European Journal of Sport Science, 2016
http://dx.doi.org/10.1080/17461391.2016.1223173

Routledge
Taylor & Francis Group

ORIGINAL ARTICLE

Time-restricted feeding in young men performing resistance training: A randomized controlled trial†

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Abstract
A randomized controlled trial was conducted to examine eight weeks of resistance training (RT) with and without time-restricted feeding (TRF) in order to assess nutrient intake and changes in body composition and muscular strength in young recreationally active males. The TRF programme consisted of consuming all calories within a four-hour period of time for four days per week, but included no limitations on quantities or types of foods consumed. The RT programme was performed three days per week and consisted of alternating upper and lower body workouts. For each exercise, four sets leading to muscular failure between 8 and 12 repetitions were employed. Research visits were conducted at baseline, four, and eight weeks after study commencement. Measurements of total body composition by dual-energy X-ray absorptiometry and muscle cross-sectional area by ultrasound were obtained. Upper and lower body strength and endurance were assessed, and four-day dietary records were collected. TRF reduced energy intake by ~650 kcal per day of TRF, but did not affect total body composition within the duration of the study. Cross-sectional area of the biceps brachii and rectus femoris increased in both groups. Effect size data indicate a gain in lean soft tissue in the group that performed RT without TRF (+2.3 kg, $d = 0.25$). Upper and lower body strength and lower body muscular endurance increased in both groups, but effect sizes demonstrate greater improvements in the TRF group. Overall, TRF reduced energy intake and did not adversely affect lean mass retention or muscular improvements with short-term RT in young males.

Keywords: *Intermittent fasting, time-restricted feeding, body composition, resistance training, muscular strength, energy intake*

Introduction

Improving body composition by increasing muscle mass and decreasing fat mass is a common goal for disease prevention, athletic performance, and everyday wellness. Individuals seeking to improve body composition often combine dietary strategies with exercise. One dietary strategy that has recently gained popularity for a number of potential health benefits, including improved body composition, is intermittent fasting (Tinsley & La Bounty, 2015). Although there are different forms of intermittent fasting, each form utilizes repeated periods of fasting that extend beyond the duration of a typical overnight fast and typically lead to reductions in energy intake (Rothschild, Hoody, Jambazian, & Varady, 2014; Varady, 2011).

Time-restricted feeding (TRF) is a type of intermittent fasting which utilizes a daily schedule allowing a limited number of hours as a feeding window and the remaining hours as a fasting window. While a form of intermittent fasting similar to this is often used in religious practice (Salim, Al Suwaidi, Ghadban, Alkilani, & Salam, 2013), very limited information about TRF is available. Stote et al. (2007) utilized a crossover design to compare TRF (20 hours of fasting and 4 hours of feeding per day)

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to consuming three meals per day. Each feeding schedule lasted eight weeks. Participants consumed enough food to meet their weight maintenance needs in each condition; however, fat mass was significantly lower (−2.1 kg, $p = .001$) after eight weeks of TRF. Interestingly, lean mass was greater by an average 1.5 kg after TRF, and the difference nearly reached statistical significance ($p = .06$).

Elsewhere in the literature, mixed results are reported regarding the ability to maintain lean body mass with intermittent fasting (Tinsley & Bounty, 2015). It is possible that programmes which reduce energy intake and body weight, such as TRF, could lead to decrements in lean body mass and muscular strength. While there are some data suggesting that resistance training (RT) can slow the loss of skeletal muscle during a restricted nutritional regimen (e.g. ketogenic diets [Jabekk, Meen, Moe, Tomten, & Hostmark, 2010]) and, at a minimum, maintain muscular strength (Paoli et al., 2012), to our knowledge, no reports of RT in combination with intermittent fasting are available.

The effects of TRF on nutrient intake, body composition, and strength have not been examined in combination with RT. The objective of the present study was to determine the effects of a modified TRF programme and RT on these variables.

Methods

Overview

This study was approved by the university institutional review board, and all participants provided informed consent prior to commencing the study. Participants were randomized to eight weeks of RT and normal diet (RT-ND) or RT plus TRF (RT-TRF). Both groups performed progressive RT three times per week consisting of alternating upper and lower body workouts. Dietary analysis and assessment of body composition and muscular performance were completed at baseline, and again at four and eight weeks after commencement of the study. Participants were contacted by study personnel via email or text message each week in order to promote adherence to the assigned programme and answer questions.

