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Research Article

The Effect Of Various Types Of Resistance Training On The Amount Oxygen Consumption After Exercise In Non-Athletic Men

Abdullah Demirli[1*], Abdorreza Eghbal Moghanlou[2], Ali Burak Toy[3], Emre Yamaner[4], Şevki Kolukısa[5]

[1*]Department of Faculty of Sport Sciences, İstanbul Yeni Yuzyil University, İstanbul, Turkey, Email : Abdullahdemirli@yeniyuzyil.edu.tr, ORCID: 0000-0003-1727-4596
[2]Department of Coaching Education, Istanbul Esenyurt University, Istanbul, Turkey,
Email: abdorrezaeghbalmoghanlou@esenyurt.edu.tr, ORCID: 0000-0003-1238-0541
[3] Department of Coaching Education, Ardahan University, Ardahan, Turkey, Email: aliburaktoy@ardahan.edu.tr, ORCID: 0000-0001-7997-7399
[4] Department of Faculty of Sport Sciences, Hitit University, Çorum, Turkey, Email: emreyamaner@hitit.edu.tr, ORCID: 0000-0001-5958-0722
[5] Department of Faculty of Sport Sciences, Giresun University, Giresun, Turkey, Email: sevki.kolukisa@giresun.edu.tr, ORCID: 0000-0002-0485-3081

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ABSTRACT

Objective: Today, it has been proven that diets alone cannot manage weight and body composition properly, especially in weight loss programs with long-term food deprivation, it is feared that the lost weight will be regained. The aim of this research is to investigate the effect of three types of resistance exercise (intensity 50, 75 and 85% of a maximum repetition) on the amount of EPOC in male students.

Research method: The statistical population included all male students of universities who were randomly selected from the available samples of 45 people and each of these people participated in all three stages of the current research tests, the resistance training stage with Intensity of 50%, 75% and 85% of one repetition maximum (n=15) were involved. To compare the three intensities in all measured variables, covariance test was used by SPSS21 software at the significant level of subjects P>0.05.

Findings: The results showed that two sessions of 50%, 75%, and 85% 1RM resistance exercise are equal in terms of training volume, but EPOC after the 85% intensity resistance exercise session is greater compared to the lower intensity resistance exercise session.

Conclusion: High resistance training intensity has a greater effect on people's EPOC.

Introduction

Many people in the society seek to reduce, stabilize or increase their weight, diets along with various sports are an effective and efficient way to achieve these goals, nowadays it has been proven that diets alone cannot manage have a proper diet and body composition, especially in weight loss programs with long-term food deprivation, it is feared that the lost weight will be regained (Broeder et al., 1992) on the other hand, in weight loss programs, increasing the desired weight means is to increase body fat mass and decrease body fat mass. Many people turn to exercise in order to control their body weight in order to increase their energy consumption. Anyway, the type of exact amount of exercise that leads to the greatest weight loss is a debatable subject that can be researched (Sirithienthad, 2006).

Usually, endurance exercises or sports are used in weight loss programs (Broeder et al., 1992; Gore & Withers, 1990; Hunter et al., 2006; Poehlman et al., 2006; Eghbal et al., 2022), but resistance exercises and sports can also be used directly and indirectly in weight loss programs weight should play a great role (Short & Sedlock, 1996; Wong & Harber, 2006; Deschenes & Kraemer, 2002; Dolezal & Potteiger, 1998). Resistance training is a form of exercise that has been well-known among the general public for its role in improving the performance of athletes through increasing strength, power, speed, hypertrophy, local muscular endurance,

