

The Effects of Time-Restricted Feeding versus a Normal Diet on Lean Body Mass in Active Individuals

Short Review

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Abstract

Introduction: Intermittent fasting (IF) is a popular dietary strategy for its health benefits and for weight management. Time-restricted feeding (TRF) is a common approach to IF, but its effects on lean mass (LM) have not been extensively studied in active individuals. All individuals must have participated in regular physical activity for at least six months to be considered in this analysis.

Methods: A search of the current literature on TRF in active individuals was conducted. Studies were critically evaluated for quality and for clinical application.

Results: Five studies fit established parameters, four of which studied TRF with a resistance training (RT) regimen, and one utilized aerobic training. TRF and normal diet (ND) groups had similar results for LM and RT outcomes when matched for calories. Results on fat mass loss and changes in body composition show mixed findings. Some data suggest a TRF is beneficial for improved aerobic performance.

Conclusions: TRF does not appear to be superior to a ND for building or sustaining LM in active individuals, neither is it detrimental. Current literature points to overall energy and protein intake, rather than nutrient timing, as a key modulator of LM outcomes.

Key Words: Intermittent fasting, muscle, sport nutrition

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Introduction

Intermittent fasting has been extensively researched for its metabolic benefits and its efficacy as a weight loss strategy. While its popularity as a dietary regimen has recently gained traction, fasting in various forms has been used for centuries as a medical therapy and religious custom. Intermittent fasting (IF) is an umbrella term that describes the alternations between feeding and fasting windows, based on chronological markers. Schedules of IF may vary widely. Common schedules include: alternate-day fasting; a modified fasting regimen of five days of normal intake and two non-consecutive days of severe restriction (20-25% of energy needs); and time-restricted feeding (TRF). ¹ TRF is based on an hourly schedule, the most common of which is 16 hours of fasting and 8 hours of feeding (16:8). Some regimens extend the fasting window to 18 or 20 hours, as it appears that a 16-hour fast is the minimum duration to elicit favorable changes in body composition. ² Additionally, IF may be based in religious practice, such as during the Islamic ritual of Ramadan, wherein all food and beverage consumption occurs between sundown and sunrise. ³ Coordinating energy intake with the circadian rhythm influences the body's "master clock" and peripheral clock-based gene expression. ¹ By this measure, IF can align cellular processes positively affect metabolic outcomes. IF has been shown to attenuate reactive oxygen species, enhance insulin action and glucose control, and improve hunger/satiety signaling. ⁴ Interestingly, while general weight loss often yields similar outcomes, many of these benefits have been reported without significant reductions in body mass. While weight loss is a primary motivator for those turning to IF, it has not been shown to be superior in the long term over a continuous caloric restriction. ⁵ The exact mechanisms by which fasting induces cellular changes have been proposed but not specifically elucidated.

Current sport nutrition recommendations revolve heavily around the timing of carbohydrates and protein to maximize training adaptations and performance outcomes. Athletes' intense training schedules and exhaustive bouts of exercise necessitate higher caloric and fluid intakes than their inactive counterparts. ⁶ Additionally, it is of particular importance to active individuals to increase, or to at least maintain muscle mass. Higher lean mass is associated with improved

performance, both in anaerobic ⁷ and aerobic athletes. ⁸ From this perspective, maximizing the daily feeding window is advantageous for muscle building and maintenance, even during a caloric deficit.

Because many IF regimens do not coincide with established recommendations on nutrient timing, a paucity of controlled studies exists in active individuals. IF has gained general popularity for its health benefits and as a weight-management strategy. Athletes, however, may seek an IF regimen for different reasons, such as: to optimize body weight and composition ²; to enhance fat oxidation during aerobic exercise ⁹; or for religious and cultural reasons. ³ However, the effects on muscle mass must be considered, as this has a direct effect on performance. Thus, this review sought to compare the effects of a normal diet (ND) to the popular TRF protocol on lean tissue changes in active individuals.

Clinical Question

All research conducted was based upon an established PICO question: “What are the effects of time-restricted feeding on lean body mass in physically active individuals, compared to a normal diet?”

