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A Review of Strategies for Achieving Simultaneous Muscle Mass Gain, Maintenance, or Minimal Loss During Fat Reduction: Insights from the Last 5 Years

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Abstract

Introduction

Body recomposition, defined as the simultaneous reduction of fat mass and the gain or maintenance of muscle mass, is considered a metabolic challenge due to the opposing processes of catabolism and anabolism. Traditionally, it has been thought that these two goals are difficult to reconcile. However, new analyses suggest that with the application of appropriate dietary and training strategies, achieving recomposition is possible.

Materials and Methods

The work used the rapid review method. This review integrates findings from studies published between 2019 and 2024, sourced from the PubMed platform, which consists of multiple databases. Keywords used included "body recomposition," "muscle gain," "fat loss," "high-protein diet," and "resistance training."

Results

Studies consistently show that certain strategies can support the maintenance or even increase of muscle mass during caloric restriction and fat loss.

Conclusions

Through a strategic combination of dietary and training interventions, significant improvements in muscle and fat tissue can be achieved. These findings provide practical guidance for clinical

and athletic applications, though further analyses are necessary to refine protocols for specific clinical groups.
Keywords: body recomposition, muscle gain, fat loss, high-protein diet, resistance training, HIIT, nutrient timing

Introduction

Muscle tissue is not only a component responsible for physical strength or appearance; it plays a key role in overall metabolic health. Muscles are highly metabolically active, which means they burn calories even at rest, directly influencing our basal metabolic rate (BMR). The more muscle we have, the higher our BMR, allowing for a greater daily caloric expenditure. This effect facilitates maintaining a healthy body weight and reduces the need for restrictive calorie limitations to achieve or sustain a healthy weight [1]. A higher BMR is associated with better lung function, suggesting that in the treatment of asthma associated with obesity, the focus should not only be on fat reduction but also on maintaining a high BMR. This can support metabolism and improve long-term lung function [2].

Improving body composition is crucial in the context of diabetes. For men, low muscle mass itself is a significant risk factor for type 2 diabetes. Even when accounting for fat levels and its distribution, men with lower muscle mass have a higher risk of developing diabetes. This indicates that increasing or maintaining muscle mass can be an essential strategy for reducing diabetes risk, independent of body fat levels. For women, however, the key risk factor for diabetes is more closely related to fat distribution rather than muscle mass. Excess fat tissue, particularly around the abdomen (android obesity), is linked to a higher risk of diabetes. Therefore, for women, it is vital not only to maintain muscle mass but also to control fat distribution to reduce metabolic risk [3].

Muscles are the primary site of glucose utilization in the body, meaning their health directly impacts metabolism and insulin response. Supporting muscle development also enhances insulin sensitivity, reducing the risk of insulin resistance and type 2 diabetes. Maintaining a high myogenic potential, or the ability of muscles to regenerate, allows them to effectively respond to the body's glucose metabolism needs. Reduced activity of key proteins supporting these processes and weakened regenerative potential can lead to a decline in muscle function, which affects their ability to uptake glucose in response to insulin [4].

In 2022, it was noted that 1 in 8 people worldwide were living with obesity, representing a significant increase compared to previous decades [5]. Moreover, in the same year, approximately 31% of adults globally did not meet recommended levels of physical activity, translating to about 1.8 billion people at increased risk of diseases associated with physical inactivity [6].

Objective

The importance of body composition percentages and related statistics highlights the urgent need for effective strategies that not only promote fat loss but also support the development and maintenance of muscle mass. Body recomposition can play a crucial role in global health initiatives aimed at counteracting the growing epidemic of obesity and associated chronic diseases. The aim of the review is to present scientific methods to preserve or minimize muscle mass loss during fat reduction and offer practical tips for achieving fat loss based on research from the past five years.

Materials and Methods

The work used the rapid review method. This review integrates findings from studies published between 2019 and 2024, sourced from the PubMed platform, which consists of multiple databases. Keywords used included “body recomposition,” “muscle gain,” “fat loss,” “high-protein diet,” and “resistance training.” The selected analyses primarily encompass experimental studies.

Results and discussion

1. Dietary Strategies for Body Recomposition

1.1 Adequate Protein Intake

Protein supplementation plays a significant role in improving muscle mass, strength, recovery, and overall body composition. Across various population groups—from young, physically active individuals to older adults and those in a caloric deficit—appropriately tailored protein supplementation can optimize anabolic processes and minimize muscle catabolism. Depending on age, physical activity level, and training goals, recommended protein doses and forms may vary, offering different benefits.

