

Acute Exercise Increases Acylated Ghrelin and Food Amount Preference in Young Malaysian Women: A Randomized Crossover Trial

Yih Sheng Shim¹, Yuh Fen Pung², Siew Siew Lee³, *Shi-Hui Cheng⁴

^{1,3,4}School of Biological and Environmental Sciences, Faculty of Science and Engineering, University of Nottingham Malaysia, Jalan Broga, 43500 Semenyih, Selangor, Malaysia

²School of Pharmacy, Faculty of Science and Engineering, University of Nottingham Malaysia, Jalan Broga, 43500 Semenyih, Selangor, Malaysia

ARTICLE INFO

Article history:

Received 1 February 2026

Revised 3 July 2026

Accepted 6 July 2026

Online first 15 September 2026

Published 15 September 2026

Keywords:

Hunger,
Exercise intensity,
Appetite regulation,
Energy intake,
Exercise

ABSTRACT

The physiological relationship between exercise, appetite regulation, and food amount preference in women remains underexplored. The study examined the acute effects of exercise intensity on appetite regulation, acylated ghrelin responses and energy intake in young women. Thirteen healthy women (mean age 22 ± 1.96 years; BMI 22.4 ± 2.51 kg/m²) participated in three experimental conditions: a control (no exercise), and two 45-minute treadmill sessions at low (60% age-predicted maximal heart rate) and high intensity (85% age-predicted maximal heart rate), in a random crossover design with at least one week between sessions. Subjective appetite ratings via visual analogue scale (VAS), food liking, and food amount preferences were assessed using a questionnaire before and after each trial. Blood samples were collected to measure plasma acylated ghrelin concentrations immediately post-exercise. Data analysis was performed using SPSS. Plasma acylated ghrelin levels significantly increased from pre- to post-trial in both low- and high-intensity exercise conditions compared to control ($p < 0.001$). Hunger rating increased significantly in both low-intensity ($p = 0.042$) and high-intensity trials ($p = 0.034$) compared to control. Post-exercise estimated mean calorie intake of selected foods was significantly higher than the pre-exercise mean calorie intake in both low-intensity ($p < 0.001$) and high-intensity exercise ($p = 0.036$). Acute exercise increased hunger perception driven by elevated acylated ghrelin levels, regardless of exercise intensity. These findings suggest that appetite-stimulating effects of exercise may counteract energy expenditure by increasing food amount preferences, highlighting the need for further research on exercise strategies for weight management and obesity prevention in women.

^{1*}Corresponding author. *E-mail address:* ShiHui.Cheng@nottingham.edu.my

1. INTRODUCTION

The global rise in overweight and obesity has become a critical public health concern. In Malaysia, 54.4% of adults are overweight or obese (Hasim et al., 2025a), and 45.5% reported weight gain during the COVID-19 pandemic, with women showing a higher prevalence (Ng & Cheng, 2023). Elevated body adiposity increases the risk of cardiovascular diseases, musculoskeletal disorders, cancers, and mental health issues (Ahmed & Mohammed, 2025). Although physical activity is a widely recognized strategy for preventing and management, exercise-induced weight loss is often modest (Hasim et al., 2025b). This limiting effect has been attributed to energy compensation mechanisms which is the increase in energy intake that offsets exercise-induced expenditure (Liu et al, 2022).

Appetite regulation is a complex process influenced by physiological, psychological, and environmental factors, with gastrointestinal hormones playing a central role. Numerous studies report that acute exercise, particularly at moderate to vigorous intensities, suppresses acylated ghrelin and reduces subjective hunger (Broom et al., 2017; Schubert et al., 2014; Anderson et al., 2021). However, these findings are predominantly derived from studies involving male participants, making their relevance to women uncertain.

Gender differences in energy compensation further underscore the need for female-specific research. While men often maintain energy deficits during exercise interventions, women partially compensate by increasing food intake, potentially explaining observed differences in weight loss outcomes (Hagobian & Evero, 2013; Shamlan et al., 2017). Although some studies suggest that higher exercise intensities suppress appetite (Anderson et al., 2021; Broom et al., 2017; Metcalfe et al., 2015), others report contradictory findings (Hagobian et al., 2009; Vatansever et al., 2010). These inconsistencies highlight that the interplay between exercise intensity, appetite regulation, and food amount preferences, particularly in women, remains insufficiently understood.