Participants

Generally healthy, recreationally active men who had not followed a consistent RT programme over the previous three months were eligible for participation in the study. Prior to participation, all interested individuals received a verbal explanation of the study and signed a university-approved informed consent document.

Body composition assessment

Body composition was assessed via dual-energy X-ray absorptiometry (Hologic Discovery W) whole-body scans. Participants were supine on the scanning table and were positioned according to the National Health and Nutrition Examination Survey recommendations (*NHANES body composition procedures manual*, 2013). Efforts were made to assess participants at the same time of day and in the same nutritional state at each assessment. Cross-sectional areas of the rectus femoris and biceps brachii muscles were assessed bilaterally by ultrasound (SonoSite M-Turbo), using recommended procedures (Bemben, 2002). Subjects were supine on a table for all measurements, and a rolled up towel was placed beneath the popliteal fossa to promote upper thigh relaxation during rectus femoris measurements. A pen was used to mark the superior border of the patella, and transmission gel was applied to the distal portion of the anterior thigh. At the first research visit, the transducer was placed on the midline of the anterior thigh in a transverse orientation and moved proximally until a clear cross section of the rectus femoris was obtained. This distance was measured, marked, and recorded and the transducer was placed in the same location for all subsequent measurements. For measurements of the biceps brachii, participants were supine with the shoulder abducted to approximately 80° and the upper arm supported by the table. Transmission gel was applied to the anterior surface of the upper arm and the transducer was placed on the midline of the anterior upper arm in a transverse orientation. The transducer was moved proximally or distally until a clear cross section of the biceps brachii was obtained. The distance between this location and the acromion process of the scapula was measured and recorded. The transducer was placed in the same location for all subsequent measurements. All body composition assessments took place a minimum of one day after exercise, and a single trained researcher performed all assessments.

Muscular performance testing

Muscular strength of the lower and upper body was assessed by obtaining the 1-repetition maximum (1-RM) using the hip sled and barbell bench press exercises. For both exercises, participants completed 2 warm-up sets: 5–10 repetitions with approximately 50% of the estimated 1-RM and 3–5 repetitions with approximately 70% of the estimated 1-RM. The estimated 1-RM was obtained through inquiring about previous RT experience, as well as the expert opinion of a Certified Strength and Conditioning

Specialist. After warm-up sets, a conservative 1-RM was attempted and weights were increased progressively after successful attempts, with the goal of obtaining the 1-RM in four attempts or fewer. Weight increases were determined through questioning the participant about the difficulty of the prior attempt. A two-minute rest period was used between warm-up sets, and a three-minute rest period was used between 1-RM attempts. For the bench press exercise, participants assumed a five-point body position and were required to lower the bar until it touched the chest, or as close as possible, without bouncing the bar off the chest. Study investigators carefully observed all repetitions to ensure consistency between attempts. For the hip sled exercise, participants self-selected foot positioning at the initial visit and were required to assume the same positioning at each subsequent visit. The sled was lowered eccentrically by the participant until a 90° angle between the lower leg and thigh was achieved, as deemed by the research personnel. The participant was then given a verbal command to begin the concentric portion of the movement. Three minutes after the final 1-RM attempt for each exercise, muscular endurance for that exercise was assessed by performing repetitions to failure using 65% of the 1-RM. These standard procedures were based on the American College of Sports Medicine guidelines (*ACSM's guidelines for exercise testing and prescription*, 2013), and the same trained researchers performed all assessments.

RT programme

The RT programme for both groups consisted of three nonconsecutive days per week of training performed at the gym of the participant's choice. Participants alternated between upper and lower body workouts. The upper body workout consisted of barbell bench press, seated row machine, dumbbell shoulder press, lat pulldown machine, dumbbell biceps curls, and triceps extension machine. The lower body workout consisted of barbell squat or hip sled machine, lunges with dumbbells, leg curl machine, leg extension machine, and calf raise machine. Participants who were unfamiliar with the RT exercises were instructed regarding the proper execution of each exercise. Participants were also instructed to utilize a weight that elicited muscular failure after 8–12 repetitions and to adjust the weight as necessary to meet this criterion. Four sets of each exercise were performed and a 90-second rest period between sets was assigned. Workout logs were utilized to track adherence to the programme.

