

# Research Paper: Effects of A 12-Week Rebound Therapy Exercise on Energy Consumption and Body Mass Index in Patients With Spinal Cord Injury



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## ABSTRACT

**Introduction:** Energy Consumption (EC) and Body Mass Index (BMI) are the major complications associated with Spinal Cord Injury (SCI), which can be improved by exercise rehabilitation. Thus, the present study aimed to evaluate the efficiency of using rebound therapy (exercise on a trampoline) on EC and BMI in individuals with SCI.

**Materials and Methods:** Sixteen individuals with SCI (ASIA classification: A=6, B=6, C=2, D=2) were selected and randomly divided into two groups of experimental (rebound exercise) and control. The experimental group performed the exercise program by a modified trampoline for 12 weeks (10-30 minutes; 3 sessions a week). EC was measured by the Physiological Cost Index (PCI) and BMI was calculated by standard formula before and after the exercise intervention. Finally, the obtained data were analyzed by Repeated-Measures Analysis of Variance (RM-ANOVA) in SPSS.

**Results:** The results of RM-ANOVA revealed significant interaction in both criteria ( $P < 0.01$ ). In other words, the experimental group changes were substantial, compared to that of the control group.

**Conclusion:** The collected results indicated that rebound therapy could, in effect, improve the SCI individuals' EC and BMI. Furthermore, it was suggested that rebound exercise can be a useful sports rehabilitation method for patients with SCI.

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## Introduction

Spinal Cord Injury (SCI) is the most critical and permanent problem following trauma. SCI can ultimately lead to a lifetime disability, decreased quality of life, high care costs, and eventually declined life expectancy in the individual [1]. This injury often occurs with various biopsychological symptoms and different abnormalities in sensory and motor function in patients based on the location of the lesion [2]. The inability to walk is among the most visible disabilities for patients who encounter SCI. Therefore, assessing walking ability in patients with SCI is an important outcome measure in rehabilitation [3].

Furthermore, inactivity and the lack of mobility are the main causes of overweight and obesity, as well as other secondary problems for individuals in a society [4]. Typically, the extent of peak power output, oxygen consumption, and cardiac output in patients with paraplegia approximately would be half of the corresponding amount in the healthy population who exercise with the maximum capacity of their feet. It can, thus, lead to higher Energy Consumption (EC) in these patients' activities [5].

Various rehabilitation techniques, like physical exercise, are non-invasive treatments that either actively or inactively helps the patient with SCI to get involved in an exercise that stimulates the damaged area [6]. One of these relatively new methods is physical therapy exercises on trampolines, also known as rebound exercise or rebound therapy. In other words, rebound therapy is employed in exercise programs and rehabilitation techniques since it is a positive approach for enhancing muscle strength, body balance, and bone mechanical ability, as well as raising health levels, and even improving injuries [7, 8]. Despite the interest, few researchers have ventured to address EC and Body Mass Index in SCI individuals following the use of the trampoline. Consequently, this study aimed to evaluate the efficiency of using rebound exercise on EC and BMI in individuals with SCI.

## Materials and Methods

A group of complete and incomplete SCI subjects, consisting of 16 individuals with lesions between T1 and T12 (ASIA classification A=6, B=6, C=2, D=2) were randomly assigned to two groups (i.e., rebound & control) in this study. Table 1 illustrates the characteristics of the research subjects. As the name implies, the rebound group received rebound therapy exercises to improve EC and BMI. Besides, ethical approval was ob-

tained from the Ethics Committee of Isfahan University of Medical Sciences. Moreover, each study subject was requested to sign an informed consent form before the data collection.

The inclusion criteria of the study were as follows: patients with SCI, aged between 20 to 40 years, generating a thoracic level of spinal cord injury for at least one year, ability to sit without aid, the ability to perform offered exercises, no history of fractures of the spine, hip, knee, and ankle joints; the lack of lower-limb deformities, and developing no other disease complications.

The exclusion criteria were as follows: non-compliance with the exercise programs, absence from the third of exercise sessions or absence from pretest or posttest phases, experiencing any radical changes in their routine medical treatment during the study, and pregnancy.

Rebound therapy exercise protocol: An appropriate trampoline was designed and developed for this study, which allowed the individuals with SCI to independently perform the exercise. All exercise programs were conducted in a sitting or lying position on the trampoline. Exercises selected for each session were challenging and attractive to the study participants who had to keep their balance with various basic exercises using assisting equipment, such as balls and balloons on the trampoline. The exercise programs lasted 10 minutes for the first 4 weeks. Thereafter, they were prolonged to 15-20 minutes in the next 4 weeks, followed by 30 minutes in the final 4 weeks. Exercise durations were set at 5-minute intervals with 3-minute rest periods 3 times per week over the 12 weeks. Exercise programs included sitting without hand help, jumping, and upper limb workout in the sitting position, core stability training in lying position (plank, side plank, curl up, bird dog, & the like), and two-person exercises in sitting and lying positions.

