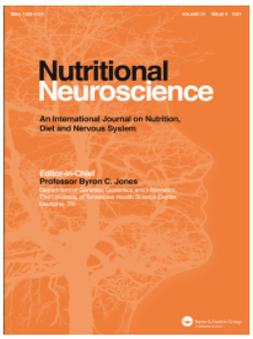

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Time-restricted feeding can increase food-related impulsivity: a randomized controlled trial

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ABSTRACT

Objectives: Although an increasing number of studies show that time-restricted feeding may improve metabolic health, studies examining the behavioral effects of this eating pattern are limited. This study examined the effect of time-restricted feeding on impulsivity in adults.

Methods: Thirty adults aged 25–41 years participated in this randomized controlled trial. The intervention group followed time-restricted feeding for 4 weeks and there was no energy restriction in the intervention group (n = 15) or control group (n = 15). Impulsivity was assessed before and after the intervention with the Barratt Impulsiveness Scale and the Go/NoGo task.

Results: The compliance rate (the percentage of days when participants had a feeding time of ≤ 8 hours/day) of the intervention group to the time-restricted feeding pattern was 92.38 ± 4.24%. The Barratt Impulsiveness Scale-11 total score of the intervention group increased from 55.53 ± 6.37 to 59.47 ± 7.67 *(p = 0.02)*. During the Go/NoGo task, an indicator of inhibitory control, the reaction time to food and non-food stimuli was significantly shortened in the intervention group *(respectively; p = 0.009, p = 0.01)*. In the control group, no significant change was detected in impulsivity determined by the BIS-11 or Go/NoGo task.

Discussion: This study showed that although time-restricted feeding may reduce body weight, it can lead to increased impulsivity and impaired inhibitory control.

Trial registration: ClinicalTrials.gov identifier: NCT04960969.

KEYWORDS

Impulsive behavior; feeding behavior; fasting; diet; nutrition therapy; neurosciences; nutritional sciences; feeding and eating disorders

1. Introduction

Time-restricted feeding (TRF) is a type of intermittent fasting that limits daily food consumption to a period of 4–12 hours and includes a fasting period of 12–20 hours per day [1]. Recently published meta-analyses and systematic reviews have shown that TRF is effective strategy in improving metabolic status, glycemic control, insulin sensitivity, blood lipid profile and weight loss in obese and non-obese individuals [2–5]. But more research is needed to understand the mechanism by which TRF exerts its effects on health and to determine whether TRF can be adapted to a normal lifestyle [6].

Impulsivity includes the tendency to react quickly without considering consequences, the inability to delay gratification, or the compulsive pursuit of exciting stimuli. Impulsive behavior may result from an increased desire for pleasure, a decreased ability to inhibit reward, or both [7]. Higher impulsivity reportedly makes tasty, readily available foods high in sugar, salt, and fat harder to resist than healthier foods, and fast-food consumption is associated with impulsive choices [8–10]. Many studies show that impulsivity is increased in obese individuals [11–18]. In addition, previous studies have associated increased impulsivity with increased uncontrolled eating and/or emotional eating [19–21].

Eliminating high-calorie foods and limiting energy intake is a solid strategy used by many dietitians to control eating behaviors. Strict diet control strategies have been shown to be inversely proportional to dietary success [22]. Difficulties in the implementation of energy-restricted feeding interventions have prompted the development of alternatives to this approach. TRF is a current restrictive feeding pattern developed as an alternative to energy-restricted feeding practices [23]. In recent years, there has been great interest in the impact of fasting periods on neurocognitive performance, and the effects of fasting on mood, behavior, and cognition have been studied [24]. This study aimed to investigate the effects of TRF on individuals' impulsivity. The H_0 hypothesis of the

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study was that TRF does not affect the level of impulsivity in adults.

2. Materials and methods

2.1. Study design and participants

This parallel group-randomized trial was conducted between 07 January 2021 and 23 May 2022. The universe of the research consisted of the academic staff (n = 716) of a foundation university in Türkiye. All staff was reached via e-mail sent by the General Secretariat of the University. Individuals who volunteered to participate in the study (n = 38) filled out a questionnaire containing the inclusion criteria, and candidates who met these criteria (n = 30) were accepted to the study (Figure 1). The sample size was calculated using the Gpower computer program with a power of 80% and a type 1 error (α) level of 0.05, and it was determined that at least fourteen participants for each group should be included [25]. Individuals aged 25–45 years, with a body mass index (BMI) above 18.5 kg/m^2 and a routine feeding time of ≥10 hours were included in the study. Individuals who have been on a diet in the last six months; pregnant or breastfeeding; known to have a neurological or psychological disorder; have family members with a history of eating disorders; those who have experienced a weight change of ≥5 kg in the last three months; have an uncontrolled medical problem; or those with a history of bariatric surgery, celiac disease, Crohn's disease, or ulcerative colitis were excluded.

The study ultimately excluded those in the intervention group (IG) whose diet compliance was below 80%; those who initially qualified for the study but later during the study process underwent a status change that disqualified them; and those who quit the study.

