Journal of Human Centered Technology
https://www.humentech.utm.my
E-ISSN: 2821-3467

Effects of Intermittent Fasting on Body Compositions Using Bioimpedance Analyzers

Nurul Diyana Zainal[1], Mohd Riduan Mohamad[1,2]*,

[1]Department of Biomedical Engineering & Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
[2]Bioinspired Device & Tissue Engineering Research Group, Department of Biomedical Engineering and Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310, UTM Johor Bahru, Johor, Malaysia

*Corresponding Author mohd.riduan@utm.my

Cite: https://doi.org/10.11113/humentech.v4n2.112

Research Article

Abstract:
Advancements in bioimpedance technology have enabled convenient tools such as smart scales for monitoring body composition. This study aimed to evaluate the accuracy of bioimpedance analyses using two types of bioimpedance analyzers (BIAs) during alternate day fasting (ADF). In this study, Bioimpedance Analyzer 450 (a professional-grade device) and the Mi Body Composition Scale (a consumer-grade device) were used to assess changes during a four-week ADF intervention. Six healthy participants, aged 20–30 years underwent ADF: Alternating between 500 kcal intake on fasting days and unrestricted eating on non-fasting days. Body fat percentage, lean mass, and total body water were measured before and after the intervention using both devices. The results showed no statistically significant changes across all parameters ($p>0.05$); however, the Biodynamics Analyzer detected +0.56% increment in the body fat and −0.56% decrement in the lean mass. While the Mi Scale showed −0.16% changed in the body fat and +0.13% in the lean mass. These discrepancies highlight the higher sensitivity of the professional-grade BIA in capturing subtle physiological changes. The total body water remained stable in both groups. The results suggest that although consumer-grade devices offer accessibility, they may lack the precision needed for detecting minor shifts during dietary interventions. This study emphasizes the importance of using validated tools in clinical and research settings. It also provides preliminary insights into the metabolic effects of ADF, including possible compensatory eating behavior on non-fasting days and minor fluid shifts. These findings underscore the limitations of consumer-grade BIAs in scientific monitoring and support further research to validate their use in long-term health tracking.

Keywords: Bioimpedance analysis; Intermittent fasting; Body composition assessment; Alternate day fasting

1. INTRODUCTION

Body composition, which includes fat mass, lean body mass, and total body water, serves as a crucial indicator of an individual's health status. Its accurate assessment is essential for monitoring interventions such as intermittent fasting (IF), a dietary approach characterized by alternating periods of fasting and eating. Bioimpedance analyzers (BIAs) are commonly employed for such assessments due to their non-invasive and practical nature (1, 2). Over the years, technological advancements have introduced consumer-grade devices like smart scales, which integrate bioimpedance technology into everyday tools. These devices offer users the convenience of monitoring their body composition at home, enabling broader access to health data. However, questions about their accuracy compared to professional-grade analyzers, such as the Biodynamics Bioimpedance Analyzer 450, remain unresolved (3, 4).

Intermittent fasting, particularly alternate day fasting (ADF), has gained traction for its potential to improve metabolic health and support weight management. ADF involves alternating between fasting days with severe caloric restriction and unrestricted eating on non-fasting days. This dietary intervention has been linked to weight loss, improved insulin sensitivity, and enhanced cardiovascular health (5, 6). Despite the growing popularity of smart scales for at-home monitoring, their reliability in detecting subtle changes in body composition remains under scrutiny. Existing literature suggests discrepancies between measurements obtained from consumer-grade devices and those from professional analyzers, raising concerns about their application in research settings (7, 8).

