ± 45.7 kcal) [20,21].

During the MRE session, participants were continuously monitored in HR and EE. The high variability of the recorded values suggests that exercising at mini-trampoline can be considered as a physical activity involving both aerobic and anaerobic metabolism of the enrolled women. This finding is also confirmed by the low level of VO2 max measured during the CPExT, if compared to VO2 max values predicted by the Wasserman's formula [25]. Indeed, subjects showed a low level of fitness, probably due to their sedentary lifestyle and overweight.

In the light of these findings, while in healthy populations and/or in subjects with low cardiovascular risk (as in our study) this type of exercise is appropriate and easily prescribable, in middle-aged patients with high cardiovascular risk, the MRE should be administered with caution and a cardiovascular check-up is definitely recommended before starting a program.

Finally, the results of our study show that the degree of engagement achieved during MRE is consistent with the guidelines provided by the ACSM which recommend that individuals consume at least 300 kcal/workout and a target volume of 500–1000 METs/min/week, in order to promote weight loss or maintain a healthy body weight [21].

5. Limitations, future aims and conclusions

A limitation of this study is the restricted population evaluated. Therefore, a goal of the immediate future will be to increase the number of participants.

A further interest in the same research area will be to expand the analysis of EE among other types of fitness activities and to evaluate the appropriateness and effects of the MRE protocols on other special populations.

In conclusion, our findings show that the MRE proved as a type of training suitable to potentially ensure beneficial effects on health in order to maintain or improve the overall fitness.

Therefore, the MRE appears to be recommendable and prescribable in adult overweight women, who need to exert effective control of body weight.

Disclosure of interest

The authors declare that they have no competing interest.

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