Protein Supplementation for Young and Physically Active Individuals

A review of the impact of protein on body composition indicates that younger, physically active individuals, particularly those engaged in strength or endurance sports, have increased protein requirements. These typically range from 1.6 to 2.0 g/kg of body weight per day, significantly exceeding general recommendations [7]. Protein supplementation, especially with whey protein, is particularly beneficial for this group for several reasons.

Firstly, whey protein is characterized by rapid absorption and high leucine content, which strongly stimulates muscle protein synthesis (MPS), especially after resistance training. Secondly, whey protein enhances the rate of recovery and muscular adaptation, promoting muscle mass gains and accelerating repair processes after intense training sessions [8].

Research on strength-trained men indicates that protein intake of 1.6 g/kg of body weight per day is sufficient to maximize muscle mass gains, strength, and performance. Consuming higher protein amounts (3.2 g/kg) in the same study did not yield additional benefits for muscle mass and strength gains compared to 1.6 g/kg, except for an increase in lower body power. Furthermore, individuals consuming higher protein levels showed elevated markers of liver and kidney function, suggesting that prolonged use of such high doses may require monitoring the health of these organs [9].

Protein Supplementation for Older Adults

Older adults are more susceptible to age-related muscle loss, known as sarcopenia, which can lead to reduced physical function and a lower quality of life. In this demographic, anabolic resistance—the diminished ability of muscles to respond to anabolic stimuli like protein and resistance training—necessitates higher protein doses to support muscle protein synthesis (MPS). Increased protein supplementation combined with resistance exercises supports muscle mass growth.

A study on older women suggests that higher protein intake (≥1.3 g/kg) may provide greater benefits, though optimal muscle mass gains are observed at intake levels of 1.4–2.0 g/kg of body weight per day. This range aligns with recommendations for older adults. Notably, all groups of women who completed a resistance training (RT) program with varying levels of protein intake also experienced reductions in fat mass. This finding indicates that protein intake levels did not significantly affect fat loss but demonstrate the potential for body recomposition [10].

In a caloric deficit, protein supplementation becomes even more critical, as the body may use amino acids as an energy source, reducing their availability for muscle synthesis [11]. Additionally, the choice of protein type can be important in an energy deficit. For instance, whey protein rapidly increases blood amino acid levels and is particularly beneficial post-exercise. Leucine, a key amino acid in whey, strongly stimulates MPS following workouts [12].

In contrast, casein, a slow-digesting protein, is suitable when sustained amino acid delivery is desired, such as before sleep [13].

Protein Type: Animal vs. Plant-Based Proteins

Animal proteins are generally considered more effective for MPS due to their complete amino acid profile and high bioavailability [13]. However, individuals following a plant-based diet can also effectively build muscle mass and strength with proper supplementation. Studies comparing mixed-protein diets with plant-based protein diets (e.g., soy isolate) show that with adequate intake (approximately 1.6 g/kg of body weight daily), comparable results in muscle mass and strength gains can be achieved.

A protein-rich plant-based diet, when appropriately balanced in amino acids, can fully support anabolic processes. However, it requires careful planning and the inclusion of sources such as soy, quinoa, and hemp seeds to ensure an adequate amino acid profile [14].

Dosing and Timing of Protein Intake

The benefits of evenly distributing protein intake throughout the day remain a debated topic, as various studies report differing results. On one hand, consuming protein every 3–4 hours helps maintain a steady level of muscle protein synthesis (MPS) throughout the day. This is particularly important not only for young individuals but also for older adults, who may be more prone to muscle protein breakdown. Research has shown that dividing protein intake into several smaller portions throughout the day, rather than consuming a large amount in a single meal, offers greater benefits for maintaining muscle mass and protein balance [8].

For example, studies involving older women indicate that consuming more protein at breakfast is associated with a higher skeletal muscle mass index (SMI) and improved grip strength. Evidence suggests that autophagy, regulated by circadian clock genes, may support muscle hypertrophy when protein intake is higher in the early active phase (e.g., breakfast). Molecular mechanisms, such as increased expression of *Igf1* and activation of autophagy pathways (measured by LC3B-II levels), have been identified as key responses to higher protein intake in the morning. However, it is worth noting that while these findings highlight critical insights, they have limitations, including a lack of long-term human data and a focus on older individuals [15].

On the other hand, other studies have not found a significant effect of specific timing (e.g., pre- or post-workout or other times of the day) on improvements in lean body mass (LBM), muscle strength, or MPS. These findings suggest that total daily protein intake is more critical for increasing LBM than the timing of supplementation [16].