Search Strategies

A search of the literature was performed in March of 2021. The following summarizes the parameters of the search.

The PICO-based search terms used included:

- Participants: athletes, trained individuals, active individuals
- Intervention: Time-restricted feeding or eating, intermittent fasting
- Outcomes: Lean mass, muscle mass

Databases used included:

- Google Scholar
- PubMed
- SPORTDiscus
- Academic Search Complete
- Health Source – Consumer Edition

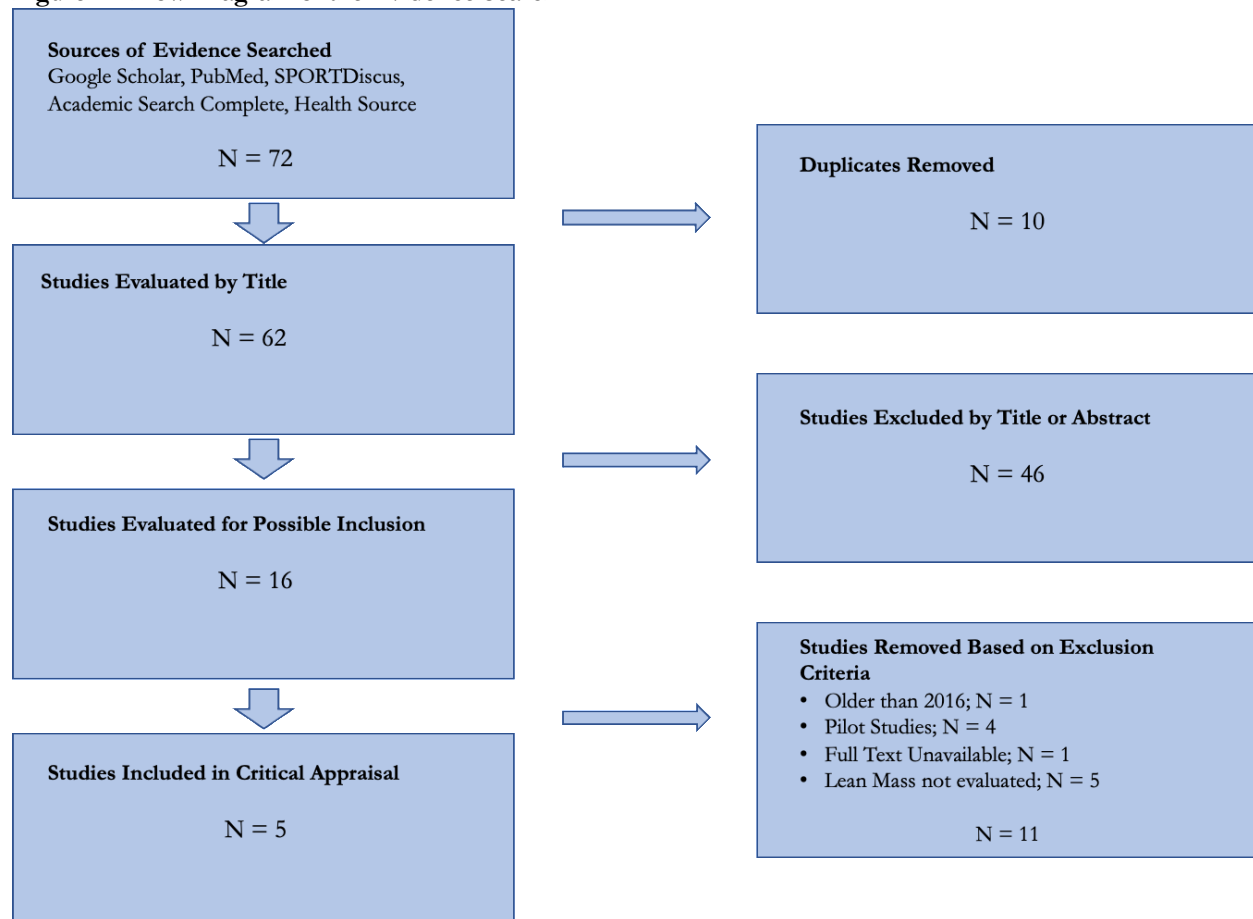
Inclusion criteria were studies that:

- Used active individuals
- Employed a control group (normal diet)
- Full text availability

Exclusion criteria were:

- Studies published before 2016
- Pilot studies
- Interventions performed on animals, such as mice
- Did not identify outcomes with respect to lean mass

Based on these search criteria, a total of 72 articles were found across the databases. After duplicates were removed, 62 articles were evaluated by title and abstract. A total of 16 articles were then thoroughly evaluated for possible inclusion based on the exclusion criteria. This review is based on the critical appraisal of five articles that met all established requirements (Figure 1).