TRF programme

The RT-TRF group was assigned a TRF programme which was a modified version of the programme used by Stote et al. (2007). On the three days per week that participants performed RT, they were allowed unrestricted food intake. On non-workout days (four days per week), participants were required to consume all calories in any four-hour window between 4 p.m. and midnight. The number of calories and specific foods were not limited. Throughout the duration of the study, daily checklists were completed in order to assess adherence to the TRF days (i.e. the days in which all calories were consumed within a four-hour period). Participants in the RT-ND group were instructed to follow their normal dietary patterns.

Dietary records

During the first, fifth, and eighth weeks of the study, participants completed a four-day dietary record form outside of the lab. Participants in both groups recorded a minimum of one training day and one non-training day, and participants in the RT-TRF group recorded intake from both TRF days and days with unrestricted intake. Dietary records were analysed by a trained researcher using the Food Processor dietary analysis software, version 10.12 (ESHA Research). Comparisons were made within the RT-TRF group (fasting days vs. non-fasting days) and between the RT-ND group and the RT-TRF group. The comparison between the RT-ND and RT-TRF groups was based on weekly energy intake. For the RT-ND group, this was calculated as seven times the average daily intake based on the diet record. For the RT-TRF group, this was calculated as four times the average daily intake on TRF days (i.e. four days per week) plus three times the average daily intake on unrestricted days (i.e. three days per week).

Subjective measurements

At both post-baseline visits, participants in the RT-TRF group were briefly interviewed regarding their experiences with the TRF programme. Questions addressed the difficulty of TRF, any desired modifications, and the participant's interest in continuing TRF after completion of the study. Additionally, individuals completed a 10-cm grounded visual analogue scale (VAS) in order to indicate the difficulty of TRF. A rating of 0 indicated that the programme was "extremely easy" for adherence, and a rating of 10 indicated that programme adherence was "extremely difficult". VAS has previously been utilized to assess the ease of compliance with dietary advice (Apfelbaum et al., 1999), but the specific VAS and survey questions used have not been previously validated. Rather, they were intended to gain basic information on the subjective feelings of participants for the purpose of discussion and future research.

Statistical analysis

Baseline characteristics of participants in both groups were compared using independent samples *t*-tests. Little's Missing Completely at Random (MCAR) test was used to examine missing data, and it was determined that all missing data for dependent variables were missing completely at random. Based on this finding, missing values were generated using expectation maximization. Repeated measures analysis of variance was conducted for major dependent variables using time as the within-subjects variable and group as the between-subjects variable. Dietary comparisons within the RT-TRF group (i.e. comparisons between fasting and non-fasting days) were conducted using repeated measures analysis of variance using both time and day type (fasting or non-fasting) as within-subjects factors. Independent samples *t*-tests were used to compare the number of RT sessions completed and the total upper body and lower body volume between conditions. The reported difficulty of following the TRF programme, as assessed by a VAS, was compared at four and eight weeks using the dependent samples *t*-test. An alpha level of <.05 was selected to determine statistical significance. Cohen's *d* effect sizes (i.e. the difference between means divided by pooled standard deviation) were calculated for dependent variables. Bivariate correlations were performed to examine the relationships between baseline characteristics of participants and responses to interventions. Analyses were conducted using SPSS version 23 (International Business Machines Corporation).

Results

Twenty-eight participants began the study, and 18 participants were included in the analysis (10 from RT-TRF and 8 from RT-ND). Of the 10 participants who were excluded from the study, 6 participants dropped out of the study prior to the 4-week visit (1 from RT-TRF and 5 from RT-ND), 3 participants from the RT-TRF group were excluded from the analysis due to low compliance to the fasting programme (compliance <80%), and one participant from the RT-ND group was excluded from the analysis due to self-report of a major lifestyle change that led to substantial unexpected weight loss. The most common reasons for dropout were illness, injury unrelated to the study, and reported lack of time to complete the programme.