Furthermore, the physiological effects of ADF extend beyond weight loss, influencing hormonal regulation, inflammation, and cellular repair processes. These systemic effects underscore the importance of accurately tracking body composition to fully understand the health benefits of fasting (9, 10). Therefore, a comparative analysis of standard and consumer-grade BIAs during ADF provides valuable insights for both clinical and personal applications. ADF has also been shown to improve markers of metabolic syndrome, including blood pressure, cholesterol levels, and insulin resistance (11). The cyclical pattern of fasting and feeding promotes autophagy, a cellular process that removes damaged proteins and organelles, which may contribute to improved metabolic health and longevity. These benefits highlight the broader health

Received day month 2025; Accepted day month 2025
Available online 06 August 2025

implications of ADF beyond body composition changes. While ADF offers promising health benefits, the choice of assessment tools plays a significant role in accurately measuring its effects. Professional-grade BIAs like the Biodynamics Bioimpedance Analyzer 450 provide detailed and precise measurements, making them suitable for clinical and research applications. However, the affordability and accessibility of consumer-grade devices such as smart scales make them popular among the general population (12).

The validation of consumer-grade devices for ADF interventions is essential for ensuring reliable data collection in both clinical and non-clinical settings. Studies comparing these devices to professional-grade analyzers have identified significant discrepancies in their ability to measure body fat percentage, lean mass, and total body water (13). These discrepancies raise concerns about the reliability of consumer-grade devices for tracking subtle body composition changes. One of the key challenges in body composition analysis is the impact of hydration status on BIA measurements. Variations in hydration levels can significantly affect the accuracy of body composition assessments, particularly for total body water measurements (14). Accurate hydration assessment is crucial for understanding the effects of ADF on body composition, as fasting and feeding cycles can influence hydration levels.

Research on the impact of ADF on lean mass preservation has yielded mixed results. While some studies suggest that ADF may promote muscle preservation due to enhanced growth hormone secretion during fasting periods, others indicate potential muscle loss due to prolonged caloric restriction (15). These findings underscore the need for accurate and reliable tools to measure lean mass changes. The role of BIA technology in assessing body composition extends beyond ADF interventions. BIAs are widely used in various settings, including clinical nutrition, sports science, and weight management programs (16). Their versatility and non-invasive nature make them valuable tools for monitoring health and fitness. In addition to assessing body composition, BIAs provide insights into other health metrics, such as phase angle, which reflects cellular health and membrane integrity. Phase angle measurements have been linked to overall health and disease prognosis, highlighting the broader applications of BIA technology in health monitoring (17).

As ADF continues to gain popularity, understanding the limitations and strengths of different body composition assessment tools is critical for optimizing health outcomes. This study aims to bridge the gap between professional-grade and consumer-grade devices by evaluating their performance in measuring body composition changes during a four-week ADF intervention. By providing a comprehensive analysis of these tools, this research contributes to the growing body of knowledge on body composition assessment and its implications for health and nutrition science.

2. MATERIALS AND METHOD

2.1 Study Design and Subject

This study employed a comparative design involving six healthy participants (3 males and 3 females) aged between 20 and 30 years who underwent a four-week alternate day fasting (ADF) intervention. To enable comparison, a control group of equal size and gender composition (3 males and 3 females) was included, maintaining their usual dietary habits throughout the study period.

Participants in the ADF group followed a structured regimen alternating between fasting days (limited to a maximum intake of 500 kcal) and non-fasting days without dietary restrictions. On non-fasting days, participants were advised to eat normally, with no specific instructions on meal frequency or caloric intake, to reflect real-world behavior and minimize compliance burden. All participants were screened to meet specific inclusion criteria, ensuring consistency and reducing potential confounding variables. The eligibility criteria are outlined according to Table 1.

Table 1. Inclusion and exclusion criteria of participants.

Inclusion Criteria	Exclusion Criteria
Aged 20–30 years	Diagnosed chronic illness (e.g., diabetes, hypertension)
Body Mass Index (BMI) between 18.5–24.9 kg/m^2	Pregnant or lactating
Not on medication affecting body composition or metabolism	History of eating disorders or irregular menstrual cycles (females)
Willing and able to comply with the ADF protocol	Participation in another weight loss, fasting, or fitness program

Participants were provided with a full briefing and gave written informed consent before enrollment. Standardized pre-measurement instructions included abstaining from caffeine, alcohol, and vigorous exercise for 24 hours, maintaining consistent hydration, and avoiding heavy meals before testing. All measurements were conducted at the same time of day to minimize circadian influence on body composition parameters.