Figure 1 – Flow Diagram of the Evidence Search**Key Findings**

When calories were matched at baseline levels, TRF and ND groups increased ¹⁰ or maintained their LM to a similar extent. ¹¹ RT adaptations and aerobic performance were sustained for both diet protocols. Significant decreases in fat mass (FM) were detected in TRF groups, but not in ND groups. The observed decrease in body weight (BW) and fat mass in trained cyclists led to a significant improvement in peak power output to body weight ratio. ¹¹ When calories and protein were matched at a slight energy deficit, both TRF and ND groups maintained LM and increased strength and hypertrophy to similar degrees. ^{12,13} No significant changes in body composition, FM, or BW were detected in these trials. When both TRF and ND feedings were ad libitum, the ND group consumed significantly greater calories and increased their LM to a greater extent than the TRF group. ¹⁴ TRF led to greater improvements in muscular endurance. Interestingly, no changes in body composition were detected between groups despite the difference in energy intake.

Evidence Quality Assessment

All studies were assessed by one author (HK) utilizing the Physiotherapy Evidence Database (PEDro) scale for randomized controlled trials (RCT).¹⁵ Each study received a strength of recommendation (SORT) grade (A-F) based on its design (Table 1).

Table 1 – Summary of Included Studies and Results

Study	Moro et al. (2016) ¹⁰	Tinsley et al. (2017) ¹⁴	Tinsley et al. (2019) ¹³	Moro et al. (2020) ¹¹	Stratton et al. (2020) ¹²
Parti- pants	34 males with 5 years' RT experience	18 recreationally active males	24 females with >1 year RT experience	23 elite U23 cyclists	26 recreationally active males with 6 months' RT experience
Exclusion Criteria	Steroid use, medical issues	None specified	Pregnant, breastfeeding, smokers, pacemakers, protein allergy	Injured, steroid use, medical issues	Injuries, medical issues, steroid or supplement use, eating disorders, and recent weight loss of >10% BW
Duration of Intervention	8 weeks	8 weeks	8 weeks	4 weeks	4 weeks
Training Protocol	3 RT sessions/week; split protocol; performed to failure at 6-8 repetitions	3 RT sessions/week; alternating upper and lower body; performed to failure after 8-12 repetitions	3 RT sessions/week; alternating upper and lower body; performed to momentary exhaustion at 6-8 or 8-12 repetitions	During offseason, 6 cycling sessions/week; mild/medium pace; total 500+/-50 km weekly	3 RT sessions/week; full body daily undulating periodization protocol
TRF Modality	16:8, three meals	Training Days: Ad libitum; Rest Days: 20:4	16:8 with 250 cal/d deficit, with and without HMB supplementation	16:8	16:8 with 25% caloric restriction
Control Group(s)	12:12, three meals	All day feeding, ad libitum	All day feeding at 250 cal/d deficit	12:12, three meals	All day feeding at 25% caloric deficit
Matched for calories?	Yes	No	Yes	Yes	Yes
Matched for protein?	Yes	No	Yes	Yes	Yes
Results (TRF Group)	No change in LM ↓FM ↑Adiponectin ↓IGF-1	↑LM ↑Strength ↑Lower Body Endurance	↑LM ↓FM ↑Hypertrophy Muscle performance maintained	No change in LM ↓BW ↓FM ↓IGF-1	↓BW ↓FM ↓Body Fat % ↓REE