In the RT-ND group, the baseline characteristics of the participants were age 22.0 ± 2.4 y, RT experience 0.8 ± 0.9 days per week, weight 79.0 ± 13.5 kg, height 180.4 ± 6.2 cm, and body fat 18.7 ± 3.8%. In the RT-TRF group, baseline characteristics were age 22.9 ± 4.1 y, RT experience 0.5 ± 0.9 days per week, weight 87.4 ± 19.2, height 179.2 ± 5.8 cm, and body fat 21.3 ± 5.4%. Independent samples *t*-tests revealed no differences in baseline characteristics between groups.

In the final sample, reported compliance with the fasting programme was high (95.9 ± 4.1%). Reported compliance with the RT programme was 92 ± 10% in the RT-ND group and 91 ± 8% in the RT-TRF. There were no differences between groups for number of workouts completed, upper body volume (i.e. total weight lifted), or lower body volume.

Dietary analysis indicated that within the RT-TRF group, individuals consumed fewer calories and less protein, carbohydrate, and fat on fasting days (Table I). On average, 667 fewer calories, 30 fewer grams of protein, 75 fewer grams of carbohydrate, and 25 fewer grams of fat were consumed on fasting days, relative to non-fasting days. However, there were no differences in the percentage of energy derived from each macronutrient between fasting and non-fasting days. When weekly energy and nutrient intake was compared between the RT-ND and RT-TRF groups, the RT-TRF group consumed fewer calories and grams of carbohydrate (Table II). There was also a trend for lower weekly fat consumption in the RT-TRF group. When expressed as a percentage of total energy intake, the RT-TRF group consumed a larger percentage of energy from protein and a smaller percentage of energy from carbohydrate, as compared to the RT-ND group.

No significant changes in body weight or total body composition (i.e. lean soft tissue and body fat) were detected in either group (Table III). However, Cohen's *d* effect sizes for body weight and lean soft tissue were disparate (RT-ND: $d = 0.23$ and 0.25; RT-TRF: $d = -0.05$ and -0.02). Time main effects were present for increased cross-sectional area of the rectus femoris ($p = .00002$, $d = 1.1$ and 0.5 in RT-ND and RT-TRF) and biceps brachii ($p = .001$, $d = 0.83$ and 0.82 in RT-ND and RT-TRF), but no group differences were present. Hip sled and bench press strength, as determined by 1-RM, increased in both groups over the course of the study, but no

Table I. Dietary intake in the TRF group. Values presented as mean ± SD

	Day type	Baseline	4 Weeks	8 Weeks	*p*-Value (interaction)	*p*-Value (time)	*p*-Value (day type)	Effect size (*d*) for day type[a]
Energy (kcal)	U	2318 ± 977	2207 ± 654	2150 ± 492	.611	.544	.00009[b]	−1.0
	TRF	1631 ± 563	1370 ± 371	1674 ± 745				
Protein (g)	U	118 ± 44	107 ± 35	97 ± 28	.505	.335	.006[b]	−0.89
	TRF	79 ± 31	72 ± 30	81 ± 41				
Protein (%kcal)	U	20 ± 6.4	20 ± 5	18 ± 4	.75	.24	.79	0
	TRF	19 ± 5	22 ± 8	19 ± 4				
Carbohydrate (g)	U	252 ± 88	237 ± 77	252 ± 62	.662	.274	.0003[b]	−1.1
	TRF	191 ± 69	143 ± 63	180 ± 72				
Carbohydrate (% kcal)	U	44 ± 8	42 ± 6	47 ± 7	.44	.25	.81	−0.1
	TRF	47 ± 7	41 ± 13	44 ± 7				
Fat (g)	U	93 ± 56	92 ± 33	84 ± 33	.64	.89	.001[b]	−0.8
	TRF	65 ± 23	57 ± 20	70 ± 39				
Fat (%kcal)	U	36 ± 8	37 ± 5	35 ± 8	.89	.78	.43	0.1
	TRF	38 ± 12	38 ± 6	37 ± 6				

Abbreviations: TRF – time-restricted feeding; U – unrestricted.
[a]Calculated as mean of TRF day measurement minus mean of U day measurement, divided by pooled standard deviation.
[b]Statistically significant result.

interaction effects were present (Table IV). Hip sled endurance also increased in both groups over the course of the study.