Despite extensive research on exercise and appetite in Western populations, there is limited evidence from Asian population, including Malaysia. To date, no study has examined the impact of physical activity intensity on hunger and food amount preferences using a hypothetical food selection task among Malaysian women. Hence, the present study aims to determine the acute impacts of low- and high- intensity physical activity on appetite regulation and food amount preferences among young women in Malaysia, compared with a control condition. Understanding these relationships will provide valuable insights into the most effective exercise strategies for achieving a negative energy balance without triggering compensatory increases in appetite or food selection, ultimately informing targeted interventions for obesity prevention and management in women.

2. METHODS

2.1 Respondents

Thirteen young women, aged between 20 and 26 years, were recruited from two universities in Selangor, Malaysia through posters, email announcements, and random campus recruitment. The target sample size of 13 was determined using G*Power 3.1 software, with an additional 10% added to account

for potential drop-outs. Eligibility criteria of the study included: (1) female; (2) ≥ 18 years old; (3) normal menstrual cycle; (4) Not pregnant or lactating; (5) not following a special diet; (6) non-smoker; (7) free from diseases; (8) abstaining from any medications that could influence food intake.

2.2 Ethical Approval

Ethical approval for this study was obtained from the Faculty of Science and Engineering Research Integrity and Research Ethics Committee of University of Nottingham Malaysia (Reference number: KYQ300922). Written informed consent was obtained from all participants prior to enrolment in the study.

2.3 Baseline Assessments

Height was measured using a portable stadiometer (Seca 217). Participants were instructed to remove their shoes and stand upright against a backboard, ensuring their head, shoulder blades, buttocks, and heels were in contact with the board. Body composition, including body fat percentage, body mass index (BMI) was determined using the Omron Body Composition Monitor (HVF-516B). Participants stood on the measurement platform with bare, dry feet, maintained a straight posture, and followed specific arm positioning guidelines. Participants were categorised into underweight ($< 18.5 \text{ kg/m}^2$), normal weight ($18.5 - 24.9 \text{ kg/m}^2$), overweight ($25 - 29.9 \text{ kg/m}^2$), and obese ($\geq 30 \text{ kg/m}^2$) based on the cut-off points provided by the World Health Organization (2010).

2.4 Questionnaires

Participants completed all surveys online at two intervals within each condition: before the start of the exercise/rest period ("pre") and right after finishing the session ("post").

2.4.1 Subjective appetite ratings

Hunger, fullness and desire to eat were assessed using a validated 100mm visual analogue scale (VAS), anchored from "Not at all" to "Extremely"

2.4.2 Food liking and Food reward

Food liking and food reward was assessed using the Leeds Food Preference Questionnaire (LFPQ) framework (Beaulieu et al., 2020). Sixteen high-resolution food images representing four categories—high-fat savoury (HFSA), low-fat savoury (LFSA), high-fat sweet (HFSW), and low-fat sweet (LFSW)—were presented individually (Table 1). Participants rated each image on a 10-unit VAS scale in response to the question.

Table 1: Photogenic food cues used to assess explicit liking (grouped by food category)

HFSA	LFSA	HFSW	LFSW
French fries	Pasta (tomato sauce)	Cookies	Banana
Pizza	Grilled chicken	Waffle	Popcorn
Cake	Wholegrain bread	Ice-cream	Yogurt parfait
Chicken burger	Fresh salad	Donut	Strawberry

HFSA: high fat savoury; LFSA: low fat savoury; HFSW: high fat sweet; LFSW: low fat sweet.

2.4.3 Food Amount Preference

Food amount preference was assessed using a questionnaire adapted from Koehler et al., (2021).

Participants selected a main course, beverage, and dessert from Malaysian food images (Table 2), then chose preferred portion sizes for each item. No calorie information was provided.