movement performance, balance and coordination since two decades ago(Ahlborg et al., 1974; Eghbal et al., 2022).
Probably one of the most beneficial effects of resistance exercise that can be beneficial in weight control is the direct caloric expenditure and the high oxygen consumption after exercise, as well as the high oxidation of fat after exercise, which is mostly achieved with intense resistance exercise (Schuenke et al., 2002; Eghbal et al., 2018). Resistance exercise can also significantly increase resting metabolism (Osterberg & Melby, 2000; Eghbal et al., 2022).
The total daily energy consumption is an indicator of the body's basic energy and metabolism, the thermal effect of activity and the thermal effect of food. Because the basal metabolic rate of the body constitutes the highest percentage of a person's daily energy consumption (approximately 60 to 75%), researchers have been interested in determining the interfering factors in the resting metabolic rate, so that by using these cases, they can increase the amount of ،ncrease resting metabolism to facilitate weight loss. Another indicator that can be correct in the energy consumption of the whole person is the oxygen consumption during physical activity and the state of recovery after it. During exercise, there is an increase in oxygen consumption to meet energy needs. After exercise, oxygen consumption does not immediately return to its resting levels, but may remain higher than its resting levels for a long time. This amount of oxygen consumption higher than resting levels, which is probably caused by exercise, is called excess post-exercise oxygen consumption (EPOC) (Foureaux et al., 2006), the excess oxygen consumption after exercise has two fast and slow components. The fast part subsides within an hour, while the slow part subsides within several hours (Thornton & Potteiger, 2002).
Probably, the type, intensity and duration of exercise can affect EPOC (Foureaux et al., 2006). Recently, a number of researches have investigated EPOC responses after various resistance exercises, which generally focus on EPOC responses to exercise. It has been a strong or circular resistance (Melby et al., 1993). Overall, these studies have shown that resistance exercise is an efficient and effective way to increase energy consumption even several hours after exercise. Meanwhile, the factor of intensity and volume of resistance exercise is very effective in prolonging the duration of the increase in energy consumption and the magnitude of this increase compared to the basic state (Laforgia et al., 1997). Tornton and his colleagues in 2002 conducted a study in which they contributed by keeping the volume of resistance training constant and using two intensities of 45 and 85% of 8 maximal repetitions, the effect of intense and light resistance exercise on the magnitude of EPOC up to 120 minutes after exercise. Review. They found that the magnitude of EPOC after resistance exercise with an intensity of 85% of 8 maximum repetitions is greater than resistance exercise with an intensity of 45% of 8 repetitions of the maximum (15). In this research, Toronto and his colleagues used resistance trained female subjects. And RMR was not calculated. Considering these cases and taking into account that the intensities of other resistance sports may have effects and resistance on EPOC indicators, the researcher has a contribution to make by keeping the amount of exercise constant, the effect of three types of resistance sports (intensity 50, 75 and 85% of a maximum repetition) on the amount of EPOC in male students.

Population and statistical sample

The statistical population included all male students of universities who were randomly selected from the available samples of 45 people and each of these people participated in all three stages of the present research tests.
1. The stage of resistance training with an intensity of 85% of a maximum repetition (n=15)
2. The stage of resistance training with an intensity of 75% of a maximum repetition (n=15)
3. The stage of resistance training with an intensity of 50% of a maximum repetition (n=15)

The method of conducting research and how to collect information

The research method is semi-experimental. After coordinating with a number of male students of universities and explaining the purpose of the research and the methodology, 45 of them were selected and voluntarily signed a written consent to participate in the research. The restriction criteria for participating in this research were smoking, having endocrine or hormonal diseases, or taking drugs that can affect the body's metabolism. The above information was collected by questionnaires prepared by the researcher.
One week before the beginning of the tests, the subjects were invited to the physiology laboratory so that the information about the purpose of the research and the working method was provided to them. Also, due to the limitation of using the only gas analyzer available in the laboratory, the time of each person's test had to be determined in order to Each stage of each person was tested on a separate day assigned to him. The researcher recorded the information about the age, height and weight of the people in the same session. The test (VO_{2max}) of each person was taken on the bike 3 or 4 days before the start of the first stage of the test. Two weeks before the start of the tests, the test was taken from the volunteers participating in the research at the IRM in the training hall of the university. Using this test, the exercise intensity of each stage should be determined for each person (75, 85, and 50% IRM).

Research steps

The research was carried out in two main stages, each with an interval of 10 days, on 45 university male subjects. The steps of all the work for each subject were as follows: at 9:00 in the morning, the subject entered the exercise physiology laboratory of the university. His resting metabolic rate after eleven hours without food and almost 8 hours of sleep is measured by indirect calorimetry.The time to measure resting metabolism was 30 minutes, and after the measurement, the subject came to eat the self-service breakfast of the university, which he consumed at 7:30 to 8:30. The subjects were advised to be as sedentary as possible after leaving the laboratory, and they were asked to eat their lunch at the university service at 11:30. Subjects returned to the laboratory at 1:30 PM to measure resting oxygen consumption before exercise (VO_2) for 30 minutes. These measurements are used to estimate excess oxygen consumption after exercise by subtracting the amount of oxygen consumption in the baseline state. And the comparison of oxygen consumption before and after exercise was at 2 o'clock in the afternoon. Each subject did about 35 minutes of weight training with an intensity of 85% of IRM for high intensity stage, 75% of IRM for high intensity stage and 50% of IRM for The low intensity stage did.

