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Original Article

Effects of Training with Free Weights and Training with Machines in The Presence of Intermittent Fasting: A Systematic Review

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Abstract

This study *aims* to analyse the scientific literature and highlight the effects of training with free weights compared to training using machines in the context of applying intermittent fasting as a method of manipulating body composition. Our research starts from the *hypothesis* that no significant differences exist between free-weight and machine-based training on body composition when intermittent fasting is applied. *Materials and method:* this paper is a review study aimed at analyzing the existing scientific literature on the influence of intermittent fasting on physical performance. The search for articles was conducted in October 2024, using the scientific databases *PubMed, Google Scholar, and ScienceDirect.* Initially, 45 articles were identified, of which 20 were selected for analysis based on various inclusion criteria. *Results:* The studies demonstrated that free-weight training leads to significant improvements in muscle strength, particularly for the legs and triceps.

1. Introduction

Sports training refers to a set of planned and structured physical activities carried out to improve performance, strength, endurance, or skills in a specific field. It can include physical exercises, specific sports practice, or personal and professional development activities. Sports training usually takes place over a period of time and follows a well-structured program (Zhong et al., 2024; Zimei, Liansu, Yuheng, Bing, & Gang, 2023). Regarding sports *training with free weights*, it refers

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to using free weights, such as barbells or dumbbells, without the use of fitness machines. These exercises are often used to develop strength and muscle mass directly (Dumitru, 2022, p. 123-124).

Training with machines is used in sports training with fitness equipment specifically designed to develop strength and muscle mass. These machines offer support and guidance during exercises, facilitating correct movement execution, reducing injury risk, and isolating specific muscles.

In the study conducted by Schott, Johnen and Holfelder (2019), they demonstrate that machine-based training is a key factor in counteracting the functional decline caused by ageing, as free weight exercises mimic daily activities. The study involved 32 male and female participants aged 60 to 86. They trained the same muscle groups for 26 weeks, with two workouts per week, performing 10-12 repetitions (3 sets) plus 20 minutes of endurance training. Three measurements were taken at the start, after ten weeks, and at the end of the 26 weeks. Dynamic strength, isometric strength, and endurance were measured. The results showed that the Mancova analysis demonstrated significant increases in both training with free weights and training with machines. However, there were two exceptions: in the legs (113% vs. 44%) and triceps (89% vs. 28.3%) for free weight exercises. The conclusion was that training with free weights led to improvements in leg and triceps strength, though the study did not indicate a clear superiority of free weights over training with machines (Schott, Johen & Holfelder, 2019).

In another comparative study conducted by Schwanbeck, Cornish, Barss and Chilibeck (2020), it is demonstrated that training with free weights is more unstable than training with machines, with the advantage provided by a "Cam" pulley system, which might better match strength curves. The study was conducted to compare the two types of training in terms of muscle mass, free testosterone, and free cortisol concentrations. Conducted on 48 subjects (26 women and 22 men), the participants were monitored over eight weeks, training with either free weights or machines, performing 4-10 repetitions in 3-4 sets (2-3 workouts per week). Muscle thickness and strength were measured in the first and last week (week 8), and hormone concentrations were measured at the start, in the middle (week 4), and at the end of week 8. The results showed that the biceps and quadriceps muscles grew in both types of training ($p<0.01$). There was a significant difference in exercises like the press, where machine-based training (press) showed a more significant increase than the bench press with free weights (13.9% vs. 8.6%). Men who performed training with free weights had a greater increase in testosterone than those who trained with machines. There were no differences between the training types regarding free cortisol during acute resistance exercises. The conclusion was that training with free weights led to an increase in testosterone in men, but overall, both free weight and machine-based training similarly led to increased strength and muscle mass (Schwanbeck, Cornish, Barss & Chilibeck, 2020).

In the recent meta-analysis carried out by researchers Haugen et al., (2023), the authors conclude that the effectiveness of training using free weight versus machine exercises is increasingly debated. This study aimed to conduct a meta-analysis

comparing these two types of training, with the final goal of measuring maximum strength, hypertrophy, and jump performance. The meta-analysis (PRISMA) was conducted on a group of individuals (1,016 participants, including 789 men and 219 women) aged 18 to 60 over six weeks. The results demonstrated that strength increased significantly more with training with free weights than with training with machines (SMD: -0.210, CI: -0.391, -0.029, p = 0.023). However, in resistance testing, training with machines showed a greater improvement than training with free weights (SMD: 0.291, CI: -0.017, 0.600, p = 0.064). Nevertheless, no differences were found between the two types of training when measuring dynamic resistance (SMD: 0.084, CI: -0.106, 0.273, p = 0.387), isometric resistance (SMD: -0.079, CI: -0.432, 0.273, p = 0.660), countermovement (SMD: -0.209, CI: -0.597, 0.179, p = 0.290), or hypertrophy (SMD: -0.055, CI: -0.397, 0.287, p = 0.751). The conclusion was that there were no significant differences in the direct comparison of strength, jump performance, or hypertrophy. The current evidence and data indicate that changes in strength are attributed to the training method, and the choice between training with free weights or using machines depends entirely on individual preferences and goals (Haugen et al., 2023).