Substantial variability in outcomes was observed in both groups. For the RT-TRF, per cent changes for individual participants ranged from −5.5% to +2.6% for body weight, −22.1% to +4.5% for fat mass, −4.0% to +4.6% for lean body mass, +4.4% to +22.7% for bench press 1-RM, and +13.7% to +48.1% for hip sled 1-RM. For the RT-ND group, per cent changes ranged from −1.4% to +2.1% for body weight, −13.5% to +12.6% for fat mass, −2.5% to +3.9% for lean body mass, +4.7% to +12.2% for bench press 1-RM, and +13.6% to +31.5% for hip sled 1-RM. In the TRF-RT group, the change in hip sled 1-RM was correlated with average caloric intake on TRF days ($r = .69$, $p = .03$), as well as average carbohydrate intake on TRF days ($r = .80$, $p = .006$). The correlation between change in hip sled 1-RM and average protein intake on TRF days was $r = .62$, $p = .06$. In the both groups, baseline fat mass was inversely related to changes in lean soft tissue ($r = -.57$, $p = .02$), and in the TRF-RT group, baseline lean soft tissue mass was inversely related to changes in body weight ($r = -.67$, $p = .03$). There were no significant correlations between overall energy or macronutrient intake and body composition or strength changes in either group.

Table II. Comparison of weekly dietary intake. Values presented as mean ± SD

	Group	Baseline	4 Weeks	8 Weeks	*p*-Value (interaction)	*p*-Value (time)	*p*-Value (group)	Effect size (*d*) for group[a]
Energy (kcal)	RT-ND	18,495 ± 3948	19,007 ± 4352	14,746 ± 4856	.20	.09	.01[b]	−0.83
	RT-TRF	15,243 ± 5020	12,677 ± 4221	13,144 ± 3722				
Protein (g)	RT-ND	797 ± 268	797 ± 313	633 ± 196	.38	.09	.28	−0.33
	RT-TRF	773 ± 244	606 ± 122	618 ± 199				
Protein (%kcal)	RT-ND	17 ± 3	17 ± 4	18 ± 4	.41	.92	.03[b]	0.79
	RT-TRF	20 ± 3	20 ± 5	19 ± 3				
Carbohydrate (g)	RT-ND	2311 ± 682	2329 ± 669	1755 ± 676	.18	.18	.004[b]	−1.00
	RT-TRF	1738 ± 598	1368 ± 554	1475 ± 365				
Carbohydrate (% kcal)	RT-ND	49 ± 5	49 ± 5	48 ± 7	.64	.70	.005[b]	−0.64
	RT-TRF	46 ± 5	43 ± 8	46 ± 7				
Fat (g)	RT-ND	663 ± 82	715 ± 181	574 ± 212	.55	.47	.08	−0.51
	RT-TRF	576 ± 208	535 ± 250	534 ± 220				
Fat (%kcal)	RT-ND	33 ± 6	34 ± 7	35 ± 9	.90	.64	.30	0.22
	RT-TRF	34 ± 4	37 ± 8	36 ± 7				

Abbreviations: RT-ND – resistance training plus normal diet; RT-TRF – resistance training plus TRF.
[a]Calculated as mean of RT-TRF minus mean of RT-ND, divided by pooled standard deviation.
[b]Statistically significant result.

Table III. Body composition results. Values presented as mean ± SD

	Group	Baseline	4 Weeks	8 Weeks	*p*-Value (interaction)	*p*-Value (time)	*p*-Value (group)	Effect size (*d*) for time[a]
Body weight (kg)	RT-ND	79.0 ± 13.5	79.3 ± 12.9	82.0 ± 11.0	.23	.54	.38	0.23
	RT-TRF	87.4 ± 19.2	86.6 ± 18.0	86.4 ± 17.6				−0.05
Lean soft tissue (kg)	RT-ND	56.4 ± 9.3	56.2 ± 7.8	58.7 ± 8.0	.30	.35	.49	0.25
	RT-TRF	60.4 ± 11.2	60.3 ± 10.7	60.2 ± 10.2				−0.02
Fat mass (kg)	RT-ND	13.7 ± 4.5	14.3 ± 5.5	14.5 ± 3.8	.14	.96	.32	0.18
	RT-TRF	17.8 ± 7.8	17.3 ± 8.1	17.2 ± 8.3				−0.07
Body fat (%)	RT-ND	18.7 ± 3.8	19.2 ± 4.8	19.1 ± 3.3	.37	.95	.44	0.11
	RT-TRF	21.3 ± 5.4	20.8 ± 6.2	20.7 ± 6.4				−0.1