2.2. Procedure

Volunteered participants were assigned to the IG or CG using the stratified randomization method [26]. Stratification depended on whether the participants were male or female, and group assignments proceeded randomly according to the order in which the participants completed the participation form. The groups were checked for similar characteristics in terms of age, education level, body weight, and BMI. The IG applied for TRF for four weeks. Participants in this group consumed food for eight hours daily and consumed only non-energy liquids for sixteen hours. Participants chose between two time periods (10:00-18:00 or 11:00-19:00) for food consumption. IG recorded the start and end times of meals (excluding liquids without energy content) each day from the first day of the intervention. Adherence to the intervention was calculated as the percentage of days when participants had a feeding time of ≤ 8 hours/day and compliance was targeted to be ≥ 80%.

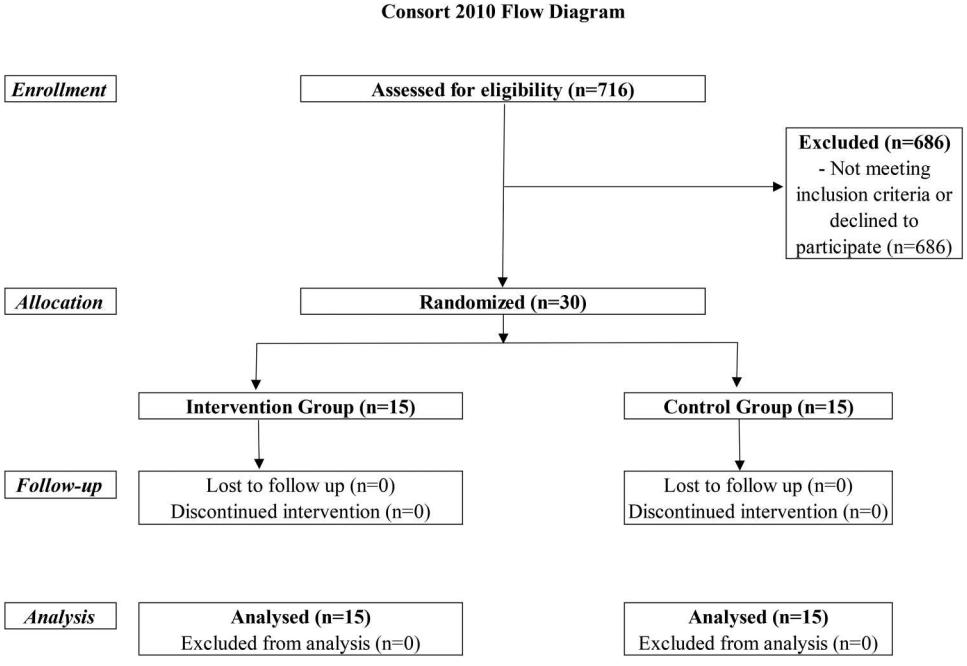

Figure 1. Consort 2010 Flow Diagram.

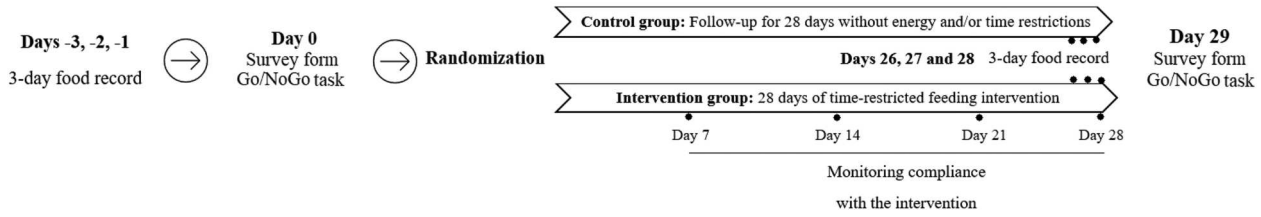

Figure 2. Study procedure.

The control group was only followed for 4 weeks, no energy or time restrictions were applied. The eating period of the control group was also monitored throughout the intervention and it was ensured that there was no significant change in daily feeding times (Figure 2).

2.3. Data collection

2.3.1. Survey form

Participant's sociodemographic characteristics (age, gender, educational status) were recorded through a questionnaire administered face-to-face.

2.3.2. Assessment of anthropometric measurements

The researcher took anthropometric measurements at the beginning and end of the intervention. Body fat mass, body muscle mass, and body weight measurements were performed using a professional body analysis measuring device *[Bioelectrical Impedance Analysis, (BIA) Inbody 270]*. BMI (BMI = body weight / height^2) (kg/m^2) was calculated from the height and body weight values of the subjects [27].

2.3.3. Assessment of impulsivity

2.3.3.1. Barratt impulsiveness scale (BIS-11). BIS-11 was used to evaluate the impulsivity of individuals at the beginning and end of the intervention. This scale was developed by Barrat in 1959; the Turkish validity and reliability study was conducted by Güleç et al. in 2008. BIS-11 includes attention impulsivity, motor impulsivity, and non-planning subscales and consists of a total of thirty questions. A high score on the scale indicates high impulsivity [28, 29].