Fasting is a practice that involves abstaining from food and drinks for a set period of time. This method has been used throughout history for religious and therapeutic reasons, and it is now increasingly popular among those seeking to improve metabolic health and manage body weight (Albosta & Bakke, 2021).

Fasting types:

1. *Intermittent fasting*: This is the most popular type of fasting today and involves cycles of fasting and eating. The most common variations are:

• *16/8:* Fasting for 16 hours with an 8-hour eating window.

• *5:2:* Eating normally for 5 days and significantly reducing calories (500-600 kcal) on 2 non-consecutive days.

• *Eat, Stop, Eat:* It involves fasting for a whole day once or twice a week.

2. *Extended fasting*: Fasting lasts for more than 24 hours, reaching up to 48 or even 72 hours, but requires careful monitoring to avoid adverse effects.

3. *Alternate-day fasting*: In this method, a person fasts for one day, followed by a day of normal eating. On fasting days, minimal calories are consumed or none at all.

4. *Religious fasting*: Practiced for centuries in various religions, such as Ramadan fasting in Islam, Lent fasting for Christians, or fasting in Hinduism (Diab, Dimachkie, Zein, Dakroub, & EID, 2024; Vasim, Majeed, & Deboer, 2022).

Benefits of fasting:

• *Weight loss*: mainly through reducing caloric intake and stimulating fat-burning processes (Moro et al, 2016).

• *Improved insulin sensitivity*: fasting helps regulate insulin levels, which can prevent type 2 diabetes and other metabolic conditions (Joaquim, Faira, Loureiro & Matafoma, 2022).

• *Autophagy*: fasting stimulates the cellular process where the body breaks down and removes damaged cellular components, with a regenerative effect at the cellular level (Takeshige, Baba, Tsuboi, Noda, & Ohsumi, 1992).

• *Improved cardiovascular health*: fasting has been shown to reduce LDL cholesterol levels, triglycerides, and blood pressure (Pammer et al., 2024).

• *Brain benefits*: fasting can enhance cognitive function, protect against neurodegenerative decline, and reduce the risk of diseases like Alzheimer's (Blumberg, Hahn, & Bakke, 2023).

Precautions:

• *Hypoglycaemia:* people with diabetes or hypoglycaemia need to be cautious, as fasting can lead to dangerously low blood sugar levels.

• *Eating disorders:* those with a history of eating disorders should avoid fasting, as it may trigger unhealthy behaviours.

• *Malnutrition:* prolonged fasting can lead to vitamin and mineral deficiencies if not well-planned.

Fasting can be an effective strategy for improving metabolic health and managing weight, but it is crucial to do it responsibly and tailor it to individual needs, especially for athletes or people with medical conditions. To avoid potential risks, it is recommended that you consult a specialist before starting a fasting program.

A systematic review conducted by Keenan, Cooke and Belski (2020), supports the growing popularity of intermittent fasting as a method of body composition manipulation, both for strategic and religious reasons (e.g., Ramadan). While resistance training has been proven effective in increasing muscle mass, it is unclear whether the same effect occurs during intermittent fasting. This review aims to analyse human studies investigating the effects of intermittent fasting with resistance training on muscle mass in untrained or non-elite-trained individuals. Body weight, fat mass, and lipid profile changes were also evaluated. Among the eight selected studies, lean body mass was generally maintained, with one reporting a significant increase. Fat mass was significantly reduced in five studies. The conclusion is that intermittent fasting and resistance training generally maintain muscle mass and promote fat loss. Long-term research is suggested to compare intermittent fasting with traditional calorie restrictions (Keenan, Cooke & Belski, 2020).