2.2 Intervention

The intervention focused on assessing body composition changes before and after the ADF regimen using two distinct bioimpedance analyzers. The Biodynamics Bioimpedance Analyzer 450, a professional-grade device, and the Mi Body Composition Scale, a consumer-grade alternative, were employed. Both devices measured key parameters such as body fat percentage, lean mass, and total body water. The Biodynamics Analyzer required electrode placements on the right wrist and ankle, while the Mi Scale utilized direct contact through standing barefoot on its sensors.

Baseline measurements established the initial body composition of the participants. Post-intervention measurements were conducted after four weeks of ADF. For the control group, measurements were repeated under identical conditions, providing a basis for comparison against the intervention group. The intervention protocol was meticulously followed, with

https://doi.org/10.11113/humentech.v4n2.112

participants maintaining daily logs to document adherence to fasting and feeding schedules. The devices were chosen based on their widespread use and contrasting capabilities. The Biodynamics Analyzer is recognized for its precision in clinical settings, while the Mi Scale offers user-friendly features for home use. This dual-device approach allowed for a comprehensive evaluation of their effectiveness in tracking ADF-induced changes in body composition.

2.3 Assessment Protocol

Each measurement followed a standardized protocol to ensure consistency and reliability. For the Biodynamics Bioimpedance Analyzer 450, participants lay supine on a non-conductive surface, with electrodes placed at specified anatomical points. The Mi Body Composition Scale required participants to stand upright with bare feet on its conductive surface. Both devices provided immediate outputs, which were recorded for analysis.

Data collection was conducted in a controlled environment to minimize external influences. The Biodynamics Analyzer involved precise electrode placement and calibration to ensure accurate readings. In contrast, the Mi Scale relied on its integrated sensors, with results automatically synced to a smartphone application for tracking. Participants were trained in the correct usage of both devices to eliminate user error. The collected data were analyzed using paired t-tests to compare pre- and post-intervention results. Differences in body fat percentage, lean mass, and total body water were evaluated to determine the impact of ADF. Statistical significance was set at $p < 0.05$, ensuring robust interpretations of the findings.

3. RESULTS

3.1 General Characteristics

The six participants who underwent the ADF intervention consisted of 3 males and 3 females, aged 20 to 30 years, with an average age of 25.83 ± 2.23 years and a baseline mean weight of 70.33 ± 7.31 kg. The control group also included 3 males and 3 females, matched by age and BMI range, who continued their regular dietary habits. Participants in the intervention group adhered to the ADF schedule, alternating between 500 kcal intake on fasting days and unrestricted eating on non-fasting days. They were advised to maintain normal eating habits on non-fasting days without any strict caloric or meal frequency guidelines.

All measurements were conducted under standardized conditions to ensure consistency. Pre- and post-intervention values for body fat percentage, lean mass percentage, and total body water were measured using both the Biodynamics Bioimpedance Analyzer 450 and the Mi Body Composition Scale.

3.2 Body Fat Percentage

As shown in Table 2, the Biodynamics Analyzer recorded a +0.56% increase in body fat percentage after the ADF intervention (from 27.52% to 28.08%), whereas the Mi Scale recorded a −0.16% decrease (from 22.93% to 22.77%). Despite these opposite trends, neither result was statistically significant ($p = 0.359$ and $p = 0.550$, respectively). In the control group, body fat percentage remained stable on both devices, with minimal changes of −0.01%, confirming that the observed fluctuations in the intervention group were associated with the ADF protocol.

Table 2. Body fat percentage before and after intervention.

Group	Device	Pre (%)	Post (%)	Change (%)	p-value
Intervention	BIA	27.52	28.08	+0.56	0.359
Intervention	Mi Body Composition	22.93	22.77	-0.16	0.550
Control	BIA	26.11	26.10	-0.01	0.670
Control	Mi Body Composition	23.15	23.14	-0.01	0.700

The slight increase in fat percentage from the BIA device may suggest compensatory overeating on non-fasting days, a behavior commonly observed in intermittent fasting studies. The Mi Scale failed to detect this subtle shift, underscoring its limited sensitivity in capturing small physiological changes.