2.3.3.2. Go/NoGo task. Inhibitory control was assessed with a Go/NoGo task in which images of food *(fruits, vegetables, chocolates, meat, fish, nuts, beverages)* and non-food *(tools, house-hold items, kitchen utensils, office supply)* were presented to the participants at the beginning and end of the intervention. Which images will be used in the task were determined by Işık and Emiroğlu in a study carried out in 2021 [30]. Images used in the Go/NoGo task were selected from the Food-Pics image database, designed for use in experimental studies on feeding behaviors [31, 32]. The codes of the images used in the task in the database: *1, 22, 26, 45, 49, 61, 73, 74, 133, 199, 218, 234, 282, 285, 313, 317, 358, 398, 413, 416, 664, 665, 675, 703, 729, 1026, 1031, 1035, 1050, 1052, 1108, 1131, 1132, 1141, 1142, 1149, 1196, 1204, 1217, 1224, 1234, 1240, 1241, 1247, 1263, 1273, 1275, 1277, 1313, 1314*. The Go/NoGo task was designed using the *Opensesame 3.2.8 Kafkaesque Koffka program* [33]. This task consists of two blocks [Food Go (FGo) and Non-Food Go (NFGo)], with 100 trials in each.

§ In the FGo block, food stimuli were assigned for 'Go' trials and non-food stimuli for 'NoGo' trials.
§ In the NFGo block, non-food stimuli were assigned for the 'Go' trials and food stimuli for the 'NoGo' trials.

Participants completed both task blocks. The type of block to start the task was distributed evenly among the participants. The task was presented to all participants on a 14" screen. Participants were expected to respond as quickly as possible by pressing the space key on the keyboard for the target stimulus (Go) in each block, and not to respond for non-target stimuli (NoGo). 75% 'Go' and 25% 'NoGo' stimuli were presented in each block. In each trial, the stimuli disappeared after being on the screen for 500 ms. After the stimulus disappeared, a fixation screen was displayed to which the participants would respond. This screen remained for a maximum of 1500 ms. Thus, participants had a maximum time of 1500 ms to respond. There was a 500 ms blank screen between the fixation screen and the next trial. After the blank screen, the next trial began (Figure 3) [34, 35]. A practice session (eight trials for each block) was conducted so that the participants could understand the task. Participants who achieved more than 80% success in the practice session started the experiment session.

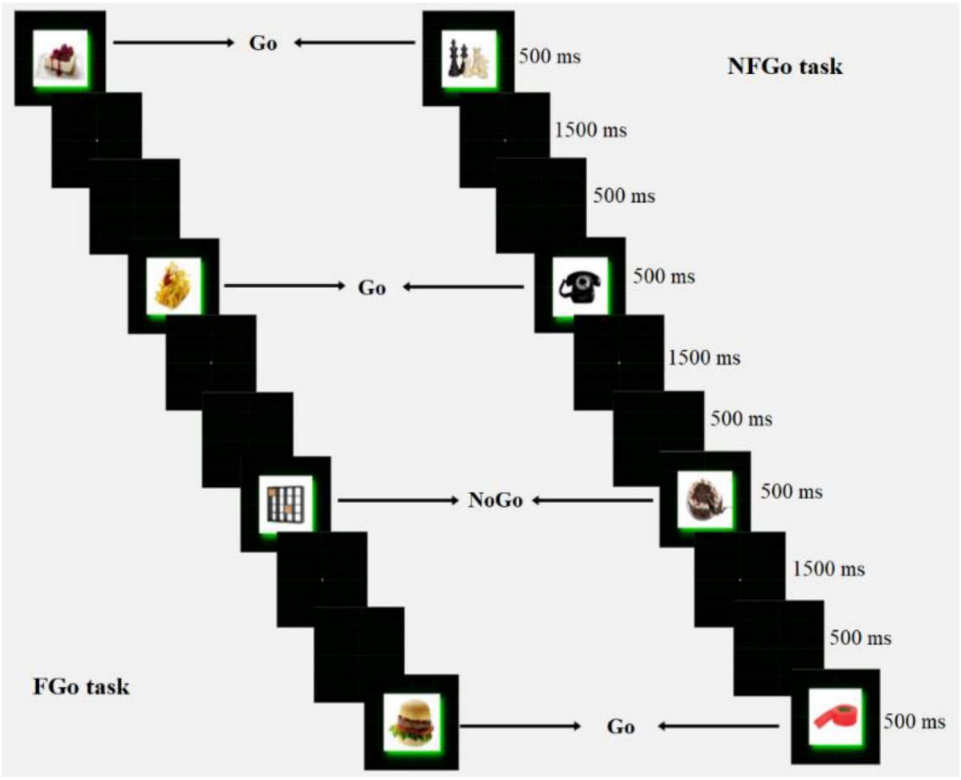

Figure 3. A task flow diagram of the food go (FGo) and the non-food go (NFGo) blocks.

Participants' overall reaction time in milliseconds during correct 'Go' trials, omission error rate (missed Go trials), and false alarm rate (response to NoGo stimulus) were calculated.

2.3.4. Assessment of food intake

Food consumption of individuals was evaluated with a 3-day food record. Records were taken at the beginning of the study and between the 26th and 28th days of intervention. Consumption records were analyzed using BeBiS – Nutrition Information System 9 *(Pacific Company, Turkey)* [36].

2.4. Data analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences *(IBM SPSS Statistics, version 22.0)*. The conformity of the variables to the normal distribution was assessed using visual (histogram and probability graphs) and analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk tests). Descriptive analyses used the mean and standard deviation for normally distributed variables and the median and interquartile range for non-normally distributed variables (body weight, FGo false alarm rate, FGo omission error). Number and percentage values are given for ordinal and nominal variables. The significance test of the difference between the two means (T-test) was used to compare the measured values of the IG and CG, and the Mann–Whitney U test was used for data that did not fit the normal distribution. Paired Sample T-test was used for the variables of the IG and CG that met the criteria for normal distribution, and the Wilcoxon test was used for those that did not meet the criteria for normal distribution. For statistical significance, the total type-1 error level was determined as $p < 0.05$.