A study by Dai et al. (2024), evaluated the effectiveness of time-restricted feeding (TRF) combined with exercising compared to a control diet combined with exercising in improving body composition and metabolic health in adults. The meta-analysis included 19 randomised controlled trials (RCTs) with 568 participants. Results showed that TRF combined with exercise significantly reduced body mass (-1.86 kg) and fat mass (-1.52 kg) compared to the control diet. In terms of metabolic health, decreases in triglycerides (-13.38 mg/dL), low-density lipoproteins (LDL) (-8.52 mg/dL), and leptin (-0.67 ng/mL) were observed. However, TRF combined with exercising did not have an additional effect on glycaemic profile (glucose and insulin) or other lipids (total cholesterol and high-density lipoproteins - HDL). The conclusion is that TRF combined with exercising may be more effective than a control diet with exercising for weight loss and fat mass reduction and improving the lipid profile. This approach may be beneficial for people looking to lose weight and improve metabolic health (Dai et al., 2024).

Drummond, Soares, Savoi and Silva (2023), investigated the effects of 12 and 16 hours of intermittent fasting (IF) on strength and power performance in young, resistance-trained men. They analysed maximum voluntary isometric contraction (MVIC), countermovement jump (CMJ) performance, as well as the maximum number of repetitions (MNR) and total volume load (TVL) in the back squat and leg press at a 45° angle. Subjects were tested in three states: fed, 12 hours of IF, and 16 hours of IF. Results showed that fasting did not significantly affect strength and power performance: MVIC, CMJ, MNR, and TVL showed no notable differences between conditions. However, hunger levels were significantly higher after 16 hours of fasting compared to 12 hours of fasting and the fed state. Additionally, the urge to eat increased after 16 hours of fasting. The study suggests that 12 or 16 hours of intermittent fasting does not significantly impact strength and power but that longer fasting periods increase hunger and the urge to eat (Drummond et al., 2023).

In their study, Williamson and Moore (2021), state that muscle protein is in a constant renewal process, with old proteins breaking down and new ones being synthesised. This balance between breakdown and resynthesis determines whether muscle mass increases, stays the same, or decreases. Muscle protein renewal is heavily influenced by diet, significantly impacting the mass, quality, and health of skeletal muscles over time. Intermittent fasting has become popular among persons interested in health and body composition due to its potential to promote a caloric deficit, increase fat burning, and enhance fat oxidation due to reduced daily insulin responses. However, this approach does not account for the anti-catabolic effect of insulin on muscles, which is an essential factor in maintaining muscle mass (Williamson & Moore, 2021).

Muscle protein synthesis (i.e., the primary process regulating its renewal) is activated by consuming amino acids from food, but there is a saturation threshold at moderate protein intake levels. Studies on the effects of intermittent fasting on muscle mass are limited, but there are concerns that prolonged fasting periods and infrequent meals, typical of this diet, may hinder the optimisation of muscle protein synthesis and the net protein balance. Thus, intermittent fasting could be a suboptimal strategy for maintaining or increasing muscle mass and quality, especially during periods of energy deficit, potentially compromising muscle remodelling goals (Williamson & Moore, 2021).

According to researchers Lange et al. (2024), intermittent fasting (IF) has proven to be as effective as continuous calorie restriction in terms of weight loss, and some studies suggest it may lead to greater fat loss compared to an unrestricted diet (ad libitum). Although the effects on fat mass and body fat percentage are positive, there are no significant differences between IF and continuous calorie restriction in terms of fat reduction, despite some recent research indicating a potential superiority of IF. The evidence is mixed regarding the impact on insulin resistance, blood glucose, and lipid profile, with some studies showing improvements and others not. Studies that analysed fasting during Ramadan in Muslim populations have shown that this type of fasting can lead to weight loss and improvements in metabolic parameters during the fasting period, but these effects may be reversible once fasting

ends. The overall conclusion is that intermittent fasting is an effective method for weight control, being more efficient than an unrestricted diet and comparable or superior to continuous calorie restriction. However, the evidence of its benefits for glucose metabolism and lipid profiles is not yet clear enough to draw definitive clinical conclusions (Lange et al., 2024).

Naous, Achkar and Mitri (2023), highlight that intermittent fasting (IF) has gained popularity as a method for weight control and reducing cardiovascular risks, being a promising strategy for controlling metabolic syndrome (MetS). This review analysed interventional studies and meta-analyses to assess the effects of different types of IF on body mass index (BMI), blood glucose, lipid profile, and blood pressure. The results show mixed effects of IF, with types like time-restricted feeding (TRF) and alternate-day fasting (ADF) consistently showing reductions in BMI. In contrast, the effects of intermittent energy restriction (IER) were less clear. Regarding blood glucose and lipid profiles, TRF and ADF had positive results, but *the impact of IER remained variable. While IF shows potential for managing* metabolic syndrome, further research is needed to understand its long-term effects and optimise its application in controlling cardiovascular risk factors (Naous, Achkar & Mitri, 2023).