Table 2: Photogenic food cues were used in the Food Amount Preference Questionnaire

Main course	Beverages	Dessert
French fries	Milo	Cookies
Pizza	Orange juice	Donut
Chicken burger	Chamomile tea	Popcorn
Pasta (tomato sauce)	Iced Lemon Tea	Strawberry
Grilled chicken breast	Latte	Cake
Wholemeal bread	Plain water	Banana
Salad	Nothing	Yogurt parfait
Nothing		Ice cream
		Nothing

2.5 Experimental protocol

Each participant completed three random experimental sessions: high-intensity exercise (85% of age-predicted maximal heart rate), low-intensity exercise (60% of age-predicted maximal heart rate), and a resting control. The sessions were randomized for each participant, with a minimum of seven days between sessions to prevent carry-over effects.

Participants were asked to avoid moderate-to-vigorous physical activity for 24 hours before each session and replicate their food intake from the previous day. All sessions were conducted during the non-menstrual phase.

On each testing day, participants arrived at 08:30 in a fasted state, completed pre-questionnaires, and consumed a standardized breakfast (bun: 186 kcal; 4.2 g protein). At 09:00, participants either performed 45 minutes of treadmill exercise at the target intensity or remained seated for 45 minutes (control). Exercise intensity was monitored using heart-rate sensors integrated into the treadmill, following ACSM guidelines. After the session, blood samples were collected, and post-questionnaires were completed.

2.6 Blood sampling and biochemical analysis

Blood samples were collected in 3ml ethylenediamine tetra-acetic acid-coated (EDTA) tubes at the end of each experimental session to measure plasma acylated ghrelin (AG) concentrations. Samples were centrifuged at 1,500rpm for 15 minutes in a refrigerated centrifuge (Newton Scientific Avante 8R Bench Top Centrifuge) at 4°C. Plasma was aliquoted into 300-μL microtubes and stored at -80°C until analysis.

AG concentrations were quantified using a commercial ELISA kit (Elabscience Human A-GHRL ELISA, E-EL-H2002; sandwich assay). The kit sensitivity was 9.38 pg/mL, with intra-assay CVs ranging from 5.08–6.61%. Concentrations were calculated using the GainData® ELISA Calculator with a four-parameter logistic standard curve.

2.7 Data processing

Delta values for subjective appetite, food liking, and food amount preference were calculated as post-session minus pre-session scores. Total food amount preference was computed as the sum of selected items across main course, beverage, and dessert categories.

2.8 Statistical analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 29.0 for Mac OS. Normality of the data was assessed using the Shapiro-Wilk test, ensuring skewness values fell within the range of -3 to 3. Paired t-tests were used to assess within-condition changes over time. One-way ANOVA was used for normally distributed hormone data; non-normal data were analysed using the Kruskal–Wallis test. Statistical significance was set at $p < 0.05$.

3. RESULT AND DISCUSSION

3.1 Respondents' Characteristics

Thirteen female participants completed all experimental sessions. Participant characteristics and anthropometric data are presented in Table 3. The mean age was 22 ± 1.96 years. Most participants had a normal BMI (84.6%), while 15.4% were classified as overweight. The sample was predominantly Chinese (84.6%). Most participants reported engaging in physical activity once per week (53.8%) or 2–3 times per week (38.5%).

Table 3: Participants' characteristics

Variables	N (%) or mean $\pm$ SD
	N=13
Age (years)	22 ± 1.96
20-21	7 (53.8%)
22-23	3 (23.1%)
>23	3 (23.1%)
Height (cm)	156.9 ± 4.80
Weight (kg)	55.2 ± 6.60
Body Mass Index (BMI)	22.4 ± 2.51
Normal	11 (84.6%)
Overweight	2 (15.4%)
Body Fat (%)	34.0 ± 4.65
Skeletal Muscle (%)	26.0 ± 2.17
Ethnicity	
Chinese	11 (84.6%)
Indian	2 (15.4%)
Year of Study	
Year 1	2 (15.4%)
Year 2	4 (30.8%)
Year 3	4 (30.8%)
Master's	1 (7.7%)
PhD	2 (15.4%)
Faculty	
Science and Engineering	13 (100%)
Physical Activity Frequency (days/week)	
Once a week	7 (53.8%)
2-3 times a week	5 (38.5%)
3-4 times a week	1 (7.7%)

3.2 Appetite Hormones

There was a significant difference in the concentrations of acylated ghrelin across the various intensity conditions (see Table 4). Acylated ghrelin levels were significantly higher in both the low and high-intensity conditions compared to the resting condition. However, no significant differences were observed in acylated ghrelin levels between the low and high-intensity conditions.