2.5. Ethical considerations

All individuals who volunteered to participate in the study were given detailed information about the study and their consent was obtained. This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethics committee approval was obtained from Istinye University Human Research Ethics Committee *(Protocol No: 157, Date: 22.12.2020)*. The study was registered on ClinicalTrials.gov under the number NCT04960969.

3. Results

Thirty adult individuals (CG = 15, IG = 15) between the ages of 25–41 participated in the study, and the

Table 1. Sociodemographic characteristics.

Variable		Intervention Group	Control Group	*P*
Age (years), mean ± SD		28.93 ± 4.30	27.13 ± 2.36	0.06†
Gender, n (%)	Female	11 (73.30)	11 (73.30)	1.00†
	Male	4 (26.70)	4 (26.70)	
Educational Status, n (%)	Undergraduate Degree Holder	1 (6.70)	0 (0.00)	0.52†
	Master's Student / Degree Holder	6 (40.00)	5 (33.30)	
	PhD Student / Holder	8 (53.30)	10 (66.70)	

† Significance test of the mean difference between independent groups (T-test); ǂ X^2, chi-square analysis; SD, standard deviation.

compliance rate of the individuals in the IG to the TRF intervention applied for four weeks was 92.38 ± 4.24% (82.14-100%). No participant had a compliance rate with the intervention below 80%, so no participants were excluded from the study. Using the stratified randomization method, 11 female and 4 male participants were assigned to each group. Table 1 compares the sociodemographic characteristics of the IG and CG. IG and CG were similar in terms of age, gender, and educational status *(p > 0.05)*.

Energy intake of individuals was evaluated with a 3-day food record and the results were presented in Table 2. There was no significant difference between the energy intakes of the IG and CG groups at baseline *(p = 0.60)*. At the end of the intervention, there was no significant change in the energy intake of the IG or CG *(p = 0.16, p = 0.27, respectively)*.

Table 3 presents data on anthropometric measurements of individuals. While there was no change in the anthropometric data of the CG *(p > 0.05)*, there was a statistical decrease in body weight, BMI, and body fat in the IG *(p = 0.001; p = 0.00 and p = 0.03, respectively)*.

Table 4 presents data on BIS-11 scores. There was no statistically significant difference between the groups in related BIS-11 scores (total score, motor impulsivity, attention impulsivity, non-planning) at baseline *(p = 0.41; p = 0.26; p = 0.24 and p = 0.09, respectively)*. After the intervention, the IG's BIS-11 total score and BIS-11 non-planning subscale score were higher than those of the CG *(p = 0.04 and p = 0.01, respectively)*. The BIS-11 total score and BIS-11 attention impulsivity subscale score of the IG differed statistically before and after the intervention period *(p = 0.02 and p = 0.04, respectively)*.

Table 5 presents Go/NoGo task data. Before the intervention, there was no statistically significant difference between the groups in Go/NoGo task scores

Table 2. Energy Intake.

		Intervention Group			Control Group		
		X ± SD	Mean change(CI 95%)	p†	X ± SD	Mean change(CI 95%)	p†
Energy (kcal/day)	**BI**	1628.56 ± 402.49	155.67 (−67.12–378.46)	0.16	1554.95 ± 357.62	36.33 (−30.80–103.47)	0.27
	AI	1472.89 ± 483.26			1518.61 ± 308.42		

†Within-group Paired Sample T Test; X, mean; SD, standard deviation; BI, before the intervention; AI, after the intervention; CI, confidence interval.

Table 3. Anthropometric measurements.

		Intervention Group			Control Group		
		X ± SD	Mean change (CI 95%)	*p*†	X ± SD	Mean change (CI 95%)	*p*†
BMI (kg/m^2)	BI	23.06 ± 3.37	0.37 (0.20–0.55)	<0.001	23.83 ± 3.41	0.90 (−0.07–0.25)	0.26
	AI	22.69 ± 3.16			23.74 ± 3.40		
Body fat (kg)	BI	19.01 ± 4.79	1.08 (0.12–2.03)	0.03	17.73 ± 4.79	−0.22 (−0.77–0.33)	0.41
	AI	17.93 ± 5.24			17.95 ± 4.75		
Body fat ratio (%)	BI	28.92 ± 4.54	1.41 (−0.13–2.96)	0.7	27.11 ± 5.43	−0.47 (−1.35–0.41)	0.27
	AI	27.51 ± 4.92			27.59 ± 5.31		
Body muscle weight (kg)	BI	25.43 ± 6.80	0.33 (−0.50–1.16)	0.41	25.23 ± 5.57	0.25 (−0.76–0.58)	0.12
	AI	25.11 ± 6.31			24.98 ± 5.6		
Body muscle ratio (%)	BI	38.29 ± 3.44	−0.32 (−1.33–0.69)	0.51	38.61 ± 4.80	0.29 (−0.15–0.74)	0.18
	AI	38.61 ± 4.10			38.31 ± 4.83		
		Median (25th-75th percentile)	Z	*p*†	Median (25th-75th percentile)	Z	*p*†
Body weight (kg)	BI	61.80 (53.20-79.20)	−3.35	<0.001	63.80 (55.10-76.60)	−0.95	0.35
	AI	61.10 (52.90-77.20)			63.60 (54.50-75.90)		

ǂ Within-group Paired Sample T-test; † Wilcoxon test; X, mean; SD, standard deviation; BMI, body mass index; BI, before the intervention; AI, after the intervention; CI, confidence interval.