2. Material and methods

2.1 Study Aim and Hypothesis of the current study

This study *aims* to analyse the scientific literature and highlight the effects of training with free weights compared to training using machines in the context of applying intermittent fasting as a method of manipulating body composition.

Our research starts from the *hypothesis* that no significant differences exist between free-weight and machine-based training on body composition when intermittent fasting is applied.

2.2 Research methods

2.2.1 Literature search

The review was conducted in accordance with the requirements for systematic reviews, and the systematic literature search was carried out until October 18, 2024. The targeted studies directly compare training using free weights with machine-based training in the context of applying intermittent fasting as a method of body composition manipulation. The reviewed studies highlight the benefits of each type of training, including the influence of intermittent fasting on physical performance and metabolic outcomes. By synthesising the results of previous research from specialised databases such as PubMed, MEDLINE, Google Scholar and Web of Science, the study aims to provide a clear understanding of how these two training methods can be integrated to maximise training efficiency and improve individual body composition.

The searches were conducted using the following *keywords*: training with free weights, training with machines, intermittent fasting, and body composition.

2.2.2 Measures

Data extraction. As for *inclusion criteria*, the studies considered eligible for this review (including studies, systematic reviews, and meta-analyses with approximately 230 citations) were selected based on strict criteria. Initially, 84 articles were identified, of which 20 were selected for analysis based on various inclusion criteria. Only studies published in the past ten years that evaluated the effects of free weight and machine-based training among healthy participants or athletes were included. Studies with inadequate methodologies, small sample sizes, or failure to align with the research objective were excluded.

2.2.3 Procedure

The data were extracted from the articles selected, focusing on *key variables* of interest such as strength, muscle hypertrophy, and metabolic parameters influenced by intermittent fasting. Each study was analysed relying on the methodologies used and the findings obtained. The extracted data were included in Microsoft Excel, and the studies were carefully grouped to identify the percentage of the total accumulated data that addressed the benefits of each type of training.

3. Results and Discussions

Out of 84 studies evaluated, 20 were included in the present research. All of these studies highlight the benefits of each type of training, including the influence of intermittent fasting on physical performance and metabolic outcomes.

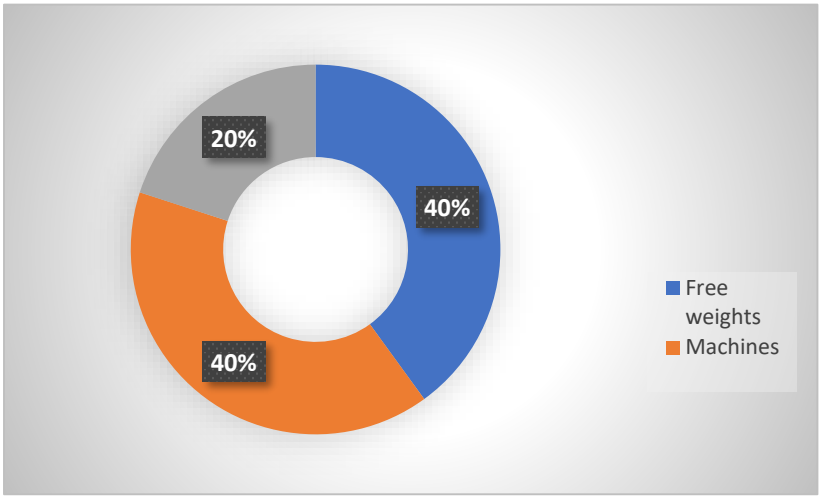

Figure 1. *Training with weights vs. training with machines*

Figure 1 illustrates that studies have shown that training with free weights offers significant improvements in muscle strength, particularly for legs and triceps, with increases of 113% and 89%, compared to 44% and 28.3% in the case of training with machines. The primary benefit of this type of exercise lies in the functional improvement, which mimics daily activities. On the other hand, training with

machines showed better results in isolated exercises, such as the press, where there was a 13.9% increase compared to 8.6% for the bench press. The main advantages of training with machines are increased safety, guided movements, and reduced risk of injury. However, some studies do not indicate the superiority of one method over the other regarding hypertrophy or dynamic resistance, highlighting mixed or insignificant results.