Throughout the exercises, blood pressure and heart rate were monitored (by pulse meter); with heart rate reserve maintained at the moderate intensity of 50%-70%, i.e., calculated by  $220 - \text{patient's age}$ . The examined participants were also supervised for subjective fatigue, dyspnea, respiratory distress, profuse sweating, and autonomic dysreflexia during the exercise activities, which indicated that they had reached maximum exertion.

**Equipment:** The BMI was calculated for each patient by the following formula:  $\text{BMI} = \text{weight (in kg)} / \text{height}^2 \text{ (in meters)}$  [9].

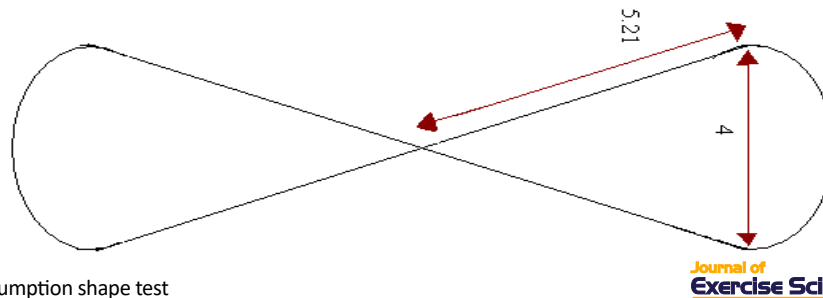


Figure 1. Energy consumption shape test

The EC measurement was performed by the Physiological Cost Index (PCI), which indirectly represents the change in energy consumption during walking. It has a high correlation with oxygen consumption change [9].

For the EC test, heart rate was collected during walking (10 min along with an 8-figure shape) and resting (5 min before and after walking) using the Polar Electro Finland (Figure 1). According to PCI, the extent of EC during walking can be determined using the following equation [10]. Additionally, the validity of this parameter was evaluated in various research studies [11-13].

$PCI (beats/metre) =$

$$\frac{\text{heart rate during exercise} - \text{heart rate during resting (beats/min)}}{\text{walking speed (metre)}}$$

The normal distribution of the parameters was evaluated by the Shapiro-Wilk test. Additionally, the influence of the intervention was determined by Repeated-Measures Analysis of Variance (RM-ANOVA).

## Results

The examined patients' descriptive statistics and results of RM-ANOVA are presented in Table 2. The Mean±SD values of EC in the rebound group equaled  $0.5 \pm 0.02$  and  $0.31 \pm 0.01$  before and after the exercise, respectively. Furthermore, these values were  $0.38 \pm 0.05$  and  $0.39 \pm 0.03$  before and after the 12 weeks, respectively. The results of RM-ANOVA demonstrated significant interaction in this criterion ( $P < 0.05$ ).

The BMI was the other parameter measured in this study. This value was measured as  $24.6 \pm 2.06 \text{ kg/m}^2$  before and  $23.8 \pm 2.09 \text{ kg/m}^2$  after exercise in the rebound group. The Mean±SD BMI value in the control group changed from  $23.3 \pm 2.2 \text{ kg/m}^2$  to  $23.7 \pm 2.3 \text{ kg/m}^2$ . Table 2 also demonstrates that interactions were significant in this parameter; thus, the control group had no progress, while the experimental group made a significant improvement.

Table 1. Participants' demographic data (Mean±SD)

| Groups        | Age (y)    | Weight (kg) | Height (m)  | Time post injury (y) |
|---------------|------------|-------------|-------------|----------------------|
| Rebound (n=8) | 37.6±8.3   | 72.1±12.4   | 1.73±0.92   | 5.8±2.3              |
| Control (n=8) | 34.7±3.8   | 70.1±8.3    | 1.75±0.89   | 4.5±1.9              |
| T (sig.)      | 2.01(0.06) | 0.39(0.70)  | -0.46(0.64) | 1.29(0.21)           |