1.2 Intermittent Caloric Restriction

Summarizing the results of studies on individuals engaging in strength training, key conclusions can be drawn regarding two caloric restriction strategies: intermittent energy restriction (IER) and continuous energy restriction (CER). Both methods can be effective in reducing fat mass and maintaining muscle mass in individuals who train, but they significantly differ in terms of their impact on hunger, metabolic adaptation, and participants' psychological comfort.

Research indicates that IER, due to reduced feelings of hunger and mitigation of metabolic adaptations, may be a more effective and comfortable option for physically active individuals, strength trainees, and those who can commit to a longer dietary intervention. Subjects using IER reported better results in terms of satiety and reduced hunger. Higher levels of peptide YY and decreased appetite suggest that IER might be more psychologically comfortable and facilitate long-term dietary adherence [17]. A study on bodybuilders practicing IER also suggests better muscle mass retention due to regular "refeed" days or cycles. IER helps alleviate the decline in resting metabolic rate (RMR); this effect can be attributed to periodic days of higher carbohydrate intake, which help prevent metabolic adaptations [18].

1.3 Reducing the Intensity of Caloric Deficit

The anabolic response of the body to strength training under caloric restriction has been evaluated. Key indicators of interest included growth hormone (GH) levels and insulin-like growth factor 1 (IGF-1).

It appears that in a state of caloric deficit, the response to an anabolic stimulus is diminished, which can lead to significant consequences for muscle mass preservation and bone health. During caloric restriction, the body's response to strength training changes. Under normal conditions, physical exercise induces an increase in GH levels, which stimulates the production of IGF-1, a hormone responsible for the regeneration and growth of muscle and bone tissue. In the case of caloric restriction, the increase in GH levels does not lead to a corresponding rise in IGF-1. This suggests a form of resistance to the anabolic stimulus triggered by strength training, significantly reducing its effectiveness in tissue growth and regeneration.

The analysis results also indicate that caloric restriction leads to a decrease in IGF-1 levels, which plays a key role in maintaining and regenerating muscle and bone tissue. A reduction in IGF-1 levels may result in increased muscle and bone mass loss, particularly during prolonged caloric restriction. Additionally, an increase in sclerostin levels, a protein responsible for inhibiting bone formation, has been observed, further increasing the risk of bone weakening.

These findings suggest that strength training alone may not be sufficient to protect muscle mass and bone health during long-term weight reduction.

Another significant aspect of the analysis was the effect of post-workout protein supplementation on muscle protein synthesis and IGF-1 levels under caloric deficit conditions. Under normal conditions, protein supplementation after physical exercise is beneficial and may increase IGF-1 levels, supporting muscle recovery. However, under caloric restriction, protein supplementation did not yield the expected benefits. The results suggest that traditional supplementation strategies may not work optimally when calorie intake is limited, posing a challenge for individuals aiming to preserve muscle mass during calorie reduction. Therefore, alternative strategies may need to be considered to enhance the body's anabolic response to exercise and prevent the negative effects of energy deficit [19].

A potential solution may involve a high-protein diet combined with strength training during moderate energy deficit. Higher protein intake during a caloric deficit of up to 40% allows for maintaining muscle protein synthesis (PS) at levels comparable to energy balance and inhibits protein breakdown (PB). When the deficit exceeds 40%, the effectiveness of a high-protein diet decreases, as the body begins to use protein as the main energy source, increasing the risk of muscle mass loss [20]. A low-carbohydrate diet (LCD) enhances fat oxidation, promoting fat tissue reduction, but carbohydrate restriction leads to increased utilization of branched-chain amino acids (BCAAs) as an energy source. Enhanced protein oxidation reduces the availability of amino acids for muscle protein synthesis, which may hinder muscle regeneration and growth. Chronic carbohydrate restriction may also impair anabolic signaling and myogenesis, limiting muscle mass gains in response to strength training [21].

Progressive Energy Restriction (PER)

Approaches to reducing dietary caloric intake may also play a significant role. Progressive energy restriction (PER) and strong energy restriction (SER) are gaining particular attention. PER involves gradually decreasing calorie intake throughout the dietary program, whereas SER entails a one-time, significant calorie reduction at the start of the diet. Some advantages of PER have been demonstrated, stemming from its flexibility. This flexibility allows for better adaptation to the calorie deficit, which can prevent a decrease in metabolic rate and feelings of fatigue often associated with a large deficit [22].

1.4 Ketogenic Diet

The ketogenic diet (KD) has been the subject of numerous scientific studies, providing a comprehensive view of its potential benefits and limitations in the context of metabolic health and recompensation.