Abbreviations: RT-ND – resistance training plus normal diet; RT-TRF – resistance training plus TRF.
[a]Calculated as mean of eight-week measurement minus mean of baseline measurement, divided by pooled standard deviation.

Four weeks after commencing the study, participants in the RT-TRF group rated the difficulty of the TRF programme a 3.6 ± 1.4 out of 10 on a VAS. At the end of the study, participants reported a similar difficulty as compared to after four weeks of the study (3.8 ± 2.2, $p = .86$).

Discussion

The major finding of this study is that modified TRF with no limitations on food consumed during the feeding window was able to reduce energy intake in young exercising males by approximately 650 kcal per day of modified fasting, but this did not translate into group body composition changes over the course of 8 weeks. Additionally, TRF did not compromise improvements in muscular strength produced by a progressive RT programme and did not lead to decrements in lean soft tissue. However, individuals performing RT-ND gained 2.3 kg of lean soft tissue on average, as opposed to −0.2 kg in RT-TRF, indicating that TRF may have hindered hypertrophic adaptations to RT. This is further supported by effect size data, which indicate a small effect of RT on lean soft tissue in the normal diet group, but no effect in the TRF group ($d = 0.25$ vs. $d = -0.02$). Importantly, effect size data indicate a small to moderate effect of the TRF programme on weekly protein intake, indicating that the TRF-RT group consumed less protein. When calculated relative to body weight, the average daily protein intake in the RT-ND group was 1.4 g/kg body weight/day, whereas the intake in the RT-TRF group, taking both TRF and non-TRF days into account, was 1.0 g/kg. While this level of intake in the RT-TRF group is similar to both the European Food Safety Authority recommendation and the US Recommended Dietary Allowance of 0.8 g/kg, it is likely suboptimal for muscular hypertrophy during weight training and lean mass retention during weight-loss diets (Morton, McGlory, & Phillips, 2015; Phillips, 2014). Phillips recently stated that the current research indicates that protein intake of 1.3–1.8 g/kg, or perhaps higher, can promote lean mass retention during hypocaloric diets (Phillips, 2014). The differences in dietary protein intake seen in this study could have played a role in the greater lean soft tissue accretion in the RT-ND group. Increases in upper and lower body strength were moderate to large in both

Table IV. Muscular performance results. Values presented as mean ± SD

	Group	Baseline	4 Weeks	8 Weeks	*p*-Value (interaction)	*p*-Value (time)	*p*-Value (group)	Effect size (*d*) for time[a]
Bench press 1-RM (kg)	RT-ND	74 ± 18	78 ± 20	81 ± 16	.35	<.001[b]	.33	0.41
	RT-TRF	83 ± 25	88 ± 24	93 ± 24				0.41
Bench press endurance	RT-ND	14 ± 3	15 ± 2	13 ± 3	.17	.20	.10	−0.33
(repetitions)	RT-TRF	15 ± 2	16 ± 1	16 ± 3				0.39
Hip sled 1-RM (kg)	RT-ND	285 ± 71	324 ± 75	359 ± 98	.07	<.001[b]	.12	0.87
	RT-TRF	326 ± 78	403 ± 99	445 ± 116				1.20
Hip sled endurance	RT-ND	17 ± 10	21 ± 10	23 ± 11	.970	.008	.46	0.57
(repetitions)	RT-TRF	15 ± 4	18 ± 7	20 ± 3				1.41

Abbreviation: 1-RM – 1 repetition maximum.
[a]Calculated as mean of eight-week measurement minus mean of baseline measurement, divided by pooled standard deviation.
[b]Statistically significant result.

groups. These increases in strength may have been primarily due to neurological adaptations, based on the relatively untrained participants utilized in this study (Folland & Williams, 2007). Interestingly, effect size data indicate that the RT-TRF group had greater improvements in lower body strength and endurance, as well as upper body endurance, as compared to the RT-ND group.