	↓Glucose ↓Testosterone ↓Leptin ↓			↓Testosterone Positive effect on immune system	↓Adiponectin ↓Testosterone ↑Strength ↓
Conclusion	Compared to ND, TRF caused a decrease in FM, testosterone, and IGF-1. Both groups maintained LM, muscle CSA, and strength	Compared to ND, TRF resulted in a lower caloric intake. Strength improved in both groups. Both groups increased LM but ND > TRF. TRF group increased muscular endurance more than ND.	Both ND and TRF groups achieved similar increases in LM, hypertrophy, and RT adaptations, as well as similar decreases in FM.	TRF resulted in greater reductions in BW and FM than ND, while both groups maintained LM and performance. TRF caused a decrease in testosterone and IGF-1.	Both ND and TRF groups achieved similar increases in strength and similar decreases in FM, BW, REE, testosterone, adiponectin. Both groups maintained LM.
PEDro Score (out of 10)	7	6	9	5	6
SORT Score	B	A	A	A	B
Support for Answer	Yes	Yes	Yes	Yes	Yes

↓Denotes a statistically significant decrease ($p < 0.05$); ↑Denotes a statistically significant increase ($p < 0.05$); TRF, time-restricted feeding; RT, resistance training; LM, lean mass; FM, fat mass; IGF-1, insulin-like growth factor 1; ND, normal diet; CSA, cross-sectional area; BW, body weight; REE, Resting energy expenditure

Results of Evidence Quality Assessment

PEDro scores ranged from 5-9 for included studies. Each elucidated all inclusion and exclusion criteria, and no significant baseline differences were detected between experimental and control groups. Furthermore, while all allocation was randomized, only two studies employed blinding upon allocation.^{13,14} Participants and investigators were not blinded to which group (TRF vs. ND) they were in. The SORT grades were high (A-B) (Table 1).

Clinical Bottom Line

This review investigated the question, “What are the effects of TRF on lean body mass in physically active individuals, compared to a normal diet?” Based on recent, available data, TRF is not superior to a ND for building lean mass, but it is not detrimental. Overall, this recommendation receives a B grade. Evidence quality is high, but client goals must be individually evaluated. The evidence presented by this review strongly suggests that TRF can be used as a valid eating strategy when an active person wishes to maintain or improve LM, as long as overall energy intake is sufficient. Furthermore, positive adaptations to both resistance and aerobic exercise can still occur with TRF. However, for elite athletes in season and for those wishing to gain substantial amounts of muscle mass, TRF is not recommended.

Implications

Intermittent fasting appears to be a viable dietary strategy, albeit not superior, for active individuals who are looking to build or maintain LM. The findings of this synthesis point to the importance of overall nutrition on LM outcomes and the potential efficacy of TRF on body composition. Two of the appraised studies investigated LM endpoints with calories and protein equated at a maintenance level in both experimental (TRF, 16:8) and control groups.^{10,11} The earlier trial included resistance-trained males during a RT regimen,¹⁰ and the later trial included elite U23 male cyclists during their offseason.¹¹ Despite the different training backgrounds of participants, the results were similar in both these trials, suggesting that the TRF feeding schedule had a slight advantage over a ND for decreasing fat mass (FM). LM was

maintained to a similar extent in both groups. However, during the RT regimen, a ND increased LM to a greater extent than TRF, although neither the increase in LM nor the difference between groups was significant.¹⁰ Despite being matched for calories, the TRF groups in both studies presented with higher levels of adiponectin than ND. Adiponectin acts through the AMPK pathway to stimulate mitochondrial biogenesis and acts in the brain to increase energy expenditure.¹⁶ This could be a possible explanation for the greater decrease in fat mass in TRF groups despite the isocaloric design and non-significant changes in REE. Lastly, TRF feeding resulted in a decrease in the anabolic hormones, testosterone, and insulin-like growth factor-1 (IGF-1), but this did not appear to be detrimental to LM. Performance did not decrease in either the RT or endurance regimens; in fact, the decrease in BW and FM in the TRF cyclist group resulted in greater peak power output to BW ratio.¹¹ In endurance sports, maintaining a lower body weight and favorable body composition is associated with improved $\text{VO}_{2\text{max}}$, maximal work performance, and aerobic economy.¹⁷ Additionally, training in the fasted state has been shown to induce a shift towards intramyocellular lipid oxidation, favorably sparing glycogen.⁹ In their study with resistance-trained men, Tinsley and colleagues found that effect size data indicated greater improvements in muscular endurance during RT after TRF.¹⁴ While short-term data on muscular endurance and aerobic outcomes suggests that a TRF may be favorable to a ND, it may not translate to overall improvements on race day. Fasted state training often results in lower training intensities, and the upregulation of fatty acid oxidation is less dramatic in long-term protocols.⁸ Therefore, it is unclear whether fasted endurance training improves performance during competition. Based on these findings, TRF that meets baseline caloric and protein needs appears to preserve lean mass and might have favorable outcomes on body composition and hence, endurance performance.