3.3 Lean Mass Percentage

As presented in Table 3, the lean mass percentage decreased by −0.56% in the intervention group using the BIA (from 72.48% to 71.92%), while the Mi Scale showed a +0.13% increase (from 76.99% to 77.12%). Neither of these changes reached statistical significance ($p = 0.359$ and $p = 0.630$, respectively). Control group values remained stable (≤0.02% change), reinforcing the reliability of the measurement environment.

Table 3. Lean mass percentage before and after intervention.

Group	Device	Pre (%)	Post (%)	Change (%)	p-value
Intervention	BIA	72.48	71.92	-0.56	0.359
Intervention	Mi Body Composition	76.99	77.12	+0.13	0.630
Control	BIA	74.12	74.10	-0.02	0.700
Control	Mi Body Composition	78.11	78.10	-0.01	0.710

The small reduction in lean mass from the BIA may be explained by mild muscle catabolism during fasting periods, as the body may shift to protein utilization for energy. The Mi Scale's detection of a slight increase suggests limited sensitivity, potentially due to algorithmic smoothing or estimation errors common in consumer-grade devices.

3.4 Total Body Water

Table 4 shows the total body water (TBW) changes. The BIA recorded a −0.50% decrease (from 51.51% to 51.01%) in the intervention group, while the Mi Scale showed a +0.07% increase (from 53.12% to 53.18%). Again, changes were not statistically significant (p = 0.343 and p = 0.727, respectively).
Control group TBW remained stable across devices.

Table 4. Total body water percentage before and after intervention.

Group	Device	Pre (%)	Post (%)	Change (%)	p-value
Intervention	BIA	51.51	51.01	-0.50	0.343
Intervention	Mi Body Composition	53.12	53.18	+0.07	0.727
Control	BIA	55.43	55.40	-0.03	0.740
Control	Mi Body Composition	56.32	56.32	0.00	0.800

Although ADF has the potential to influence hydration through fluid shifts during fasting, the minimal TBW changes observed here suggest participants maintained adequate hydration across the study. The discrepancy between device readings again highlights the greater sensitivity of the BIA in detecting physiological shifts.

4. DISCUSSION

4.1 Body Fat and Lean Mass Changes

Changes in body composition metrics, though statistically non-significant, provided valuable insights into the effects of ADF. The slight increase in body fat percentage observed with the Biodynamics Analyzer may be attributed to compensatory eating behaviors, where participants consumed higher calorie meals on non-fasting days. This aligns with existing literature on metabolic adaptations during intermittent fasting. Despite no statistically significant body fat reduction in the intervention group, the slight increase observed on the BIA device suggests possible compensatory eating on non-fasting days. This behavior is commonly reported in ADF studies, contributing to variable results in fat mass outcomes (15). Regarding lean mass, the modest −0.56% decrease detected by BIA may reflect mild muscle catabolism during fasting days. Conversely, the Mi Scale's small increase (+0.13%) could reflect biases in consumer algorithms. Existing research on intermittent fasting similarly shows mixed effects on lean mass preservation, often depending on protein intake, resistance training, and fasting regimen (9,16). Lean mass preservation, as indicated by minimal changes in lean mass percentage, suggests that ADF may not significantly impact muscle mass over short durations. However, the decrease observed in the Biodynamics Analyzer highlights the need for longer studies to assess potential long-term effects.

Discrepancies between the Biodynamics Analyzer and the Mi Scale highlight the limitations of consumer-grade devices in capturing nuanced changes. This emphasizes the importance of selecting appropriate tools based on the specific requirements of research or clinical applications. Additionally, the broader implications of these findings indicate the necessity of integrating technological advancements in BIAs with traditional dietary practices. Combining precise tools with controlled dietary interventions may enhance understanding of metabolic processes and lead to improved health outcomes. Future studies should explore multi-device comparisons across diverse populations to further refine the application of BIAs.