Table 4. BIS-11 scores.

		Intervention Group			Control Group		
		X ± SD	Mean change (CI 95%)	$p^{\dagger}$	X ± SD	Mean change (CI 95%)	$p^{\dagger}$
BIS-11 (total score)	**BI**	55.53 ± 6.37	−3.93 (−7.08 to − 0.79)	**0.02**	53.47 ± 7.05	−0.07 (−2.26–2.12)	0.95
	AI	59.47 ± 7.67			53.53 ± 7.26		
BIS-11 (motor impulsivity)	**BI**	11.93 ± 2.49	−0.27 (−1.68–1.15)	0.69	10.93 ± 2.017	0.13 (−0.70–0.97)	0.74
	AI	12.20 ± 1.78			10.80 ± 2.145		
BIS-11 (attention impulsivity)	**BI**	24.20 ± 3.36	−2.40 (−4.62 to − 0.18)	**0.04**	24.67 ± 4.12	0.47 (−1.58–2.52)	0.63
	AI	26.60 ± 5.15			24.20 ± 4.84		
BIS-11 (non-planning)	**BI**	19.40 ± 2.80	−1.27 (−2.65–0.11)	0.07	17.80 ± 2.18	−0.27 (−1.06–0.53)	0.48
	AI	20.67 ± 2.99			18.07 ± 2.43		

†Within-group Paired Sample T Test; X, mean; SD, Standard Deviation; BIS, Barrat Impulsiveness Scale; BI, before the intervention; AI, after the intervention; CI, confidence interval.

(for all measurements $p > 0.05$), but after the intervention, the NFGo reaction times of the IG were significantly shorter than the CG *($p = 0.04$)*. FGo and NFGo reaction times in the IG were statistically significantly shortened after the intervention *($p = 0.009$ and $p = 0.01$, respectively)*.

4. Discussion

This randomized controlled intervention study examined the effects of TRF (16:8) on impulsivity in adults over four weeks. Results showed that TRF increased impulsivity and decreased body weight, BMI, and body fat.

Meta-analysis studies and reviews show that the focus is on the effects of TRF on metabolic parameters and anthropometric measurements (37-39). A meta-analysis by Pellegrini et al. found that this dietary pattern resulted in weight loss and reduced blood glucose levels [37]. A meta-analysis by Moon et al. determined TRF to be a promising strategy to control body weight and improve metabolic dysfunction in overweight or obese individuals [38]. Yet another meta-analysis study examined the effect of early TRF (eTRF), a model in which dinner is eaten in the afternoon, on the metabolic profile of adults with a BMI above 25 kg/m^2; eTRF reported reduced fasting blood glucose and HOMA-IR [39]. The statistically significant decrease in body weight, BMI, and body fat of individuals who applied TRF in the present study was consistent with the results of meta-analysis studies in the literature.

A recently published meta-analysis study reported that the health effects of TRF practiced under ad libitum conditions may be due to a decrease in energy intake, and emphasized that this makes it difficult to attribute the health effects to TRF or energy restriction. In the article, it was reported that there is a need for studies comparing the effectiveness of TRF, calorie restriction (CR), and TRF with CR [40]. In our study, it was observed that there was no decrease in energy intake due to TRF and the decrease in body weight occurred independently of energy intake.

Limited intervention studies exist examining the effects of different dietary patterns and/or nutritional supplements on impulsivity in humans [24, 41–44].

Table 5. Go/NoGo task score.

		Intervention Group			Control Group		
		X ± SD	Mean change (CI 95%)	$p^{\dagger}$	X ± SD	Mean change (CI 95%)	$p^{\dagger}$
FGo reaction time (ms)	BI	318.50 ± 139.92	81.40 (18.60–108.76)	0.009	322.38 ± 74.23	17.86 (−12.23–47.96)	0.22
	AI	254.82 ± 80.21			304.52 ± 71.63		
NFGo reaction time (ms)	BI	270.59 ± 94.58	41.04 (12.47–69.62)	0.01	294.74 ± 58.23	8.24 (−11.53–28.00)	0.39
	AI	229.54 ± 77.25			286.51 ± 72.69		
NFGo omission error rate (%)	BI	0.98 ± 1.92	0.01 (−0.48–0.49)	0.99	0.27 ± 0.55	−0.01 (−0.55–0.56)	0.10
	AI	0.98 ± 1.71			0.27 ± 0.75		
NFGo false alarm rate (%)	BI	2.40 ± 3.64	−1.07 (−3.50–1.37)	0.36	2.40 ± 4.22	0.53 (−1.31–2.38)	0.55
	AI	3.47 ± 4.75			1.87 ± 2.56		
	AI	2.00 ± 2.51			1.37 ± 1.70		
		Median (25th-75th percentile)	Z	$p^{\dagger}$	Median (25th-75th percentile)	Z	$p^{\dagger}$
FGo false alarm rate (%)	BI	0.00 (0.00-0.00)	0.00	1.00	1.97 (1.07-0.00)	−0.30	0.76
	AI	0.00 (0.00-0.00)			1.71 (0.98-0.00)		
FGo omission error (%)	BI	0.00 (0.00-2.66)	−0.86	0.39	1.66 (0.80-0.00)	−0.09	0.93
	AI	0.00 (0.00-1.33)			1.64 (0.87-0.00)		

†Within-group Paired Sample T-test; †Wilcoxon test; X, mean; SD, standard deviation; BI, before the intervention; AI, after the intervention; FGo, food go; NFGo, non-food go; CI, confidence interval.