Although the reported energy intake was substantially lower in the TRF group, the lack of changes in body weight and body fat, as well as the very small effect sizes for these parameters, indicates that there could have been spontaneous reductions in energy expenditure (e.g. decreased non-exercise activity thermogenesis), substantial misreporting of dietary intake, or metabolic adaptations in the TRF group that conserved energy, thereby minimizing weight loss (Byrne, Wood, Schutz, & Hills, 2012; Müller et al., 2015). It is also plausible that reductions in body weight and body fat could potentially occur if the energy intake reductions reported in this study were carried out over a longer period of time. Additionally, it should be noted that individual participants were dissimilar in their body composition alterations, with some individuals in the TRF-RT group losing up to 5.5% of initial body weight and 22% of initial fat mass. Of the 10 TRF-RT participants who completed the study, 5 had higher absolute lean soft tissue mass at the end of the study (i.e. changes greater than 0), while 5 had lower absolute lean soft tissue. In both RT-ND and RT-TRF, individuals who had less body fat at study commencement tended to experience increases in lean soft tissue over the course of the study, whereas individuals with more body fat tended to lose lean soft tissue.

Energy and macronutrient intake on TRF days appears to have played a role in the strength changes seen in this study. While there were no significant correlations between overall energy or macronutrient intake and body composition or strength changes in either group, the energy and macronutrient intake on TRF days in the RT-TRF group was associated with changes in maximal strength. Specifically, individuals who consumed more calories, carbohydrate, and protein on TRF days tended to have greater improvements in maximal lower body strength. Future research should examine the impact of total caloric and macronutrient intake during TRF days on RT performance, as well as employ higher protein intakes in individuals undergoing intermittent fasting programmes to determine if this promotes greater lean mass accretion.

Questionnaire responses provided some insight into participants' experiences with TRF. The majority reported that performing the short-term fasts was initially difficult, but became appreciably easier after several days. Some reported that fasting was only difficult when multiple fasting days in a row were utilized, which could lend support to intermittent fasting programmes which cycle between fasting and non-fasting days, such as alternate-day fasting (Tinsley & Bounty, 2015). Participants also reported that fasting on weekdays was much easier than weekends due to the differences in daily schedules and social eating opportunities. The majority said that, after making these modifications, they would consider utilizing TRF in the future. This information, coupled with the relatively low ratings of difficulty of adherence, could indicate that young males are able to adhere to a TRF programme, although long-term evidence is not readily available.

The present study had several limitations, including the usage of self-reported food intake, unsupervised RT, a small sample size, and a lack of dietary control. Measuring only 12 days of dietary intake over the course of the study is also a limitation, and the specific food items selected by individuals likely played a role in the results of the study. Although efforts were made to ensure that the participants followed the workout programme (i.e. through detailed instruction, weekly follow-up contact, and workout logs), the actual adherence to the programme and effort put forth during RT were not observed by study investigators. We examined only young recreationally active men, but future studies should examine populations of differing activity levels and ages.

TRF is a unique eating style that can be used to decrease energy intake, but further research is needed to examine the potential short- and long-term effectiveness and feasibility of these programmes. TRF does not appear to be detrimental to muscular improvements in young males beginning a RT programme, and the magnitude of improvements in muscular strength and endurance was equal to or greater than the improvements of those following their normal diet. While it is possible that TRF limits the ability to gain lean tissue during an RT programme, additional research utilizing matched protein intake at optimal levels for muscular hypertrophy is necessary. Some individuals may find TRF to be a simpler style of eating to adhere to rather than decreasing energy consumption at each meal, and personal eating preferences should be evaluated when considering a TRF programme. Researchers should continue to examine TRF as a means of reducing energy intake, as well as the potential interactions of TRF, nutrient intake, and exercise programmes.

Acknowledgements

The authors would like to thank the research participants for their dedication and perseverance during this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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