LM outcomes and RT adaptations are similar in both TRF and ND conditions when matched for calories at a small deficit.^{12,14} As IF is commonly used as a weight-loss strategy, this is clinically relevant. When combined with a RT regimen, TRF (16:8) does not appear to attenuate muscular adaptations, such as LM accretion, strength, and hypertrophy. Furthermore, it is well established that caloric deficits often result in a decrease in LM.¹⁸ Tinsley et al.¹⁴ employed a small daily caloric deficit of 250 calories for 8 weeks in resistance-trained women. They found that both ND and TRF groups were able to increase LM to a similar extent. Stratton and colleagues¹² used a more aggressive 25% caloric deficit for a shorter intervention period (4 weeks) in recreationally-active males. Outcomes on LM, body composition, and muscular performance were similar in both TRF and ND groups. Taken together, these studies suggest that while a hypocaloric TRF regimen is not superior for body composition outcomes and LM gains, it is not detrimental either. Unlike the findings of Moro and colleagues,^{10,11} FM did not decrease to a greater extent as a result of TRF. This might be explained by the differences in training status of participants at baseline.

Only one of the studies investigated in this review did not use a matched-calories design and instead investigated ad libitum feedings in resistance-trained males on a TRF schedule.¹⁴ TRF attracts many individuals with the premise of restricting eating based solely on the time of day, rather than by the quantity of food. Thus, these results are of practical importance. This was the only study that employed a 20:4 schedule on rest days, while training days (3 days/week) were ad libitum. On the fasting days, energy intake was about 670 calories lower than on feeding days. While positive muscular adaptations to the RT regimen occurred in both groups, the effect size demonstrated a greater increase in LM in the ND group. This is consistent with findings that a greater calorie intake results in greater LM gains.¹⁹ Further, consumption of protein and carbohydrates is considered important for the initiation of muscle repair; however, mammalian target of rapamycin (mTOR) activity, a key pathway in muscle protein synthesis (MPS), may remain elevated for 48 hours post-workout.⁶ Thus, a 20:4 schedule on rest days may not support MPS to its potential. Of note, despite the lower caloric intake in the TRF group, body composition did not differ significantly after the intervention.

For active individuals, the growth and maintenance of LM are of critical importance from both metabolic and performance perspectives. Current nutritional guidelines suggest that consuming a bolus of a high-quality protein (20-40 grams, providing 10 grams of essential amino acids) with carbohydrates every 3-4 hours has the most favorable outcomes on MPS.⁷ In a practice known as protein pacing, consuming the first meal within an hour of waking and the last meal, ideally containing casein protein, within 3 hours of going to sleep appears to be advantageous for muscular strength and power.²⁰ These recommendations to consume protein in moderate quantities throughout waking hours are not solely for muscle building, but appear to attenuate LM loss during periods of caloric restriction when combined with an exercise regimen.¹⁸ In fact, consuming very high daily amounts of protein compared to the normal recommended range for active individuals (2.3-3.1 g/kg vs. 1.2-2.0 g/kg) may be indicated in hypocaloric periods to preserve LM. In cases where muscle hypertrophy is the main goal, an initial caloric surplus of about ~350-475 kcal/day is indicated.¹⁹ MPS is an energy-costly process, and the addition of LM to the body further increases REE, warranting more energy intake. To maximally fuel the mTOR pathway for MPS while simultaneously minimizing muscle protein breakdown, creating a caloric surplus from small, frequent meals containing a high-quality protein source and carbohydrates is ideal. Synthesizing these points, current research supports a continuous feeding regimen to preserve and build LM.