Table 2. Patients' descriptive statistics and results of RM-ANOVA

| Criteria                    | Groups  | Mean±SD   |           | Mean Difference | Group Interaction Df (1,14) |
|-----------------------------|---------|-----------|-----------|-----------------|-----------------------------|
|                             |         | Pretest   | Posttest  |                 |                             |
| Energy consumption (HR/min) | Rebound | 0.5±0.02  | 0.31±0.01 | -0.19           | F=6.2, P=0.04*, η²=0.69     |
|                             | Control | 0.38±0.05 | 0.39±0.03 | 0.01            |                             |
| Body mass index (kg/m²)     | Rebound | 24.6±2.06 | 23.8±2.09 | -0.8            | F=30.2, P=0.0001*, η²=0.68  |
|                             | Control | 23.3±2.2  | 23.7±2.3  | 0.4             |                             |

\* P<0.05

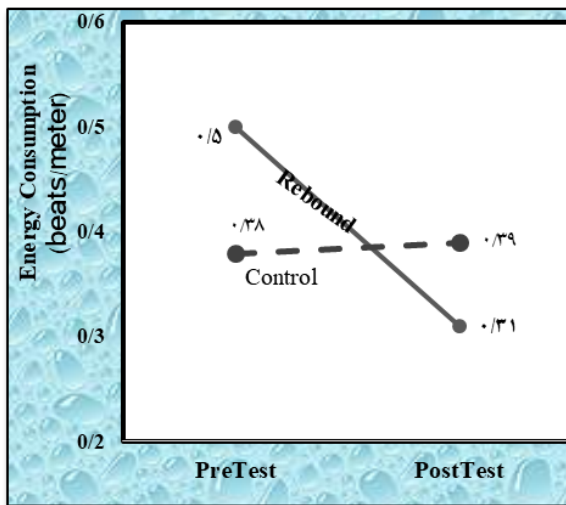


Figure 2. Chart line of BMI

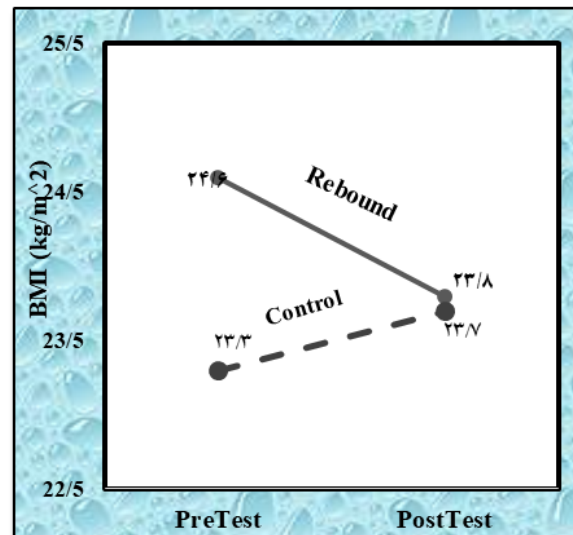


Figure 3. Chart line of PCI

### Discussion

Various exercise rehabilitation programs have been used for patients with SCI to improve their performances while performing daily living activities; however, there is no definitive method in this regard. Efficacy, safety, independence in use, possibility, cost efficiency, and availability are the main criteria for selecting an exercise rehabilitation method. The main training method associated with paraplegic SCI rehabilitation includes strength and flexibility training, standing and walking training, aerobic training, as well as hydrotherapy.

The obtained data indicated a higher reduction in BMI in the rebound group, compared to that of the control group. The decreasing slope of the rebound line in Figure 2 confirms this claim. Likewise, mean changes in the rebound group were 0.8(3.2%), while it manifested an increase of 0.4(1.7%) in the control group. According to the direct effect of weight on BMI, and the difficulty of weight loss, especially among patients with SCI, the 3.2% change in this indicator is also of great importance. BMI designates body status concerning weight and can be indicative of being overweight. In other words, these results can be expressed as the average weight had a decrease of about 2 kg in the rebound group and an increase of more than 1 kg in the control group. Accordingly, the rebound exercises can be considered appropriate and effective for the improvement of BMI in individuals with SCI. These results were inconsistent with those of the review study by Hicks and associates. Having reviewed 82 relevant papers, we concluded that they found little evidence regarding the effectiveness of exercise on body composition [14].

BMI between 18.5 and 24.9 kg/m<sup>2</sup> indicates the healthy range for individuals without any problems and disabilities in society. Naturally, the values higher than this represent overweight in an individual [15]. Regarding muscle atrophy in lower extremities, individuals with paraplegia SCI naturally have lower BMI, compared to normal individuals. For example, among healthy individuals, the estimates of BMI above 25 kg/m<sup>2</sup> and above 30 kg/m<sup>2</sup> indicate the overweight and obesity boundary, respectively. However, this value is 21 kg/m<sup>2</sup> among the subjects with tetraplegia SCI and 23 kg/m<sup>2</sup> and 28 kg/m<sup>2</sup> for subjects with paraplegia SCI, respectively. Based on these interpretations, a BMI higher than 23 kg/m<sup>2</sup> can be considered overweight among individuals with paraplegia SCI. Therefore, according to the mean values obtained in the present study, the explored participants lay in the overweight range [16, 17].