A randomized controlled study examining the effect of TRF on impulsivity has not been found in the literature. A study of circadian differences' effects on impulsivity and food addiction administered a Morningness-Eveningness Questionnaire to 1323 university students and divided them into morning, evening, and intermediate categories according to their responses. It has been shown that evening-type individuals were more impulsive than morning-type individuals according to BIS-11, and this increased impulsivity promotes food addiction in evening-type individuals [45]. Hasler et al. (2022) also showed impulsivity to be higher in evening-type individuals [46]. The present study hypothesized that TRF, a nutritional approach targeting the circadian rhythm, may influence impulsivity and determined that impulsivity, as assessed by BIS-11, increased in individuals who applied TRF; further, inhibitory control was impaired in these individuals as the Go/NoGo task demonstrated. These findings suggested that TRF, which was representative of an approach suitable for circadian rhythm, may increase impulsivity. This finding opposes the findings of Kandeger et al. and Hasler et al. It is unclear by what mechanism(s) TRF may increase impulsivity. However, since this nutritional model is a restrictive approach, it is thought that similar results to the effects of energy-restricted diets may occur in TRF. Previous studies suggest that restrictive feeding may exhibit altered neural responses in a food-based Go/NoGo task and changes in orbitofrontal cortex activity [35, 47]. In future studies, the mechanisms through which the effects of TRF on impulsivity may occur and the effects of different types of TRF (such as eTRF) can be examined.

This study is the first known randomized controlled study to examine 4 weeks TRF's effects on impulsivity. A strength of this study is that it was randomized and controlled. The limitation of the study is that the sample consists of academic staff with at least a bachelor's degree in education; data obtained from populations with different education levels and work patterns may differ.

The World Health Organization defines health as '*a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity*' [48]. Publications that deal with the health effects of TRF interventions, which have been growing in the literature in recent years, focus on the physical effects of this nutrition model. This study reports that impulsivity, which holds an important place in nutritional attitudes and behaviors and may play a role in the development of eating disorders, increases when TRF is applied for four weeks. The study provides a new perspective to experts who want to apply the TRF model and a new research area in this field.

Suggestions

I. More studies of the effects of nutritional models on social and mental health at the clinical level.
II. Use of larger samples in studies of the effects of different TRF applications (e.g. eTRF) in different populations.
III. Recognition that TRF, a restrictive nutritional approach, can increase impulsivity.
IV. Regular monitoring of nutritional behaviors of individuals who apply time-restricted feeding; in cases of emergent impaired eating behavior, interruption, or termination of TRF.

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Author Contributions

Elif Güner: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – Original Draft, Writing – Review & Editing. **Şule Aktaç:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft, Writing – Review & Editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

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References

[1] Adafer R, Messaadi W, Meddahi M, Patey A, Haderbache A, Bayen S, et al. Food timing, circadian rhythm and chrononutrition: a systematic review of time-restricted eating's effects on human health. Nutrients. 2020;12(12):3770, doi:10.3390/nu12123770.

[2] Liu L, Chen W, Wu D, Hu F. Metabolic efficacy of time-restricted eating in adults: a systematic review and meta-analysis of randomized controlled trials. J Clin Endocrinol Metab. 2022;107(12):3428–41. doi:10.1210/clinem/dgac570.

[3] Jaramillo AP, Castells J, Ibrahimli S, Jaramillo L, Briones Andriuoli RR, Moncada D, Revilla JC. Time-restricted feeding and intermittent fasting as preventive therapeutics: a systematic review of the literature. Cureus. 2023;15(7):e42300, doi:10.7759/cureus.42300.

[4] Tsitsou S, Zacharodimos N, Poulia KA, Karatzi K, Dimitriadis G, Papakonstantinou E. Effects of time-restricted feeding and Ramadan fasting on body weight, body composition, glucose responses, and insulin resistance: a systematic review of randomized controlled trials. Nutrients. 2022;14(22):4778, doi:10.3390/nu14224778.

[5] Kang J, Ratamess NA, Faigenbaum AD, Bush JA, Beller N, Vargas A, et al. Effect of time-restricted feeding on anthropometric, metabolic, and fitness parameters: a systematic review. J Am Nutr Assoc. 2022;41(8):810–25. doi:10.1080/07315724.2021.1958719.

[6] Flanagan A, Bechtold DA, Pot GK, Johnston JD. Chrono-nutrition: from molecular and neuronal mechanisms to human epidemiology and timed feeding patterns. J Neurochem. 2021;157(1):53–72. doi:10.1111/jnc.15246.

[7] Heshmat S. Overeating and decision-making deficits. Eating behavior and obesity – behavioral economics strategies for health professionals. Newyork: Springer Publishing Company; 2011, p.160–5.