Current sport nutrition guidelines for the retention and building of LM need not be changed based on these current studies on TRF. The goals of nutrient timing are to:

- Maximize fuel availability and attenuate fatigue during training and competition
- Initiate tissue repair and recovery, especially immediately following exercise
- Prevent injury
- Maximize MPS, or at least preserve LM during periods of hypocaloric intake ⁷

While the practice of timing has been extensively studied as a way to optimize metabolic processes, it comes as a far second to overall nutritional intake. TRF has yet to be shown to be a superior dietary strategy to those currently endorsed by the ISSN and sports nutritionists and does not warrant adjustment to nutrient timing guidelines. However, it should not be dispelled as invalid if protein and energy needs can be met within the feeding windows. TRF is not recommended for certain populations. Individuals seeking maximal muscular hypertrophy and mass increases should adhere more closely to current nutrient timing recommendations, such as those outlined by the ISSN. Energy and protein demands are high to support training and recovery, and the timing of nutrients and supplementation might play a significant role in this process. For similar reasons, precaution should be taken when with elite athletes who are training and competing in-season. From a practical standpoint, consuming enough food to meet these demands during a short feeding window would be difficult, as supported by Tinsley et al. ¹⁴ Overall, nutrition recommendations should be individualized to best address the client's goals and situations.

Future research on TRF is warranted to solidify these conclusions. With the exception of the study on elite U23 cyclists, ¹¹ these TRF studies were conducted with active individuals. More research is needed on elite athletes, especially of varying sports (team sports, power sports, aesthetic sports, etc.). Furthermore, each of these studies had participants perform their exercise bouts within the feeding windows. While many studies have investigated time-of-day effects on training in Muslim athletes during Ramadan, little research has been conducted with TRF. Studies on Ramadan feeding schedules have shown mixed results in markers of performance and may not be generalizable to a TRF modality of IF. ²¹ Lastly, these studies employed either a 4-week intervention¹² or an 8-week intervention. ^{10,11,13,14} The undertaking of longer-term intervention studies is substantial, but as IF gains popularity, it might be a worthwhile investigation to see how TRF feedings affect LM, performance, and metabolic biomarkers over time.

Media-Friendly Summary

With the increase in obesity and metabolic disorders, intermittent fasting has gained popularity as a dietary strategy. IF has been shown to improve appetite control, reduce inflammation, and heighten insulin sensitivity. These results stem from studies in overweight and obese individuals; however, many active individuals are turning to IF as well. Maintaining muscle mass is an important aspect of any nutritional approach, as it sustains performance and plays an important role in overall metabolism. This review examined five studies on time-restricted feeding (TRF) with active individuals and found that it does not appear to be harmful to one's lean mass. However, for those wishing to maximize muscle growth, TRF is less effective than a normal, non-restricted diet. Overall, the TRF method of intermittent fasting has a neutral effect on lean body mass.