4.2 Hydration Stability

Total body water (TBW), an essential component of overall hydration and metabolic function, was evaluated using both devices. The Biodynamics Bioimpedance Analyzer 450 reported a slight decrease from 50.00% to 49.76%, whereas the Mi Body Composition Scale showed stable measurements at approximately 50%. TBW remained largely stable (Table 3), with a slight −0.50% decrease detected by BIA and negligible change by the Mi Scale. This stability suggests participants maintained adequate hydration throughout the intervention. Similar findings come from Ramadan fasting research, which reported <1% reductions in TBW using BIA (16). However, consumer-grade devices often underperform in accurate fluid compartment estimation, particularly when compared against reference methods (17). Statistical analysis yielded p-values of 0.343 for the Biodynamics Analyzer and 0.726 for the Mi Scale, indicating no significant changes in total body water post-intervention. The control group exhibited consistent hydration levels, corroborating the intervention group's findings. These results suggest that ADF had minimal impact on hydration status. Variations between devices highlight differences in measurement sensitivity, emphasizing the need for precise tools in hydration assessments during dietary interventions.

4.3 Device Sensitivity and Accuracy

The study's findings revealed nuanced differences between professional-grade and consumer-grade BIAs in measuring body composition changes during ADF. The Biodynamics Analyzer demonstrated higher sensitivity, capturing subtle variations that the Mi Scale may have overlooked. This underscores the importance of using validated tools for research purposes. The results (Table 2) indicated a +0.56% increase in body fat over four weeks on Biodynamics BIA, while Mi Smart Scale showed a −0.16% decrease—neither change was statistically significant ($p>0.05$). Similarly, lean mass and total body water shifts remained minimal and non-significant (Table 3 and 4). However, the Biodynamics Analyzer consistently detected slightly smaller changes, which may reflect its higher sensitivity compared to the consumer-grade Mi Scale. This finding aligns with prior evidence showing that consumer devices often lack precision in detecting subtle longitudinal changes (18). Consumer-grade BIA devices have demonstrated cross-sectional validity but limited longitudinal accuracy relative to four-compartment models or professional-grade analyzers (18). For example, Siedler et al. reported longitudinal validity errors ranging from −0.4% to +1.3% in percent body fat across consumer-grade devices, suggesting that only a subset is reliable for tracking changes over time.

4.4 Hormonal and Cellular Adaptations to ADF

ADF initiates complex hormonal adaptations that influence metabolism. Fasting increases secretion of human growth hormones, which promotes lipolysis and may aid in lean mass preservation (19). It also reduces circulating levels of insulin, leptin, and IGF-1, shifting the body toward fat utilization (20). These changes facilitate the metabolic switch from glucose to fatty acid ketone metabolism (18, 19). At a cellular level, ADF stimulates autophagy which is a regenerative process enhancing protein turnover, organelle recycling, and systemic resilience (21). In animal models, six-week ADF improved autophagic flux and reduced ischemic damage, demonstrating cardioprotective potential (21).

While this small-scale study did not measure these biomarkers directly, the subtle physiological shifts in body composition observed align with these underlying metabolic and hormonal responses, albeit below detection threshold for consumer-grade BIAs.

5. CONCLUSION

The limitations of this study primarily revolve around the accuracy and reliability of the body composition measurement devices utilized. Firstly, while bioimpedance analyzers and smart scales offer convenient means for assessing body composition, they are susceptible to inherent limitations and sources of error. Factors such as variations in hydration status, skin temperature, and electrode placement can all influence the precision of bioimpedance measurements. Moreover, different models of bioimpedance analyzers may exhibit disparities in their performance and calibration, potentially leading to inconsistencies in the obtained results. Without thorough validation against gold standard methods like dual-energy X-ray absorptiometry (DEXA) or underwater weighing, it remains challenging to ascertain the true accuracy of these devices.