[8] Dassen FC, Houben K, Jansen A. Time orientation and eating behavior: unhealthy eaters consider immediate consequences, while healthy eaters focus on future health. Appetite. 2015;91:13–9. doi:10.1016/j.appet.2015.03.020.

[9] Garza KB, Ding M, Owensby JK, Zizza CA. Impulsivity and fast-food consumption: a cross-sectional study among working adults. J Acad Nutr Diet. 2016;116(1):61–8. doi:10.1016/j.jand.2015.05.003.

[10] Bennett C, Blissett J. Interactive effects of impulsivity and dietary restraint over snack intake in children. Appetite. 2020;146:104496, doi:10.1016/j.appet.2019.104496.

[11] Bénard M, Camilleri GM, Etilé F, Méjean C, Bellisle F, Reach G, et al. Association between impulsivity and weight status in a general population. Nutrients. 2017;9(3):217, doi:10.3390/nu9030217.

[12] Cook RL, O'Dwyer NJ, Donges CE, Parker HM, Cheng HL, Steinbeck KS, et al. Relationship between obesity and cognitive function in young women: the food, mood and mind study. J Obes. 2017;2017:5923862, doi:10.1155/2017/5923862.

[13] Loeber S, Grosshans M, Korucuoglu O, Vollmert C, Vollstädt-Klein S, Schneider S, et al. Impairment of inhibitory control in response to food-associated cues and attentional bias of obese participants and normal-weight controls. Int J Obes. 2012;36(10):1334–9. doi:10.1038/ijo.2011.184.

[14] Meule A, Lutz A, Krawietz V, Stützer J, Vögele C, Kübler A. Food-cue affected motor response inhibition and self-reported dieting success: a pictorial affective shifting task. Front Psychol. 2014;5:216, doi:10.3389/fpsyg.2014.00216.

[15] Nederkoorn C, Smulders FTY, Havermans RC, Roefs A, Jansen A. Impulsivity in obese women. Appetite. 2006;47(2):253–6. doi:10.1016/j.appet.2006.05.008.

[16] Rasmussen EB, Lawyer SR, Reilly W. Percent body fat is related to delay and probability discounting for food in humans. Behav Processes. 2010;83(1):23–30. doi:10.1016/j.beproc.2009.09.001.

[17] Satyal MK, Basso JC, Tegge AN, Metpally AR, Bickel WK. A novel model of obesity prediction: neurobehaviors as targets for treatment. Behav Neurosci. 2021;135(3):426–42. doi:10.1037/bne0000385.

[18] Wen HJ, Tsai CL. Neurocognitive inhibitory control ability performance and correlations with biochemical markers in obese women. Int J Environ Res Public Health. 2020;17(8):2726, doi:10.3390/ijerph17082726.

[19] Elif E, Mevlüde I. Impulsivity as a determinant of food intake: a cross sectional study of its role in eating attitudes and behaviors. Turkiye Klinikleri J Health Sci. 2022;7(3):635–41. doi:10.5336/healthsci.2021-86816.

[20] Leitch MA, Morgan MJ, Yeomans MR. Different subtypes of impulsivity differentiate uncontrolled eating and dietary restraint. Appetite. 2013;69:54–63. doi:10.1016/j.appet.2013.05.007.

[21] Yeomans MR, Leitch M, Mobini S. Impulsivity is associated with the disinhibition but not restraint factor from the three factor eating questionnaire. Appetite. 2008;50(2-3):469–76. doi:10.1016/j.appet.2007.10.002.

[22] Meule A, Westenhöfer J, Kübler A. Food cravings mediate the relationship between rigid, but not flexible control of eating behavior and dieting success. Appetite. 2011;57(3):582–4. doi: 10.1016/j.appet.2011.07.013.

[23] Duregon E, Pomatto-Watson LCDD, Bernier M, Price NL, de Cabo R. Intermittent fasting: from calories to time restriction. Geroscience. 2021;43(3):1083–92. doi:10.1007/s11357-021-00335-z.

[24] Howard M, Roiser JP, Gilbert SJ, Burgess PW, Dayan P, Serpell L. Short-term fasting selectively influences impulsivity in healthy individuals. Front Psychol. 2020;11:1644, doi:10.3389/fpsyg.2020.01644.

[25] Erdfelder E, Faul F, Buchner A. Gpower: a general power analysis program. Behav Res Meth Instrum Comput. 1996;28:1–11.

[26] Kanik A, Tasdelen B, Erdogan S. Randomization in clinical trials. Marmara Med J. 2011;24:149–55. doi:10.5472/MMJ.2011.01981.1.

[27] Litchford MD. Clinical: biochemical, physical, and functional assessment. In: Mahan LK, Raymond JL, editor. Krause's food & the nutrition care process. 14th ed. St. Louis: Elsevier; 2017. p. 111–6.