Generally, the basic metabolism rate among individuals with SCI is lower than that of the healthy population. This is among the factors causing weight gain in this group, which would be attributed to other factors [18], like inactivity. As previously mentioned, the level of physical activity among the SCI is 40% less than that of healthy subjects [19]. This inactivity is due to many factors. The mental conditions, inadequate facilities, and economic problems (the SCI often come from the lower reaches of society) in our country. Furthermore, the attractiveness of physical activity can be a major barrier to physical activities among individuals with SCI [20]. In the present study, using the new and attractive trampoline tool in the interventions led to more duration of exercises and increased physical activity. Moreover, considering that the trampoline was designed suitably

respecting size and dimensions for wheelchair-bound individuals, the individual who referred to use it did not require others' assistance; this helped to feel of independence in the individual. Consequently, more tendency was shaped in them to perform exercises. The impact of rebound exercises on the lymphatic system is among the factors encouraging the continuation of exercises, which, indeed, increased energy consumption. Since the flow in the lymph system is a function of human body movement (the more mobility, the easier the movement of the lymph fluid), less fatigue occurs in this respect. Moreover, the lymphatic system facilitates the disposal of toxins and waste materials from the body [21]. The muscles are longer involved in the activity. In general, exercise in a longer period increases EC; thus, it positively affects fat loss before weight loss [22].

Another crucial factor in rebound exercises is more EC over a specified period of physical activity. Cugusi et al. introduced trampoline as an effective tool for increasing the energy expenditure among overweight women and an appropriate tool for weight loss [22]. The considerable part of the exercises suspended in the air is a crucial factor for the superiority of rebound exercises in higher energy consumption. This causes all organs to get involved in retaining the balance of the body in the air [8]. This involvement of various parts of the body is what rebound exercises are often referred to as "cellular exercise". Such a name can be attributed to the belief in the involvement of each cell of the body during movements and exercises on the trampoline [23]. Consequently, the increased EC in a particular activity on the trampoline is the unique advantage of rebound exercises to improve the BMI. For individuals with SCI, the collapse of energy balance for various reasons increases the odds of obesity. This increase in weight can be accompanied by numerous metabolic and cardiopulmonary problems [18]. Based on the present study hypothesis, rebound therapy can reduce BMI, weight, and prevent obesity as well as its complications.

The inclining slope of the rebound line in Figure 3 confirms the superiority and effectiveness of rebound exercises on EC. The average variations in the rebound group from 0.5 to 0.31 from the pretest to posttest indicated a 38% reduction in EC (i.e., 38% improvement) in this training group. Furthermore, the mean variations from 0.38 to 0.39 in the control group verified a 2% increase in EC, i.e., a 2% decline. Therefore, rebound exercises can be considered suitable and effective on the amount of energy consumed by individuals with SCI. Most studies in the field of EC among the SCI have investigated

the different manners of walking with braces or different patterns and their effect on EC.

As stated before, the main criterion for the effectiveness of a rehabilitation program for the SCI is the evaluation of the participants' walking performance [24]. The EC rate during walking is an essential indicator of walking performance. Indeed, the lower the EC, the better the quality of walking of the subjects. Muscle strength, skill, and balance play a crucial role in EC [25]. However, the walking skill was not significantly affected by the present study since the type of training did not include it. Still, the improvement in balance mentioned above is an effective factor in reducing EC. Moreover, improving muscle strength in the central region of the body and upper limbs can be considered as a determining factor effective in improving the quality of walking performance; therefore, reducing energy consumption. The effectiveness of rebound exercises in the cardiovascular system and EC, which has been proven in various studies [22], can be considered as another important factor in reducing EC in this study.

## Conclusion

The obtained results suggested that rebound therapy could improve the SCI patients' BMI and EC. It also suggested that rebound exercise is a useful complementary method for SCI. Due to some limitations associated with this study, it is recommended that the same investigation be replicated with a larger number of subjects, also with separated groups of SCI individuals with complete and incomplete paralysis.

## Ethical Considerations

### Compliance with ethical guidelines

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (approved by Isfahan University of medical sciences, ethical committee) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards (approved by Isfahan University). Participants were given verbal and written information about the procedures and potential risks of exercises and gave written informed consent to participate in this study consent for publication.

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### Authors' contributions

All authors equally contributed to preparing this article.

### Conflict of interest

The authors declared no conflicts of interest.

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