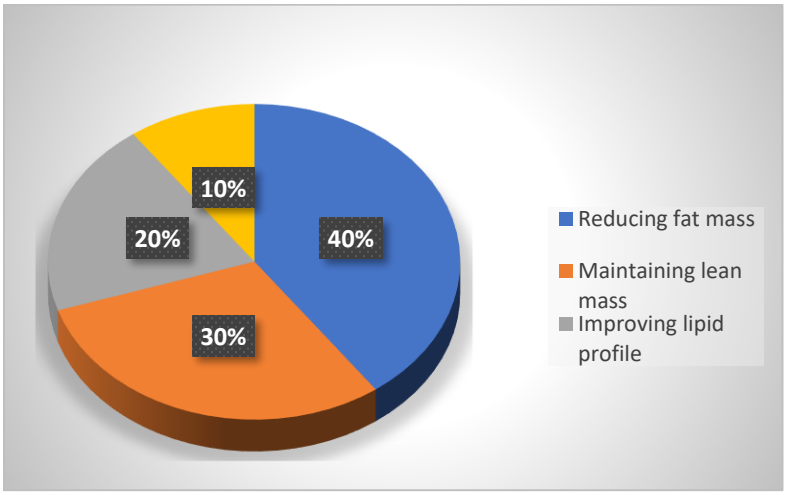

Figure 2. *Impact of intermittent fasting*

Most studies show that intermittent fasting, combined with physical exercise, leads to a significant reduction in fat mass, with some research reporting a decrease of 1.86 kg in total body mass and a loss of 1.52 kg of fat. In terms of muscle mass, studies generally indicate that it does not decrease, especially when intermittent fasting is combined with resistance training, with some research even showing a slight increase in muscle mass. In addition to these effects, intermittent fasting has been associated with improved lipid profile, including reductions in triglycerides and LDL cholesterol, as well as an overall improvement in metabolic health, such as decreased leptin levels. However, some studies have reported mixed or insignificant results, failing to find apparent effects on glycaemic profiles or other lipids, such as HDL cholesterol (Figure 2).

Discussions

The study conducted by Ashtary-Larky et al. (2021), and the current research study share a common approach in evaluating the impact of intermittent fasting (IF) combined with resistance training (RT) on body composition, but there are some notable differences. For instance, Ashtary-Larky's et al. (2021), study focused on a meta-analysis that included eight studies with 221 participants, comparing the effects of IF and non-IF diets. The findings of this study showed a significant effect of IF on body weight, fat mass, BMI, and body fat percentage, but it did not have a significant impact on fat-free body mass. On the other hand, our research expands the analysis to include the effects of both free weight and machine-based training in

the context of intermittent fasting. This research study emphasises improvements in muscle strength and body composition in both types of training, with a particular focus on the combined effects of IF and RT on muscle mass and fat reduction. While Ashtary-Larky's study focuses more on the comparison between IF and non-IF diets without observing significant changes in lean muscle mass, *the current research* highlights that, in some instances, IF combined with RT can even lead to muscle mass gain, suggesting a more diversified approach to the impact of intermittent fasting on training (Ashtary-Larky et al., 2021).

4. Conclusions

This research study highlighted the significant impact of both free weight and machine-based training on physical performance and body composition, especially in the context of intermittent fasting. Findings suggest that both types of training offer clear benefits, although the specific effects vary depending on individual goals. Training with free weights has been shown to be more effective in improving dynamic and isometric strength, particularly for leg and triceps muscles, while machine-based training provides better safety and muscle isolation, making it ideal for individuals seeking controlled muscle development.

Additionally, intermittent fasting demonstrated positive effects on body composition, mainly through fat mass reduction and the preservation of muscle mass. These findings emphasise that intermittent fasting, combined with resistance training, can effectively improve metabolic parameters and optimise body composition.

However, more long-term studies are required to fully assess the combined effects of intermittent fasting and resistance training, particularly regarding physical performance and muscle mass preservation during periods of calorie deficit. Our study contributes to understanding how these methods can be integrated into training routines, offering valuable insights for future research.

Research limitations

This study presents several limitations that must be considered when interpreting the findings. First, the variability among the analysed studies regarding participant samples represents a significant limitation. Differences in age, gender, fitness levels, and training styles among participants make it difficult to generalise conclusions to a broader population. Additionally, the varying duration of interventions and the different types of intermittent fasting protocols used in the studies may influence the results, limiting the ability to draw clear conclusions about the long-term effects of intermittent fasting on physical performance and body composition. Another limitation is related to the methods used to measure the results. The studies applied different methods to evaluate strength, hypertrophy, and metabolic parameters, which could introduce variations in the results and make direct comparisons between studies difficult. Furthermore, many studies included here had a short duration (e.g., 6-8 weeks), which does not allow for a full assessment of the long-term effects of intermittent fasting and free weight or machine-based training. Lastly, a significant limitation is the lack of long-term randomised controlled trials,

which could provide more solid data regarding the effectiveness of these combined methods. Additionally, the findings may have been influenced by other factors, such as participants' diets, which were not controlled in all the studies.

Future research directions

As future research directions, we propose analysing these effects in the long term.

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