EPOC measurements were started between 5 and 6 minutes after the end of the exercise with weight and measurements were carried out for 90 minutes. The subjects then went to eat dinner at 7:45 PM. Returning to their residence, they were advised to remain as still as possible and to refrain from eating any food or drinking any attractive liquid.

EPOC measurement

Resting VO_2 and VCO_2 before exercise were measured for 30 minutes before the exercise phase in the same way as RMR measurement. The use of this VO2 is the basis of resting VO2, which is subtracted from the VO_2 after exercise in the calculation of EPOC. For 5 to 6 minutes, after completing the last movement of the exercise with weights, the subjects returned to the laboratory and immediately collected the mask. Breathing gases were placed on their faces and the measurement was started. Subjects were transported with a car device. Continuous measurements of VO_2, VCO_2, and Respiratory Exchange Ratio (RER) were performed for 90 minutes by means of indirect calorimetry. EPOC averages were calculated every 30 minutes, and the subjects' calories consumed during these 90 minutes were estimated.

Calculation of maximum oxygen consumption (VO_2 max)

To measure this index, the YMCA bicycle submaximal test was used (Vivian, 2023). VO_2max was taken during a separate session from the subjects who performed the exercise protocol during a ten-minute period with three different levels of pedal resistance. The subjects did not perform any special sports activities for at least 48 hours before this test. The information was recorded from the device itself. The maximum oxygen consumption of the subjects was used only to introduce the characteristics of the subjects along with their age, weight and height, and the average the index showed that the subjects were untrained people.

Weight training protocol

In general, 15 subjects performed the main phase of weight training individually during the research, and for each subject, the first phase was 12 to 13 days apart from the second phase. As mentioned earlier, this issue was due to the limitation of using only one gas analyzer in the laboratory.

In the first stage of weight training, resistance training was performed with standard sets and intensity of 85% of IRM with 3 sets of 7 resistance movements in 8 repetitions. In the second stage, after a week, with intensity of 75% of IRM with 3 sets of 7 resistance movements were performed in 8 repetitions, but in the third stage of training, circular resistance training with 50% intensity of IRM was followed from the same 7 movements with 3 rounds and 12 repetitions. The first stage of weight training, which was done in the form of standard sets, was considered as a high-intensity resistance exercise, and in this stage of weight training, in terms of training volume, it was equal to the second stage of 50% IRM training, the movements in two stages Weight training included chest press, leg squat, shoulder press with barbell, leg press, underarm boat, front thigh with front arm standing machine with barbell, the rest interval between each set was one minute, and at this stage of the training, the subject was under strict supervision. The trainer was close to the subject in all the movements and accompanied the subject in all the movements to avoid injury and to perform the weight training techniques correctly.

In the second stage of weight training (resistance exercise stage with intensity of 50% of IRM), the movements were exactly the same as the first stage, with the difference that first one round of 7 movements was performed in the order mentioned before, then a test of 2 more rounds of the same 7. He performed the movement in the same way as the first round, the rest between the movements was 60 seconds, in this part of the weight training, the work intensity was considered low, the whole time of the weight training, except for the warm-up time, lasted about 35 minutes.

Measuring tools and devices

1- Medical scale made of element and measuring the weight of subjects 0.1 kg
2- tape measure made in Türkiye: to measure the subject's height
3- Medical history questionnaire

4- Questionnaire of readiness to start physical activity
6- Bike work meter Cateye model EC-1600 to calculate $VO_{2\ max}$
7- 3B Meta Max respiratory device for measuring breathing gases
8- Computer device for displaying respiratory system data and information

Statistical Methods

Descriptive statistics were used to calculate central and dispersion indices. Covariance test was used to compare three intensities in all measured variables. All statistical operations were performed by SPSS21 software at the significant level of subjects P>0.05