Table 4: Appetite hormone concentration at post-conditions.

Condition	Acylated Ghrelin (pg/mL)	P-value
Low	352.13 a	<0.001*
High	385.57 a	
Control	106.39 b	

*p<0.05. Values sharing the same superscript letter are not significantly different, whereas values with different superscript letters differ significantly (p<0.05)

3.3 Subjective Appetite Ratings

Baseline hunger, fullness, and desire to eat were similar across the conditions. Significant differences were observed in delta hunger across the different conditions ($p = 0.016$) (refer to Figure 1). Post-hoc Dunn's test for pairwise comparisons revealed that delta hunger ratings were significantly higher in both the low and high exercise conditions compared to the control trial ($p = 0.042$ and $p = 0.034$, respectively). In contrast, delta fullness and delta desire to eat did not differ across different experimental conditions. Within-condition comparisons showed no significant pre- to post-trial changes in hunger or desire to eat in any condition. However, fullness increased significantly from pre- to post-trial in the control condition ($p = 0.045$), whereas no significant changes in fullness were observed in either exercise condition.

Table 5: Changes in appetite ratings at pre and post during all experimental conditions.

Variable	Low			High			Control		
	Pre (mm)	Post (mm)	p-value	Pre (mm)	Post (mm)	p-value	Pre (mm)	Post (mm)	p-value
Hunger	42.62	48.54	0.415	38.69	48.23	0.152	45.15	29.38	0.088
Fullness	18.62	17.15	0.728	22.69	24.23	0.819	18.54	34.85	0.045*

Desire to eat	44.92	50.62	0.362	45.62	48.69	0.591	48.54	44.15	0.315
----------------------	-------	-------	-------	-------	-------	-------	-------	-------	-------

3.4 Food reward

Food liking ratings for HFSA, LFSA, HFSW, and LFSW were similar across the conditions at baseline. Additionally, there were no significant differences observed in delta food liking for any of the food categories across the three different experimental conditions. Table 6 shows no main effect of time on food liking in any of the conditions.

Table 6: Changes in food liking at pre and post during all experimental conditions.

Variable	Low			High			Control		
	Pre (mm)	Post (mm)	p-value	Pre (mm)	Post (mm)	p-value	Pre (mm)	Post (mm)	p-value
HFSA	14.08	15.00	0.557	13.08	14.46	0.293	13.92	13.69	0.931
LFSA	17.46	18.62	0.527	16.54	16.08	0.699	17.69	17.00	0.791
HFSW	18.38	20.00	0.361	18.46	18.77	0.837	19.62	17.62	0.341
LFSW	21.85	23.23	0.410	18.23	20.31	0.141	22.00	19.00	0.231

HFSA: high fat savoury; LFSA: low fat savoury; HFSW: high fat sweet; LFSW: low fat sweet.

3.5 Food Amount Preferences

Total food amount preferences did not differ at baseline across low-, high-intensity exercise and control ($p=0.861$). However, mean preferred calories intake increase significantly from pre- to post-exercise in both low- and high-intensity exercise trials (see Table 7).

Table 7 : Changes in total food amount preferences during all experimental conditions.

	Pre (kcal)	Post (kcal)	p-value
Low	682.66	961.36	<0.001*
High	713.25	953.71	0.036*
Control	709.79	889.6	0.125

* $p<0.05$

3.2 Discussion

The primary objective of this study was to examine the impact of acute exercise of varying intensities on acylated ghrelin, appetite regulation, and food amount preferences in young women. Our findings indicate that both low- and high-intensity exercise significantly increased acylated ghrelin concentrations, suggesting that acute exercise stimulates appetite in young women irrespective of exercise intensity. This aligns with previous studies, such as those by Hagobian et al. (2009), Larson-Meyer et al. (2012) and Ueda et al. (2013) which reported increased concentrations of acylated ghrelin post-exercise in women, irrespective of energy balance. These increases likely reflect an adaptive mechanism to counterbalance energy expenditure by promoting energy intake, mediated through ghrelin's effects on hypothalamic appetite-regulating centers (Liu et al, 2022).