[28] Barratt ES. Anxiety and impulsiveness related to psychomotor efficiency. Percept Mot Ski. 1959;9:191–8. doi:10.2466/pms.1959.9.3.191.
[29] Güleç H, Tamam L, Güleç MY, Turhan M, Karakuş G, Zengin M, Stanford MS. Psychometric properties of the Turkish version of the Barratt impulsiveness scale-11. Bull Clin Psychopharmacol. 2008;18 (4):251–8.
[30] Işık M, Emiroğlu E. Designing of a food-specific Go/No-Go task. Paper presented at: international Eurasian health sciences congress; 2021; Trabzon, Turkey.
[31] Teslovich T, Freidl EK, Kostro K, Weigel J, Davidow JY, Riddle MC, et al. Probing behavioral responses to food: Development of a food-specific Go/No-Go task. Psychiatry Res. 2014;219(1):166–70. doi: 10.1016/j.psychres.2014.04.053.
[32] Blechert J, Lender A, Polk S, Busch NA, Ohla K. Food-pics_extended – an image database for experimental research on eating and appetite: additional images, normative ratings and an updated review. Front Psychol. 2019;10:307, doi:10.3389/fpsyg.2019.00307.
[33] Mathôt S, Schreij D, Theeuwes J. OpenSesame: an open-source, graphical experiment builder for the social sciences. Behav Res Methods. 2012;44(2):314–24. doi: 10.3758/s13428-011-0168-7.
[34] Oomen D, Grol M, Spronk D, Booth C, Fox E. Beating uncontrolled eating: training inhibitory control to reduce food intake and food cue sensitivity. Appetite. 2018;131:73–83. doi:10.1016/j.appet.2018.09.007.
[35] Price M, Lee M, Higgs S. Food-Specific response inhibition, dietary restraint and snack intake in lean and overweight/obese adults: a moderated-mediation model. Int J Obes. 2016;40(5):877–82. doi:10.1038/ijo.2015.235.
[36] Ebispro for Windows, Stuttgart, Germany; Turkish Version, Pasifik Elektrik Elektronik Ltd. Şti. (www.bebis.com.tr); Istanbul, 2019.
[37] Pellegrini M, Cioffi I, Evangelista A, Ponzo V, Goitre I, Ciccone G, et al. Effects of time-restricted feeding on body weight and metabolism. A systematic review and meta-analysis. A Syst Rev Meta-Anal. Rev Endocr Metab Disord. 2020;21:17–33. doi:10.1007/s11154-019-09524-w.
[38] Moon S, Kang J, Kim SH, Chung HS, Kim YJ, Yu JM, et al. Beneficial effects of time-restricted eating on metabolic diseases: a systemic review and meta-analysis. Nutrients. 2020;12(5):1267, doi:10.3390/nu12051267.
[39] Pureza IROM, Macena ML, da Silva Junior AE, Praxedes DRS, Vasconcelos LGL, Bueno NB. Effect of early time-restricted feeding on the metabolic profile of adults with excess weight: a systematic review with meta-analysis. Clin Nutr. 2021;40 (4):1788–99. doi:10.1016/j.clnu.2020.10.031.
[40] Sun JC, Tan ZT, He CJ, Hu HL, Zhai CL, Qian G. Time-restricted eating with calorie restriction on weight loss and cardio metabolic risk: a systematic review and meta-analysis. Eur J Clin Nutr. 2023;77:1014–25. doi:10.1038/s41430-023-01311-w.
[41] Arteaga-Henríquez G, Rosales-Ortiz SK, Arias-Vásquez A, Bitter I, Ginsberg Y, Ibañez-Jimenez P, et al. Treating impulsivity with probiotics in adults (PROBIA): study protocol of a multicenter, double-blind, randomized, placebo-controlled trial. Trials. 2020;21(1):161, doi:10.1186/s13063-019-4040-x.
[42] Nederkoorn C, Guerrieri R, Havermans RC, Roefs A, Jansen A. The interactive effect of hunger and impulsivity on food intake and purchase in a virtual supermarket. Int J Obes. 2009;33(8):905–12. doi: 10.1038/ijo.2009.98.
[43] Ross KM, Eastman A, Ugwoaba UA, Demos KE, Lillis J, Wing RR. Food reward sensitivity, impulsivity, and weight change during and after a 3-month weight loss program. PLoS One. 2020;15(12):e0243530, doi:10.1371/journal.pone.0243530.
[44] San Mauro Martina I, Sanz Rojoa S, González Cosanoa L, Conty de la Campaa R, Garicano Vilaray E, Blumenfeld Olivaresb JA. Impulsiveness in children with attention-deficit/hyperactivity disorder after an 8-week intervention with the Mediterranean diet and/or omega-3 fatty acids: a randomised clinical trial. Neurología. 2019;S0213–4853(19):30132–X. doi:10.1016/j.nrl.2019.09.007.
[45] Kandeger A, Selvi Y, Tanyer DK. The effects of individual circadian rhythm differences on insomnia, impulsivity, and food addiction. Eat Weight Disord. 2019;24(1):47–55. doi:10.1007/s40519-018-0518-x.
[46] Hasler BP, Wallace ML, Graves JL, Molina BSG, Pedersen SL. Circadian preference is associated with multiple domains of trait and state level impulsivity. Chronobiol Int. 2022;39(6):792–804. doi:10.1080/07420528.2022.2035392.
[47] Su Y, Bi T, Gong G, Jiang Q, Chen H. Why do most restrained eaters fail in losing weight?: Evidence from an fMRI study. Psychol Res Behav Manag. 2019;12:1127–36. doi:10.2147/PRBM.S228430.
[48] WHO. World Health Organization. [accessed: 2023 April 15]. https://www.who.int/about/governance/constitution