Impact on Fat Mass Reduction

Research conducted on bodybuilders [23] and semi-professional football players [24] clearly indicates that KD effectively supports fat mass reduction, which is crucial for improving body composition in athletes. However, a study on trained middle-aged men [25] observed that both the ketogenic diet and a low-carbohydrate, high-fat diet led to similar results in terms of fat mass reduction, suggesting that ketosis may not be the key factor influencing this reduction. Other studies [26] also suggest that a low-carbohydrate diet without ketosis effectively lowers fat mass levels. Based on this, it can be concluded that while KD facilitated fat mass reduction in athletes [27], calorie restriction and carbohydrate control may remain the primary factors influencing fat mass reduction [25, 26].

Muscle Mass Preservation and Growth

In the context of hypertrophy and muscle mass gain, KD has limitations, making it less advantageous during muscle-building phases [27]. Bodybuilders following KD have been observed to experience a decrease in testosterone and IGF-1 levels [23], which may hinder muscle growth. Other studies [28] have also shown that while KD can support the maintenance of lean body mass, it is less effective than carbohydrate-rich diets when the goal is to increase muscle mass. When comparing the effects of a ketogenic diet and a non-ketogenic high-fat diet [25], both demonstrated similar outcomes in maintaining muscle mass, suggesting that carbohydrate restriction, paired with adequate protein intake, may suffice for muscle maintenance but is not optimal for muscle growth.

Lipid Profile and Metabolic Parameters

Improvements in lipid profile and reductions in glucose levels are key benefits of KD. Studies have shown decreases in triglycerides and increases in HDL levels [29], indicating a positive impact of KD on metabolic health. Research on bodybuilders has reported significant reductions in triglyceride levels [23]. KD also promotes the browning of fat tissue, enhancing thermogenesis and energy expenditure, which supports weight loss processes. Additionally, KD may be a valuable tool for individuals needing glycemic control or inflammation reduction. Lowering levels of pro-inflammatory cytokines such as IL-6 and TNF-α can support muscle recovery and reduce the risk of overtraining [29].

1.5 Time-Restricted Eating (TRE)

The effectiveness of TRE remains a topic of debate and depends on additional factors such as calorie control, diet quality, and adequate protein intake. A study [30] involving overweight and obese participants found that those practicing TRE (eating between 12:00 PM and 8:00 PM) achieved greater weight loss (3.3%) and fat mass reduction (9.0%) compared to the control group, which showed reductions of 0.2% and 3.3%, respectively. The results suggest that TRE, combined with exercise, can effectively reduce fat mass.

However, another study [31] comparing TRE to the standard three-meals-a-day pattern found that weight loss in the TRE group (0.94 kg) was not statistically significantly greater than in the control group (0.68 kg). The TRE group also showed an increase in lean mass by 0.6%. Additionally, the study noted that 65% of the weight loss in the TRE group was lean mass, which may be unfavorable, particularly for older adults. Another study [32] similarly concluded that the primary factor driving fat mass reduction is the calorie deficit, not the timing of meals, suggesting that proper protein and calorie control can help preserve muscle mass regardless of the chosen approach.

Cardiometabolic Indicators and Cardiovascular Health

TRE may have a positive impact on cardiovascular health. A study on obese individuals [30] observed beneficial changes in resting heart rate and post-exercise heart rate recovery among those practicing TRE, suggesting an influence on cardiovascular health. However, another study [31] found no significant changes in metabolic markers such as glucose, insulin, or lipid levels, indicating that TRE alone may not provide additional metabolic benefits without a controlled diet.

TRE and Individual Preferences

TRE can be effectively used as an alternative to traditional calorie-restriction methods and is relatively easy to adhere to. A study [30] reported that individuals following TRE rarely experienced adverse effects, suggesting it may be a convenient option for those who struggle with maintaining restrictive diets. However, both TRE and traditional meal patterns can effectively reduce body weight and improve body composition if a calorie deficit and adequate protein intake are maintained [32].

2. Exercise Protocols for Simultaneous Muscle Growth and Fat Loss

2.1 Resistance Training

Numerous studies highlight the critical role of resistance training (RT) for individuals aiming to reduce fat mass while preserving muscle mass. Research examining the role of training volume in maintaining muscle mass during caloric restriction (CR) indicates that higher RT