Findings

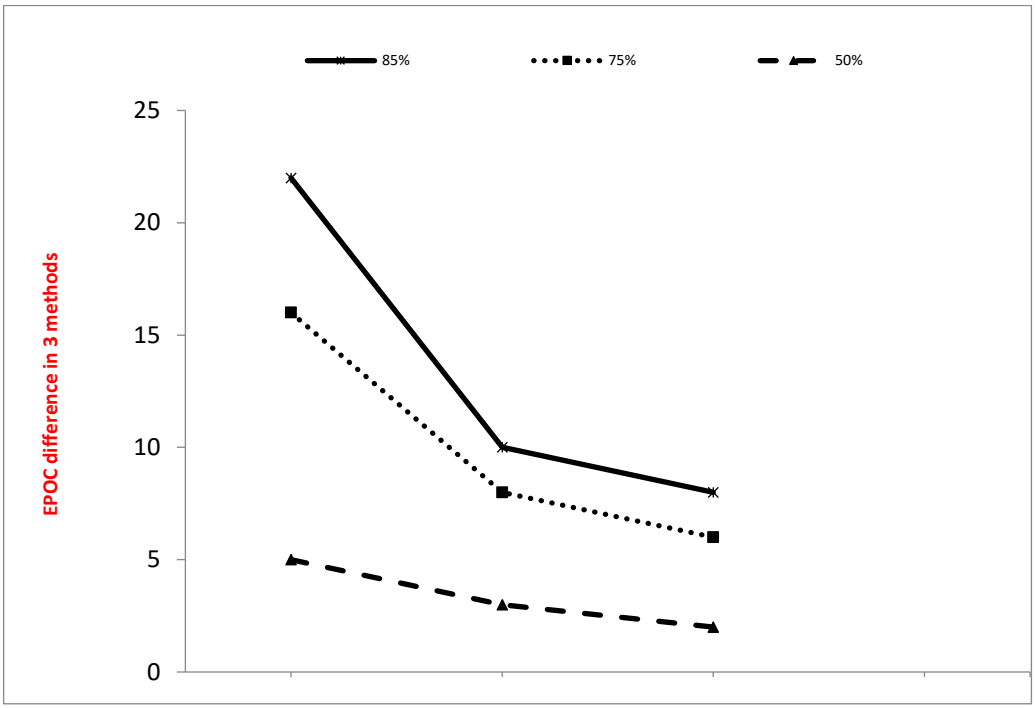

Fig. EPOC differnces in 3 methods

According to the results of the table, the average in milliliters in the first stage after the activity and in the second stage and the third stage, it can be concluded that after a resistance training session with high intensities 1 RM is significantly different from each other. EPOC in the first stage after a resistance training session with an intensity of 85% is significantly higher than 75% and 50%. However, no significant difference was observed between the second stage of 85% and 75% in the second and third stages

Discussion

The main findings of the current research are that when two resistance exercise sessions of 50%, 75% and 85% 1RM are equal in terms of training volume, but EPOC after the resistance exercise session with 85% intensity is highr compared to the resistance exercise session with lower intensity. EPOC was present for each time step after a resistance training session during these 90 minutes, and its highest value was in the first 30 minutes after both resistance training sessions, because the resistance training session was similar in terms of rest intervals between movements and intermittent sports sets (Foureaux et al., 2006; Dolezal et al., 2000; Sirithienthad, 2006; Eghbal et al., 2018)
Therefore, EPOC has not been calculated for the rest intervals between sets and movements in this research, as a result, it is not possible to fully calculate the actual total EPOC after each resistance training session in this research. The findings of this research and previous research in this field indicate that the intensity of exercise is a very important factor (Foureaux et al., 2006; Dolezal et al., 2000; Eghbal et al.,2022). In the present study, the resistance training program that was performed with an intensity of 85% and 75% of 1RM, the total EPOC during 90 minutes after exercise was higher than 50%. Although the total EPOC during these 90 minutes after both resistance training programs is insignificant for weight loss, the difference in total EPOC between the two programs with higher intensity is significant and this indicates the effect of higher intensity in these two training methods. . In both resistance training programs conducted in the present research, the EPOC value was statistically significant and in the first 30 minutes after exercise, it was much higher than in the second and third 30 minutes.
It can probably be concluded that the application of such resistance training programs used in the present research causes the body's metabolism to remain high significantly in the first 30 minutes after exercise, and

within an hour after it increases slowly and evenly. It happens in the first minute after exercise, and during the next hour, it increases slowly and evenly. When we compare the amount of oxygen consumed (on average per minute) between before and after exercise, statistically, the difference in VO_2 in the first, second and third minutes after the high intensity protocol was greater than the baseline VO_2. This issue was the same for the intensity program of 50% of RM 1, with the difference that the difference of the average VO2 between the final 30 minutes after exercise and the baseline values was not significant.