Secondly, a notable limitation concerns the lack of consideration for potential confounding variables and the absence of long-term follow-up in the study design. The research did not account for various factors that could have influenced body composition changes among participants, such as their dietary habits, levels of physical activity, and hydration status. The omission of these variables may have introduced bias into the findings and limited the generalizability of the results. Additionally, the study did not conduct a detailed analysis of participants' daily calorie intake or expenditure, which could have provided valuable insights into the underlying mechanisms driving the observed changes in body composition. Furthermore, the sample size of the study may be considered a limitation. With only a small number of participants included in the research, the findings may lack sufficient statistical power to detect subtle differences or associations between body composition measurements obtained from different devices. A larger and more diverse sample would have enhanced the robustness and generalizability of the study findings. Another limitation is the potential for measurement error associated with the use of bioimpedance analyzers and smart scales.

Despite efforts to standardize measurement protocols and ensure consistency in data collection, minor variations in device calibration or user technique could introduce variability in the obtained results. Additionally, factors such as participant movement during measurements or variations in electrode contact with the skin may have influenced the accuracy of body composition assessments. Moreover, the duration of the intervention period in the study may have limited the ability to capture longer-term changes in body composition resulting from intermittent fasting. With only a four-week intervention period, the study may not have fully captured the potential effects of intermittent fasting on body composition over an extended period. Longer-term studies with extended follow-up periods would provide a more comprehensive understanding of the sustained impact of intermittent fasting on body composition changes.

AUTHORSHIP CONTRIBUTION STATEMENT

Nurul Diyana Zainal: methodology, experimental work, formal analysis, investigation, data collection, writing – original draft. Mohd Riduan Mohamad: supervision, methodology, resources, writing – review & editing, validation, funding.

DATA AVAILABILITY

Data supporting this study’s findings are available on reasonable requests.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no conflict of interest.

ACKNOWLEDGMENT

The authors would like to acknowledge the members and facilities provided in the Mechano-Biology Laboratory, Department of Biomedical Engineering and Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia.

REFERENCES

(1) Kyle UG, Bosaeus I, Lorenzo AD, Manuel G. Bioelectrical impedance analysis - part I: Review of principles and methods. Clin Nutr. 2004; 23(5):1226–1243. https://doi.org/10.1016/j.clnu.2004.06.004.

(2) Mialich MS, Maria J, Sicchieri F, Afonso A, Junior J. Analysis of body composition: A critical review of the use of bioelectrical impedance analysis. Int J Clin Nutr. 2014; 2(1):1–10.

(3) Biodynamics. Quick Start Guide for the BIA 310e [Internet]. 2013. [cited 2025 Aug 5]. Available from: http://www.biodyncorp.com

(4) Tinsley GM, La Bounty PM. Effects of intermittent fasting on body composition and clinical health markers in humans. Nutr Rev. 2015; 73(10):661–674. https://doi.org/10.1093/nutrit/nuv041.

(5) Stekovic S, Hofer SJ, Tripolt N, Aon MA, Royer P, Pein L, et al. Alternate day fasting improves physiological and molecular markers of aging in healthy, non-obese humans. Cell Metab. 2019; 30(3):462–476. https://doi.org/10.1016/j.cmet.2019.07.016.

(6) Liu B, Page AJ, Hutchison AT, Wittert GA, Heilbronn LK. Intermittent fasting increases energy expenditure and promotes adipose tissue browning in mice. Nutr. 2019; 66:38–43. https://doi.org/10.1016/j.nut.2019.03.015.

(7) Domaszewski P, Konieczny M, Pakosz P, Łukaniszyn-Domaszewska K, Mikuláková W, Sadowska-Krępa E, Anton S. Effect of a six-week time-restricted eating intervention on the body composition in early elderly men with overweight. Sci Rep. 2022; 12(1):9816. https://doi.org/10.1038/s41598-022-13904-9

(8) Yi Y, Baek JY, Lee E, Jung HW, Jang IY. A comparative study of high-frequency bioelectrical impedance analysis and dual-energy X-ray absorptiometry for estimating body composition. Life. 2022; 12(7):1094. https://doi.org/10.3390/life12070994

(9) Lima CHR, Oliveira IKF, Frota KMG, Carvalho CMRG, Paiva AA, Campelo V, Martins MDCCE. Impact of intermittent fasting on body weight in overweight and obese individuals. Clin Nutr. 2020; 66(2):222–226. https://doi.org/10.1590/1806-9282.66.2.222.