volume, particularly ≥10 sets per muscle group per week, effectively minimizes muscle mass loss, especially in women. Studies suggest that women may better preserve muscle tissue during intensive RT protocols, likely due to the beneficial effects of estrogen on muscle tissue [33]. Research on older women also indicates that lower baseline fat mass (FM) may favor improved body recomposition. For older women, an individualized training approach considering FM levels is recommended to maximize recomposition effects. A study investigating how initial FM influences body recomposition after 24 weeks of resistance training found that women with lower FM experienced greater changes in body recomposition, particularly in fat mass reduction, compared to those with higher FM. However, muscle strength increased uniformly across all groups, suggesting that FM levels do not significantly affect the ability to build strength [34].
A comprehensive review of 12 systematic reviews and 149 studies evaluated the effectiveness of exercise programs for weight loss, body composition changes, and weight maintenance in overweight or obese adults. The findings showed that aerobic training was more effective for weight and fat reduction than resistance training alone. High-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) produced similar effects when energy expenditure was equivalent. However, resistance training proved more effective in preserving muscle mass during weight loss, which is especially critical during fat reduction. Additionally, exercise alone did not significantly impact long-term weight maintenance post-weight loss [35].
Another extensive review confirmed that resistance training, especially when combined with caloric restriction, effectively reduces both visceral and subcutaneous fat while increasing muscle mass. This is particularly beneficial for metabolic health and physical function, especially in middle-aged and older individuals, where health risks associated with excess fat are heightened. The review analyzed the effects of resistance exercise programs on body composition, fat reduction in various body areas, and weight changes in overweight and obese individuals. Conducted according to PRISMA guidelines, the study reviewed nine databases up to December 2020 and included 116 articles describing 114 studies with 4,184 participants across age groups, including children, adolescents, young adults, middle-aged adults, and older individuals [36].
Studies examining the effects of resistance training on body composition, bone density, muscle strength, and functional fitness in older women with obesity revealed that the control group experienced muscle mass and bone density declines, while the training group maintained or improved these parameters. Improvements in functional fitness were also noted in the resistance training group [37].

A meta-analysis highlighted the significant impact of resistance training on muscle health and muscle mass in postmenopausal women. The findings showed that resistance training could increase lean body mass in postmenopausal women without significantly affecting fat mass. For this population, resistance training is a valuable intervention to counteract sarcopenia, although dietary support may be needed alongside physical activity to influence fat mass reduction [38].

2.2 HIIT + RT

The effects of moderate-intensity continuous training (MICT), high-intensity interval training (HIIT), and a combination of HIIT with resistance training (HIIT + RT) on body composition and fat oxidation (FatOx) were compared in postmenopausal women with overweight or obesity. Researchers aimed to determine if fat reduction was associated with increased fat oxidation. The study involved 30 postmenopausal women, aged 62.4 years on average, with a BMI of 25–40 kg/m². Following initial screening and randomization, participants were divided into three groups of 10: MICT, HIIT, and HIIT + RT[39].

Interventions:

- MICT: Training three times a week, 40 minutes at 55%–60% of maximum workload.
- HIIT: Training three times a week, 60 cycles of 8 seconds at 80%–90% of maximum heart rate, with 12 seconds of recovery.
- HIIT + RT: HIIT combined with full-body resistance training (1 set of 8–12 repetitions).

Results: All groups experienced reductions in total body weight and fat mass. However, reductions in abdominal and visceral fat were observed only in the HIIT and HIIT + RT groups. Furthermore, the HIIT + RT group demonstrated an increase in the percentage of lean muscle mass, which was not observed in the MICT group[39].

Fat Oxidation (FatOx):

Fat oxidation did not change at rest but increased in all groups during and after exercise, so the greater fat loss in the HIIT groups was not associated with an increase in fat oxidation during or after training.

Comparison of MICT and HIIT:

The study showed that HIIT, either alone or combined with RT, was more effective than MICT in reducing abdominal and visceral fat, which may lower the risk of cardiovascular diseases in postmenopausal women.

Effects of HIIT + RT:

Adding resistance training did not result in greater reductions in abdominal fat compared to HIIT alone, but it contributed to an increase in the percentage of lean muscle mass, which may support a healthier body composition.

Therefore, HIIT, as a time-efficient strategy, may be a better choice for postmenopausal women with overweight or obesity, especially if the goal is to reduce the risk of cardiovascular diseases associated with high levels of abdominal and visceral fat. However, additional resistance training, although it did not significantly enhance abdominal fat reduction, improved body composition by increasing lean muscle mass, which may positively affect metabolism in the long term [39].

2.3 COM-HI

The combination of COM-HI is largely similar to the combination of high-intensity interval training (HIIT) with resistance training (RT). Both programs—COM-HI and HIIT + RT—include intensive aerobic and resistance exercises; however, they differ in terms of training structure and the organization of intervals. COM-HI typically focuses on continuous or longer bouts of aerobic training combined with intensive resistance exercises, while HIIT + RT is based on short, intense intervals with limited rest [40].

In a network analysis, the effectiveness of different types of physical activity in adults with obesity was assessed to determine the best exercise program for body composition, cardiorespiratory fitness (CRF), and metabolic health.