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References

1. Patterson RE, Sears DD. Metabolic effects of intermittent fasting. *Annual Review of Nutrition*. 2017 Jul 17;37:371-393. doi:10.1146/annurev-nutr-071816-064634
2. Laza V. Intermittent fasting in athletes: Pros and cons. *Health, Sports & Rehabilitation Medicine*. 2020 Mar;21(1):52-58. doi:10.26659/pm3.2020.21.1.52.
3. Zouhal H, Saeidi A, Salhi A, et al. Exercise training and fasting: Current insights. *Open Access Journal of Sports Medicine*. 2020 Jan 21;11:1-28. doi:10.2147/OAJSM.S224919
4. Paoli A, Tinsley G, Bianco A, et al. The influence of meal frequency and timing on health in humans: The role of fasting. *Nutrients*. 2019 Mar 28;11(4):719. doi:10.3390/nu11040719
5. Welton S, Minty R, O'Driscoll T, et al. Intermittent fasting and weight loss: Systematic review. *Canadian Family Physicians*. 2020 Feb;66(2):117-125.
6. Jeukendrup A., Gleeson M. *Sport Nutrition*. 3rd ed. Champaign, IL: Human Kinetics; 2019.
7. Kerksick CM, Arent S, Schoenfeld BJ, et al. International Society of Sports Nutrition position stand: Nutrient timing. *Journal of the International Society of Sports Nutrition*. 2017 Aug 29;14(1):33. doi:10.1186/s12970-017-0189-4
8. Vicente-Salar N, Urdampilleta Otegui A, Roche Collado E. Endurance training in fasting conditions: Biological adaptations and body weight management. *Nutrición Hospitalaria*. 2015 Dec 1;32(6):2409-2420. doi:10.3305/nh.2015.32.6.9488
9. Van Proeyen K, Szlufcik K, Nielens H, et al. Beneficial metabolic adaptations due to endurance exercise training in the fasted state. *Journal of Applied Physiology (1985)*. 2011 Jan;110(1):236-245. doi:10.1152/japplphysiol.00907.2010
10. Moro T, Tinsley G, Bianco A, et al. Effects of eight weeks of time-restricted feeding (16/8) on basal metabolism, maximal strength, body composition, inflammation, and cardiovascular risk factors in resistance-trained males. *Journal of Translational Medicine*. 2016 Oct 13;14(1):290. doi:10.1186/s12967-016-1044-0
11. Moro T, Tinsley G, Longo G, et al. Time-restricted eating effects on performance, immune function, and body composition in elite cyclists: A randomized controlled trial. *Journal of the International Society of Sports Nutrition*. 2020 Dec 11;17(1):65. doi:10.1186/s12970-020-00396-z
12. Stratton MT, Tinsley GM, Alesi MG, et al. Four weeks of time-restricted feeding combined with resistance training does not differentially influence measures of body composition, muscle performance, resting energy expenditure, and blood biomarkers. *Nutrients*. 2020 Apr 17;12(4):1126. doi:10.3390/nu12041126
13. Tinsley GM, Moore ML, Graybeal AJ, et al. Time-restricted feeding plus resistance training in active females: A randomized trial. *The American Journal of Clinical Nutrition*. 2019 Jul 3;110(3):628-640. doi: 10.1093/ajcn/nqz126
14. Tinsley GM, Forsse JS, Butler NK, et al. Time-restricted feeding in young men performing resistance training: A randomized controlled trial. *European Journal of Sport Science*. 2017;17(2):200-207. doi:10.1080/17461391.2016.1223173
15. PEDro scale. Physiotherapy Evidence Database website. <https://pedro.org.au/english/resources/pedro-scale>. Amended 1999 Jun 21. Accessed March 31, 2021.
16. Gulcelik NE, Halil M, Ariogul S, et al. Adipocytokines and aging: Adiponectin and leptin. *Minerva Endocrinologia*. 2013 Jun;38(2):203-210.
17. Ramana V, Surya KM, Sudhakar RS, et al. Effect of changes in body composition profile on VO2max and maximal work performance in athletes. *Journal of Exercise Physiology*. 2004 Feb;7(1):34-39.
18. Aragon AA, Schoenfeld BJ, Wildman R, et al. International Society of Sports Nutrition position stand: Diets and body composition. *Journal of the International Society of Sports Nutrition*. 2017 Jun 14;14(1):16. doi:10.1186/s12970-017-0174-y
19. Slater GJ, Dieter BP, Marsh DJ, et al. Is an energy surplus required to maximize skeletal muscle hypertrophy associated with resistance training? *Frontiers in Nutrition*. 2019 Aug 20;6:131. doi:10.3389/fnut.2019.00131
20. Arciero PJ, Ives SJ, Norton C, et al. Protein-pacing and multi-component exercise training improves physical performance outcomes in exercise-trained women: The PRISE 3 study. *Nutrients*. 2016 Jun 1;8(6):332. doi:10.3390/nu8060332
21. Trabelsi K, Stannard SR, Ghilisi Z, et al. Effect of fed- versus fasted state resistance training during Ramadan on body composition and selected metabolic parameters in bodybuilders. *Journal of the International Society of Sports Nutrition*. 2013 Apr 25;10(1):23. doi:10.1186/1550-2783-10-23