In a study conducted by Wong & Harber (2006), the researchers investigated 45 minutes of resistance exercise on EPOC and substrate metabolism up to 120 minutes after exercise. EPOC became 2.6 liters in these 120 minutes(Wong & Harber, 2006); However, compared to the present study, which was measured in 90 minutes, the results are somewhat aligned with the research conducted by Haltman et al. (1999) (Haltom et al., 1999)

The researchers applied a resistance exercise protocol including 8 movements and 20 repetitions per set with 75% IRM on healthy young men. They found that when the rest between sets is set to 60 seconds (as was done in the present study), the total EPOC decreases to 40.7 liters within one hour after exercise. but in terms of the weight training program, these two studies have nothing in common. Perhaps this is why, although in the study of Haltman and his colleagues, EPOC was measured only during one hour, but its value in liters of EP in the study that conducted by Osterberg & Melby (2000) on women, researchers found that after a 100-minute resistance exercise session that consisted of 5 sets of 10 different movements with 10 to 15 repetitions per set and an intensity of 70% IRM , the amount of oxygen consumption decreased rapidly during the initial stages of recovery, but it became uniform almost a minute after exercise.

But EPOC was still present during the 3 hours of post-exercise measurement, so that during the last 30 minutes, VO_2 was 13% higher than the baseline VO_2 before exercise. Probably, the longer duration of the exercise program and the high number of sets and the repetitions in this study caused a large and long-term increase in EPOC compared to the present study. In a study conducted by Thornton & Potteiger (2002) on 14 trained women, the researchers showed that when two sessions of resistance exercise in terms of Equalize the volume and manipulate the intensities, exercise with a higher intensity produces a greater EPOC. In this research, for the low intensity stage, the movement was performed in 2 sets of 15 repetitions at 45% 8RM, and for the high intensity stage, the same 9 movements were performed in 2 sets of 8 repetitions at 85% ARM, and each stage lasted 26 and 23 minutes, respectively (Thornton & Potteiger, 2002). The research of Thornton & Potteiger (2002) is very similar to the present research in terms of the type of comparison he made. The research of Thornton & Potteiger (2002) measured EPOC at 0 to 20 minutes, 45 to 60, and 105 to 120 minutes after exercise. This problem made it difficult to compare the results of two studies.

Anaerobic exercise and especially resistance exercise can cause disturbances in metabolic processes during exercise, which are manifested by increasing heart rate and RER during resistance exercise. Many of the mechanisms mentioned above return to resting levels almost quickly after the end of the exercise session, and these mechanisms do not increase metabolism 12 to 21 hours after exercise. These mechanisms include rebuilding the phosphagen system, rebuilding hemoglobin and myoglobin reserves, solving the increased requirements in cardiac and respiratory muscles, improving increased muscle blood flow, improving body fluid distribution, and clearing lactate to resting levels (Sirithienthad, 2006; Eghbal et al., 2018). Others, such as increased protein synthesis, regeneration of glycogen stores, increased hormones, increased body temperature, and increased lipid oxidation may require more than 12 hours to return to resting levels.

Some studies have reported a positive relationship between resting metabolic rate and body temperature (Laforgia, 1997; Sirithienthad, 2006; Eghbal et al., 2018). In most researches, the body temperature of the subjects and the temperature of the environment are controlled in different ways, but in the present study, this issue was not addressed. Also, in the present study, due to the distance between the weight training hall and the sports physiology laboratory of the university. Inevitably, there was a 5-6 minute break between the end of exercise and the beginning of breathing gas collection. Due to the The fact that the initial minutes of recovery after resistance exercise is very important in EPOC calculations, probably one of the reasons for the low estimate of EPOC in the present study is the loss of the initial minutes of exercise, one of the important factors that contribute to increased RMR and EPOC after exercise. Residual effects of hormones and glycogen regeneration are why researchers have reported high levels of growth hormone and plasma norepinephrine after exercise. Their effects may increase metabolism for hours, growth hormone increases lipolysis, and the amount of growth hormone in plasma is directly related to the intensity and duration of exercise, which causes more responses in people who are not ready than those who are ready, the levels of catecholamines later it remains high from resistance exercise, but its effects do not last for many hours.

The underlying mechanism that affects resting metabolic rate more than 12 hours after resistance exercise may be due to an increase in protein turnover. Because protein repair is energetically expensive and consumes approximately 15-20% of RMR during resting conditions, resistance exercise usually produces a specific amount of muscle damage that increases protein synthesis. reported an increase in RMR and showed that the increase in RMR is due to an increase in protein synthesis due to muscle damage. In another study, Dolizal et al. 1998 reported that creatine kinase significantly increased up to 72 hours after exercise compared to the baseline state. Of course, in this research, resistance exercise with eccentric workload was used, however, this increase in RMR, which occurs due to protein regeneration, may appear in the initial stages of a resistance training program, and it may be used as one in the later stages of training. This increase in RMR

should be reduced from the adaptations of training. In the present study, the subjects had not exercised and the possibility of muscle damage was one of the reasons for the increase in RMR on the day after their exercise.

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