The analysis included six categories of exercise:

- High-intensity aerobic exercise (AE-V),
- Moderate-intensity aerobic exercise (AE-M),
- High-load resistance training (R-HI),
- Moderate-load resistance training (R-LM),
- A combination of high-intensity aerobic and high-load resistance training (COM-HI),
- A combination of moderate-intensity aerobic and moderate-load resistance training (COM-LM).

The most effective combination turned out to be COM-HI—intensive aerobic training combined with high-load resistance training. COM-HI demonstrated the best effects in terms of abdominal fat reduction and muscle mass increase, as well as the highest results in reducing waist circumference and body fat percentage. Despite moderate reductions in body weight, COM-HI brought significant health benefits, such as a decrease in visceral fat and an improvement in CRF, which is crucial for metabolic health [40].

The improvement in CRF was also the greatest in the COM-HI group, which may contribute to reducing the risk of cardiovascular diseases regardless of weight loss. COM-HI, combining intensive aerobic training with resistance training, may be more effective in reducing metabolic disease risk factors than either aerobic or resistance exercises alone. This emphasizes the value of such a combination for individuals with obesity [40].

2.4 HIIT

A study on older adults highlighted the benefits of HIIT in maintaining and increasing muscle mass. An increase in lean mass (LM) by 0.68 kg and an increase in muscle area by 0.40 cm^2 were observed, which is significant for preventing sarcopenia and improving motor function. The study suggests that the intense intervals characteristic of HIIT may induce similar adaptive effects as resistance training, particularly regarding the stimulation of muscle growth and maintenance of muscle mass [41].

Molecular mechanisms associated with HIIT (e.g., activation of satellite cells, modulation of gene expression such as MYOD1 and FZD7) indicate that HIIT may stimulate muscle protein synthesis and increase muscle mass. Although HIIT does not fully replace resistance training in terms of hypertrophy, it can be used as an alternative, especially for older adults or those before/after surgery who are more susceptible to muscle loss and have limited ability to perform intensive resistance training [42].

A study on young adults with overweight or obesity assigned participants to groups with varying frequencies of HIIT (once, twice, or three times per week) and a MICT group. Participants in all exercise groups showed a significant increase in lean body mass and a reduction in fat mass compared to the control group, with HIIT groups demonstrating fat tissue reduction as early as four weeks, which was not observed in the MICT group. All exercise groups showed improvements in cardiorespiratory fitness (VO2max and distance covered), with the greatest increases observed in higher-frequency HIIT groups. Even HIIT once a week improved fitness, suggesting that even a low frequency of HIIT can be effective. Additionally, all HIIT groups demonstrated significant reductions in systolic blood pressure after eight weeks, which was consistent with results for the MICT group [43].

The impact of HIIT on muscle protein synthesis under sleep restriction

It has been observed that HIIT can counteract the decline in the rate of myofibrillar protein synthesis (MyoPS) under conditions of sleep restriction. Sleep restriction, typical of modern lifestyles, is associated with reduced muscle protein synthesis, which may lead to muscle mass loss. The findings suggest that HIIT may help maintain muscle protein synthesis at control levels, which could be applicable for individuals exposed to chronic sleep deprivation, such as shift workers [44].

2.5 LIPOXmax and FATmax Training

LIPOXmax training, also known as FATmax training, involves performing physical exercises at an intensity level where the body reaches its maximum rate of fat oxidation. Typically, this intensity falls within the range of 30–50% of maximal oxygen uptake (VO_2max), corresponding to approximately 50–70% of maximal heart rate. This training involves prolonged aerobic activities, such as walking, jogging, cycling, or swimming [46].

The primary goal of LIPOXmax training is to maximize fat burning while minimizing carbohydrate utilization. As exercise intensity increases, the body increasingly relies on carbohydrates for energy, making it essential to identify the intensity level at which fat oxidation is at its peak. This optimal intensity is often determined through calorimetric or exercise tests to pinpoint the individual's LIPOXmax point. While approximate values can be estimated based on VO_2max or maximal heart rate, the most accurate assessment requires specialized equipment [46].

Training Characteristics

- Duration and Frequency: Sessions typically last 45–60 minutes and are performed 3–4 times per week.
- Intensity: Due to its moderate intensity, this training is not overly exhausting, making it easier to sustain regularly.
- Outcomes: This type of training supports long-term weight maintenance or loss, improves insulin sensitivity, reduces inflammation, and enhances the blood lipid profile.

Compared to high-intensity cardio workouts, LIPOXmax training is less taxing and produces more sustainable effects, especially in the long-term reduction of fat tissue.

