Effects of Resistance Training on EPOC

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Introduction

In a study by Wescott (1), found that inactive adults experience 3-8% loss of muscle mass per decade with a reduction of metabolic rate and increases in fat accumulation. Unfortunately, according to the CDC, only 23.2% adults 18 years and older are meeting physical activity guidelines for aerobic and muscle strengthening activity. Aerobic exercise has many benefits and in a study by Azad, Gharakhanlou, Niknam, and Ghanbari (2), found aerobic exercise can improve lung function by strengthening the respiratory muscles in overweight and obese students. An increase in lung function and stronger respiratory muscles is important because it allows for greater oxygen consumption and better gas exchange which can help with exercise and activities of daily living.

Excess post oxygen consumption (EPOC) or "afterburn" usually associated with aerobic training but now research is showing that EPOC may occur after resistance training as well. EPOC is the amount of oxygen the body consumes following an exercise session that is greater than the amount of oxygen the body was consuming before exercise. During exercise we bring the body out of homeostasis by increasing heart rate, increasing blood pressure, accumulating local metabolites around the skeletal muscle, and elevate our oxygen consumption. According to Arney, Blaine, and Foster et al., (3), the excess oxygen is used to create the energy necessary to restore the body after exercise. Although, aerobic exercise is shown to cause EPOC researchers are finding more and more that resistance training (RT) is not only good for muscular adaptations but is beginning to prove similar benefit in increasing caloric expenditure and increasing oxygen consumption after exercise.

Resistance training is a type of physical activity in which the individual lifts an external load potentially causing gains in strength, power, or muscle growth. RT has many benefits which includes improved physical performance, movement control, walking capacity, independence, cognitive abilities, and self-esteem. As stated before RT programs also aid in muscular adaptations and weight loss and with manipulation of a RT program a person can have various different results as researchers found during a 10-week RT program RT increased lean weight by 1.4kg, increasing resting metabolic rate by 7%, and reduced fat weight by 1.8kg (1). For many, resistance training is used to increase muscle mass and aid in weight loss and resistance training that is focused on hypertrophy is associated with amount of muscle damage is associated with greater EPOC responses (3). Previously, EPOC has usually been associated with aerobic exercise but recent literature has demonstrated that EPOC occurs after RT as well. Accordingly, EPOC's contribution towards weight loss following RT may be a significant source of energy expenditure and warrants further investigation. Therefore, the purpose of this review is to show the effects of RT on EPOC.

Exercise and Energy Expenditure

Typically, when people think of lifting weights they only think of the amount of muscle and strength gained that occurs and not the benefit it has on the energy expenditure and their resting metabolic rate seen in a study by Greer, Sirithienthad, Moffatt, Marcello, and Panton (4), compared EPOC between isocaloric bouts of steady state aerobic, intermittent aerobic, and RT. They took 10 men and had them perform 3 bouts of exercise RT, steady state (SS), and high intensity aerobic (IT) separated by 7 days. Although, total energy expenditure did not differ among the groups, respiratory exchange ratio (RER) was higher in RT than SS and at 12-hours post exercise, resting metabolic rate (RMR) was also higher in RT at 4.3mL/kg/min verses IT at 3.5mL/kg/min. Researchers found that RT increased the RMR and RER meaning the subjects had a greater reliance on anerobic metabolism. They concluded EPOC was significantly greater in RT and IT than SS. This study showed that RT has a greater effect than steady state aerobic exercise at increasing EPOC. Although, aerobic exercise has been established as an effective training method to induce EPOC and increases in caloric expenditure, RT is beginning to show similar findings.

There are many different ways to resistance train and many different training volumes that can shows us the effects of RT has on EPOC. In many RT programs training variables such as volume (sets, reps) and intensity (weight) are manipulated depending on the training goal as well as increases in energy expenditure (EE) and RER. Farinatti, Neto, and Amorim (5), states resistance exercise has been shown to increase resting energy expenditure and increase post exercise lipid oxidation. Lipid oxidation is the breakdown of fats for the use of energy during physical activity. In the same study 10 male volunteers performed multiple sets of leg press (LP) and chest fly (CF) for 5 sets of 10 repetitions with a 15-repetition maximum, and 1 minute rest between intervals. Researchers found EPOC increased following both exercises but was significantly greater following LP compared to CF, 7.36 ± 1.10L vs 4.73 ± 0.99L, respectively. Additionally, RER was higher in LP than during CF exercise(5). These findings show that when RT is done on large muscle groups like the legs, energy expenditure is greater and can cause a grater response in energy expenditure and EPOC during and after RT.

Oxygen Supply and Demand

Oxygen consumption is going to very depending on the type of exercise and the intensity and it can also very depending on the type of resistance exercises someone is engaging in as seen in a study by Vianna, Werneck, Coelho, Damasceno, and Reis (6). Researchers studied oxygen uptake during different types of resistance exercise in 14 males and found Vo2peak values after the half squat, followed by the pull-down, and triceps pushdown exercises and found the values were all higher than the VO2 observed for the bench press and EPOC was highest for the half squat than the bench press. This is important

because it shows that in the squat there is an increase in oxygen uptake and causes EPOC to occur afterwards which shows that the bigger the muscle used the more oxygen used during the exercise.