In line with the hormonal changes, delta hunger ratings were significantly higher following both low and high exercise sessions compared to the control trial. This suggests that the rise in acylated ghrelin is directly associated with increased hunger perception. The results support the hypothesis that ghrelin acts as an acute hunger stimulant and are consistent with Kawano et al. (2012), who reported increased appetite in women following 30 minutes of rope skipping, underscoring gender-specific responses to physical activity. Importantly, the lack of significant differences between low and high-intensity conditions indicates that the exercise-induced hunger response is more dependent on the presence of physical activity rather than its intensity.

However, contrasting findings in the literature indicate that hunger responses can vary across studies. For instance, Martins et al. (2015) reported no significant changes in hunger ratings across different exercise intensities in sedentary overweight and obese populations. Such discrepancies may stem from differences in participant characteristics, exercise modalities, or nutritional protocols. Unlike our study, which involved treadmill exercise and a light pre-exercise meal (~186 kcal), Martins et al. (2015) employed cycling and provided participants with a heavier standardized breakfast (~600 kcal) before exercise. The heavier meal likely induced greater satiety, potentially masking acute hunger responses to exercise. These differences underscore the importance of considering dietary and demographic variables when investigating exercise-induced appetite responses.

Food reward plays a crucial role in weight management, balancing the body's nutritional needs with the pleasurable aspects of the food environment (Cheng & Wong, 2021). Despite increased hunger, we observed no significant changes in food liking for high-fat sweet, low-fat sweet, high-fat savory, or low-fat savory items across exercise and control conditions. Our findings are in agreement with Martins et al. (2015) and McNeil et al. (2015), who also observed no significant differences in food reward or relative preference for high-fat food compared to low-fat food. Maintaining stable food reward patterns, even under conditions of elevated hunger, indicates that appetite stimulation following exercise may primarily influence food quantity rather than preference or palatability.

A key novel finding of this study is that post-exercise food amount preferences significantly increased in both low- and high-intensity trials, with average increments of 279 kcal and 240 kcal, respectively. Consistent with our findings, a study by Pomerleau et al. (2004) found increased energy intake after exercise sessions in women, using an ad libitum buffet following each experimental condition (control, low- and high-intensity exercise) to determine the energy intake. They reported approximately 878 kcal were

consumed after a high-intensity exercise session, compared to 751 kcal in the control session, resulting in a difference of around 127 kcal. Unlike Pomerleau et al. (2004), however, the present study assessed food amount preferences using a hypothetical food selection task rather than measuring actual food consumption. Therefore, our findings indicate an increased intention to select larger food portions following exercise. Nevertheless, the observed increase in food amount preferences suggests that the hormonal and subjective appetite responses following exercise may translate into behavioural intentions that could contribute to compensatory eating. Our finding is also in agreement with recent research by Koehler et al. (2021), who reported that participants selected larger food amounts immediately after exercise compared to the control condition. This is attributed to cognitive factors, including the belief that exercise increases hunger, and the habitual use of food as a reward for physical activity (Martins, et al. 2015). Up to 75% of exercisers have been found to experience compensatory eating, which is an increase in food consumption following exercise (Moshier et al., 2016). This phenomenon is well recognised as the main obstacle to weight reduction (Liu et al, 2022).

The present study is the first to determine the shifts in the selection of food amount post-exercise among young women in Malaysia. By allowing participants to select their preferred foods and portion sizes in a realistic cafeteria-like context, immediate post-exercise eating behavior that closely mirrors real-world choices was captured. Our findings have important implications for women engaging in physical activity. Acute exercise may stimulate appetite and increase the intention to select larger food portions, which could contribute to compensatory eating. Recognizing these behavioral and hormonal responses can help guide nutritional strategies, such as timing of meals and portion control, to optimize energy balance. Additionally, these findings underscore the need for personalized exercise and dietary prescriptions that account for sex-specific appetite responses.