A Suitable Option for Low Fitness Levels

Because of its moderate intensity, LIPOXmax training is well-tolerated by individuals with obesity, type 2 diabetes, those recovering from bariatric surgery, as well as older adults or beginners.

Observed Benefits

1. Fat Loss and Body Composition:

    - Significant reductions in body weight, fat mass, and waist circumference.
    - Studies report an average weight loss of approximately 4.3 kg and a fat mass reduction of about 4.03 kg over 8–20 weeks of FATmax training.
    - Waist circumference decreased by 3.34 cm, indicating abdominal fat loss, crucial for reducing the risk of metabolic and cardiovascular diseases.
2. Cardiorespiratory Fitness:
    - VO_2max increased by 2.96 $ml \cdot kg^{-1} \cdot min^{-1}$, reflecting improved aerobic capacity and cardiovascular function.
3. Muscle Preservation:
    - Lean body mass (FFM) remained unchanged, meaning FATmax training did not cause muscle loss. This is particularly advantageous for body recomposition, as maintaining muscle mass is essential for sustaining metabolic rate [46].

Long-Term Effects

Additional studies emphasize that LIPOXmax-level exercises offer lasting benefits in weight reduction and metabolic improvement, beyond the traditional calorie-deficit approach. Training at the LIPOXmax level enhances mitochondrial respiration, a key factor in improving lipid oxidation.

Moreover, muscle activity during training releases bioactive molecules, such as myokines and "myometabokines," which improve insulin sensitivity and support overall metabolic health [46].

2.6 Functional Training (FT) and Conditional Training (CT)

A study published in the journal *Healthcare* in 2024 analyzed the impact of FT and CT on body composition and muscle strength in postmenopausal women.

Functional Training (FT): FT is a form of physical activity that mimics movements performed in daily life, simultaneously engaging multiple muscle groups. The goal is to improve overall fitness, coordination, balance, and strength.

In the study, FT. CT combines elements of strength and endurance training.

Both types of training contributed to an increase in muscle mass and a reduction in fat tissue, without changes in total body weight, indicating body recomposition. Additionally, an increase in lower limb muscle strength was observed as early as the fourth week of training [47].

2.7 COMB

A study published in *Scientific Reports* in 2023 compared the effects of COMB training (combining HIIT and MICT) with MICT alone on body composition, physical fitness, and metabolism in obese adolescents.

COMB training integrates high-intensity intervals (HIIT) with moderate-intensity continuous training (MICT). The study's results show that both types of training (COMB and MICT) effectively reduced body weight and fat mass, but only COMB allowed for the preservation of muscle mass. This indicates that the HIIT elements in COMB support anabolic processes, preventing muscle loss—a critical factor during weight loss to not only reduce fat but also maintain strength and fitness[48].

COMB training resulted in a greater increase in $V'O_2$ peak (aerobic capacity) and oxygen pulse (O_2 pulse), reflecting better cardiovascular fitness. Additionally, increased fat oxidation (MFO) in this group indicates more efficient utilization of fat as an energy source. These findings suggest that combined training can have a more comprehensive impact on metabolic health compared to moderate-intensity training alone [48].

2.8 Higher Frequency with Matched Weekly Volume

Higher training frequency can be considered a potentially beneficial method for body recomposition. This conclusion is drawn from a study aimed at evaluating how different frequencies of strength training (2 vs. 3 times per week) with a fixed number of weekly sets affect muscle strength and body composition in older women.

The results showed that both groups (training 2 and 3 times per week) experienced similar gains in lean mass and muscle strength. However, higher training frequency (3 times per week) was more effective in reducing fat mass. This indicates that higher training frequency may promote fat mass reduction, while the total number of sets is crucial for muscle mass gains [49].

3. Additional Supplementation

3.1 Unsaturated Fatty Acids

Reducing oxidative stress is crucial for muscle protection, especially during regular, intense training. Poor management of oxidative stress can lead to the accumulation of muscle cell damage and decreased long-term performance. Omega-3 fatty acids have a beneficial effect on oxidative stress markers, particularly the GSH/GSSG ratio, which protects muscle cells from oxidative stress-induced damage [50].

Another study indicated that supplementation with high doses of ω-3 and ω-6 PUFAs along with antioxidant vitamins can support changes in body composition during High-Intensity Functional Training (HIFT) but does not influence performance adaptations [51].

3.2 Creatine

A pilot study on men suggests that creatine supplementation combined with a high-protein diet and cluster-set resistance training significantly enhances lean body mass gains and power in certain muscles compared to the control group [52].

Research conducted on older women indicates that resistance training supported by creatine supplementation provides strength gains, although it does not significantly affect muscle mass. A review of studies highlights the potential of creatine as a supplement that, when paired with resistance training, can support muscle adaptations and slow down sarcopenic processes [53].