The amount of oxygen consumed after the different exercises were different as working different muscles require more energy possibly due to the size of the muscle and amount of energy needed to use it seen in the study by Vianna, Werneck, Coelho, Damasceno, and Reis (6). The amount of external load placed on that muscle will also be vastly different as we are able to handle more weight with our legs, chest, and back than our arms and abdominals due to the muscle size. In the study Farinatti, Neto, and Amorim (5), looking at the oxygen uptake between different exercises they found VO2 during exercise was higher in LP than in CF and EPOC was also higher after LP than CF until four minutes of recovery. The leg press in the study produced greater EPOC than the chest fly and total VO2 net in LP was significantly higher than CF at 40min recovery (5). This study found that LP caused a greater EPOC response due to the type of muscles used. This supports the larger muscle hypothesis which was made earlier in the review as this study also finds that larger muscles cause a greater EPOC response. In this study the legs were being compared to the chest, the legs being a bigger muscle than the chest caused a greater response in EPOC in the LP compared to CF.

VO2 was found to be greater among different exercises in RT but what about the various other types of RT styles of training? A study by Alves, Freitas, and Saavedra et al., (7) compared oxygen uptake during exercise in RT and exercise performed on ergometers. Alves, Freites, and Saavedra et al., found statistically greater values in VO2 in ergometer exercise (Ee) compared to strength training (St) with Ee at 24.96ml/kg/min compared to St at 21.66ml/kg/min. These differences were only seen after 20 minutes of exercise but absolute VO2 values between the sessions did not reveal significant differences between Ee and St as VO2 was not significant between the different trials. They concluded that load and intensity and not the material/equipment used for exercise are variables that best influence oxygen uptake (7). Although, the previous study found that an EPOC response occurs depending upon intensity this still supports the purpose of this review to show the effects of RT on EPOC.

Volume and Intensity

When we train for a long time at high enough intensity or just the amount of time we spent exercising there is going to be some EPOC that occurs and this doesn't only happen just a few minutes after exercise, EPOC can occur hour after exercise and a study by Binzen, Swan, and Manore (9)., found how long EPOC can occur after exercise. Researchers put 10 resistance trained women through two trials of controlled sitting and RT. The RT consisted of 3 sets of 10 exercises, at 10 repetition maximum with 1-minute rest period. They found EPOC lasted for 2-hours and within the RT group EPOC was 33.4L ± 5.1L compared to the control group of 27.2L ± 0.3L (9). Doing resistance training of

10 repetitions which can be difficult depending on the amount of weight lifted can induce various changes in EPOC depending on intensity and volume.

High volume exercise like doing 3 sets of 10 exercises, at 10 repetitions induces an EPOC response and a study looking at lifting a high percentage of 1RM also showed a response in EPOC. In a study by Elliot, Goldberg, and Kuehl (10), had 9 subjects conduct 40-minutes of cycling at 80% HR max, 40-minutes of circuit training, 40-minutes of heavy resistance training at 80-90% of 1RM for 3-8 repetitions for 3 sets, and 40-minutes cycling. Researchers found all forms of exercise increased metabolic rate post exertion. Circuit training and heavy RT was significant 30-minutes post exertion in metabolic rate with an average caloric use of 51kcal ± 31kcal in RT, 49kcal ± 20kcal in circuit training, and cycling caloric use of 32kcal ± 16kcal. These researchers found EPOC was significant in all forms of training and concluded that the amount of exercising skeletal mass is an additional variable to consider when relating exercise to EPOC (10). This finding is supported by others who demonstrated that RT using large muscle groups showed significant increases in EPOC (5).

Conclusion

In the past EPOC was mainly associated with aerobic exercise but as more research is being done researchers are finding that EPOC can also occur after resistance training as well. Researchers have also shown EPOC occurs following both low volume high intensity as well as high volume low intensity exercise and can last over 30 minutes and upwards of 2 hours post exercise depending on the exercise, intensity, and muscle groups involved (9). Although, doing less intense exercise like 3 sets of 10 repetitions is enough to cause EPOC as well as other studies have shown intensities of 80-90% of a 1RM (10) also has a positive effect on EPOC as well as an increase in caloric expenditure and using larger muscles elicited a greater consumption of oxygen. Based on the findings of the current review, we recommend that more individuals engage in RT that is both high volume low intensity, and low volume high intensity appear to be effective at increasing EPOC, large muscle groups should be used, and longer duration of exercising these muscles seems beneficial to the response as well to take advantage of EPOC in addition to the known muscular skeletal benefits.

ELEMENTS

1. Apply It
    - Implementing more compound movements like squat, bench, and deadlift in a resistance training program will increase caloric expenditure during and after training.
    - High volume training like 3 sets of 10 repetitions and 10 exercises is shown to cause the effects of EPOC up to 2-hours.
2. Bridging the Gap

- Excess post oxygen consumption (EPOC) which is the amount of oxygen consumed following exercise used to be more associated with aerobic exercise, but researchers are finding it can occur during resistance exercise as well. Manipulating sets, reps, and exercise intensity you can extend the amount of time EPOC occurs after exercise. Including compound exercises can lead to EPOC and an increase caloric expenditure because of the large muscle masses used.

3. Summary
    - Resistance training is showing to have a great effect on EPOC in training volumes that include 3 sets of 10 repetitions and 10 exercises can make EPOC last for up to 2-hours as well as exercises that use large muscle masses that include the legs have shown to cause EPOC and increases in caloric expenditure. RT is showing more than just a method to aid in weight loss and body composition.
4. Pulled Text
    - Although, aerobic exercise is a good way to reach EPOC and also has other benefits in increasing cardiorespiratory function, resistance training is beginning to show similar findings.

Bio

Dominic Donio, currently he is student pursuing his bachelors degree in Exercise Science at the University of New Mexico where and will pursue a certification in Clinical Exercise Physiology after graduation. His interests include powerlifting, listening to epic movie scores while cooking, and reading everything from fiction to research articles.

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