(10) Asl R, Zekiye N, Bayraktaro E. The effect of intermittent fasting diets on body weight and composition. Clin Nutr ESPEN. 2022; 51:88–95. https://doi.org/10.1016/j.clnesp.2022.08.030.

(11) Teong XT, Liu K, Vincent AD, Bensalem J, Liu B, Hattersley KJ, Zhao L, Feinle-Bisset C, Sargent TJ, Wittert GA, Hutchison AT, Heilbronn LK. Intermittent fasting plus early time-restricted eating versus calorie restriction and standard care in adults at risk of type 2 diabetes: A randomized controlled trial. Nat Med. 2023; 29:1–12. https://doi.org/10.1038/s41591-023-02287-7.

(12) Ballarin G, Scalfi L, Monfrecola F, Alicante P, Bianco A, Marra M, Sacco AM. Body composition and bioelectrical-impedance-analysis-derived raw variables in pole dancers. Int J Environ Res Public Health. 2021; 18(23):12638. https://doi.org/10.3390/ijerph182312638.

(13) Gao Y, Tsintzas K, Macdonald IA, Cordon SM, Taylor MA. Effects of intermittent (5:2) or continuous energy restriction on basal and postprandial metabolism: A randomised study in normal-weight, young participants. Eur J Clin Nutr. 2022; 76(1):65–73. https://doi.org/10.1038/s41430-021-00909-2

(14) Vitale R, Kim Y. The effects of intermittent fasting on glycemic control and body composition in adults with obesity and type 2 diabetes: A systematic review. Metab Syndr Relat Disord. 2020; 18(10):450–461. https://doi.org/10.1089/met.2020.0048.

(15) Hoddy KK, Gibbons C, Kroeger CM, Trepanowski JF, Barnosky A, Bhutani S, Gabel K, Finlayson G, Varady KA. Changes in hunger and fullness in relation to gut peptides before and after 8 weeks of alternate day fasting. Clin Nutr. 2016; 35(6):1380–1385. https://doi.org/10.1016/j.clnu.2016.03.011.

(16) Najafi MT, Sadoogh Abbasian A, Mohammadi H, Abbasi MR, Khatami MR, Ghafari A, Shojamoradi MH. Alteration in body water compartments following Ramadan fasting in healthy adults: A longitudinal bioimpedance analysis study. Front Nutr. 2023; 10:1232979. https://doi.org/10.3389/fnut.2023.1232979

(17) Elortegui Pascual P, Rolands MR, Eldridge AL, Kassis A, Mainardi F, Kim-Anne L, Karagounis LG, Gut P, Varady KA. A meta-analysis comparing the effectiveness of alternate day fasting, the 5:2 diet, and time-restricted eating for weight loss. Obesity. 2023; 31(S1):9–21. https://doi.org/10.1002/oby.23568

(18) Shabkhizan R, Haiaty S, Moslehian MS, Bazmani A, Sadeghsoltani F, Bagheri HS, Rahbarghazi R, Sakhinia E. The beneficial and adverse effects of autophagic response to caloric restriction and fasting. Adv Nutr. 2023; 13:125. https://doi.org/10.1016/j.advnut.2023.07.006.

(19) Fink J, Tanaka M, Horie S. Effects of fasting on metabolic hormones and functions: A narrative review. Juntendo Med J. 2024; 70(5):348–359. https://doi.org/10.14789/jmj.JMJ24-0012-R.

(20) Patterson RE, Laughlin GA, LaCroix AZ, Hartman SJ, Natarajan L, Senger CM, Martínez ME, Villaseñor A, Sears DD, Marinac CR, Gallo LC. Intermittent fasting and human metabolic health. J Acad Nutr Diet. 2015; 115(8):1203–1212. https://doi.org/10.1016/j.jand.2015.02.018

(21) Longo VD, Mattson MP. Fasting: Molecular mechanisms and clinical applications. Cell Metab. 2014; 19(2):181–192. https://doi.org/10.1016/j.cmet.2013.12.008