4. Comprehensive Approach

The effectiveness of dietary and exercise interventions in improving body composition has been confirmed in numerous studies. The general conclusion from these studies emphasizes the importance of integrated strategies rather than focusing on a single aspect.

When applying body recomposition strategies, it is necessary to consider the diverse physiological and health needs of specific population groups. For patients with obesity, older adults, athletes, or individuals with chronic illnesses, dietary and training approaches can differ significantly. Implementing individualized recommendations that account for metabolic, hormonal, and recovery needs enables optimal outcomes in maintaining muscle mass while reducing fat mass.

A systematic review and network meta-analysis analyzed 92 studies, including 66 randomized controlled trials (RCTs) with 4,957 participants, evaluating dietary and exercise interventions aimed at improving body composition (fat/muscle mass), body mass index (BMI), and waist circumference (WC) in individuals aged 55–70 years with obesity/overweight. The best results were achieved through a combination of caloric restriction, resistance training, and a high-protein diet [54]. This approach led to significant fat mass reduction while preserving muscle mass. Caloric restriction alone, while effective in reducing body weight, often results in undesirable muscle mass loss. Therefore, resistance training is a key aspect of interventions as it minimizes muscle loss and supports muscle growth, particularly when combined with a high-protein diet. The importance of resistance training is also highlighted in the treatment of sarcopenic obesity [55].

In combination with regular resistance training, protein intake supports muscle mass development and limits muscle catabolism [56]. Studies have also shown that combining aerobic-resistance training with a high-protein, low-glycemic-index diet provides particular benefits in reducing abdominal obesity and improving metabolic parameters. Research conducted on men with abdominal obesity demonstrated that only the combination of training and a high-protein diet led to significant reductions in fat mass, abdominal fat, and waist circumference—effects not observed in the exercise-only group [57].

These findings indicate that integrating an appropriate diet with physical activity is essential for achieving optimal results in metabolic health and reducing abdominal obesity. The impact of the Mediterranean diet on body composition has also been a subject of research, revealing the complexity of body composition management. The findings suggest that individualized approaches to diet and exercise may be more effective than general calorie-restriction recommendations [58].

Gender-Specific Protocols

A review of the literature highlights the critical role of maintaining muscle mass throughout life for overall health, with particular emphasis on the impact of hormones. The hormone-dependent muscle-building strategy focuses on appropriate management of training and diet to maximize the effects of anabolic hormones such as testosterone, growth hormone (GH), and insulin-like growth factor 1 (IGF-1). Practical recommendations based on research allow for effective muscle mass gains and recovery by leveraging hormonal responses [59].

1. Intensive Resistance Training (RE):

   High-intensity strength training involving both large and small muscle groups, with loads of at least 70% of one-repetition maximum, increases testosterone, GH, and IGF-1 levels, accelerating muscle growth and recovery.

2. Menstrual Cycle Consideration in Women:

   During the luteal phase, when estrogen levels are higher, more intensive resistance training may yield greater benefits by reducing muscle damage and enhancing recovery.

3. Age-Related Hormonal Adaptations:

   In older adults, declining testosterone and IGF-1 levels can reduce training efficiency. Regular resistance training combined with adequate protein intake may mitigate this effect. In some cases, hormone therapy under professional supervision may be considered.

4. Short Rest Intervals Between Sets:

   Shorter rest periods, lasting approximately one minute, increase GH secretion, promoting muscle mass gains and recovery.

The study also emphasizes the complexity of hormonal signaling and the roles of testosterone, GH, IGF, and cortisol in muscle growth and recovery processes. Cortisol, as a catabolic hormone, can contribute to muscle protein breakdown, particularly in cases of overtraining. Therefore, managing training intensity and recovery is essential to minimize its adverse effects [60].

These findings suggest the potential benefits of developing training programs tailored specifically for men and women across different age groups.

Conclusions

A review of the literature highlights the effectiveness of body recomposition as a health strategy with great potential. However, fully utilizing this strategy requires further research into its application in clinical practice, including the determination of optimal methods that would be both effective and safe for a broad range of patients. It is crucial to tailor interventions to the specific needs of various population groups, such as the elderly, women, children, or patients with chronic diseases, which could enhance effectiveness and minimize the risk of adverse effects. At the same time, the literature points to the importance of a holistic approach that considers not only physical aspects but also individual patient preferences and limitations. Individual adaptation of strategies to the lifestyle and needs of each person is key to achieving lasting results, as well as increasing acceptance and motivation to sustain interventions over the long term.

Disclosure

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