Nevertheless, the study had several limitations. First, blood samples for acylated ghrelin concentration quantification were collected only once during each experimental trial. With this, fluctuations of acylated ghrelin levels throughout the experimental conditions especially during the exercise sessions could not be observed. Second, we did not track food amount preferences beyond the immediate post-exercise period, limiting our ability to capture a comprehensive picture of how exercise at different intensity levels influences food preferences over time. Lastly, our study sample consisted solely of untrained young women, which may not fully represent broader demographic diversity.

4. CONCLUSION

Our current study demonstrated that acute exercise, regardless of intensity, significantly elevates acylated ghrelin concentrations in young, untrained Malaysian women (predominantly Chinese ethnicity), accompanied by increased subjective hunger. While exercise did not alter food liking, participants selected significantly larger food amounts post-exercise, indicating a compensatory response to energy expenditure. These findings, to our knowledge, provide the first evidence describing these responses in a Malaysian female population. This contextual contribution addresses an important gap in the literature, although the relatively small sample size ($n=13$) warrants cautious interpretation and limits the generalizability of the findings.

Understanding this compensatory response is crucial for designing effective exercise-based interventions aimed at weight management. The stimulation of appetite following acute exercise could potentially undermine weight loss efforts, particularly among women trying to achieve a calorie deficit. Further studies with larger and more diverse Asian populations should investigate the effects of prolonged physical activity durations on hunger hormone fluctuations and subsequent food intake. Longitudinal studies are essential to explore the long-term impact of acute physical activity on food intake and weight regulation in women. These studies will provide valuable insights into the sustainability of compensatory eating behaviours over time, helping to develop effective weight management strategies to combat obesity in women.

5. ACKNOWLEDGEMENTS

This research was funded by the University of Nottingham Malaysia Faculty of Science and Engineering cross-disciplinary research (LH 744019)

6. CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflict of interest concerning this research.

7. AUTHORS' CONTRIBUTION

Yih Sheng Shim was responsible for the data collection, data analysis and writing of the first draft. **Yuh Fen Pung, Siew Siew Lee and Shi-Hui Cheng** contributed to the methodology, funding acquisition and critical evaluation of the manuscript. All authors read, reviewed, and approved the final version of the manuscript.

8. DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

During the preparation and revision of this manuscript, generative artificial intelligence (AI) tools may have been used to assist with language editing, grammar checking, and improvement of manuscript clarity. AI tools were not used to generate research data, perform statistical analyses, or replace the authors' scientific judgement. The authors remain fully responsible for the study design, data collection, data analysis, interpretation of findings, and final content of the manuscript. All AI-assisted outputs, where applicable, were critically reviewed and verified by the authors prior to submission.

9. ETHICS STATEMENT

Ethical approval for this study was obtained from the Faculty of Science and Engineering Research Integrity and Research Ethics Committee of University of Nottingham Malaysia (Reference number: KYQ300922). Written informed consent was obtained from all participants prior to enrolment in the study.

10. REFERENCES

- Ahmed, S. K., & Mohammed, R. A. (2025). Obesity: Prevalence, causes, consequences, management, preventive strategies and future research directions. *Metabolism open*, 27, 100375. <https://doi.org/10.1016/j.metop.2025.100375>
- Anderson, K. C., Zieff, G., Paterson, C., Stoner, L., Weltman, A., & Allen, J. D. (2021). The effect of acute exercise on pre-prandial ghrelin levels in healthy adults: A systematic review and meta-analysis. *Peptides*, 145, 170625. <https://doi.org/10.1016/j.peptides.2021.170625>
- Beaulieu, K., Oustric, P., & Finlayson, G. (2020). The Impact of Physical Activity on Food Reward: Review and Conceptual Synthesis of Evidence from Observational, Acute, and Chronic Exercise Training Studies. *Current Obesity Reports*, 9(2), 63-80. <https://doi.org/10.1007/s13679-020-00372-3>
- Broom, D. R., Miyashita, M., Wasse, L. K., Pulsford, R., King, J. A., Thackray, A. E., & Stensel, D. J. (2017). Acute effect of exercise intensity and duration on acylated ghrelin and hunger in men. *Journal of Endocrinology*, 232(3), 411-422. <https://doi.org/10.1530/JOE-16-0561>
- Cheng, S. H., & Wong, S. E. (2021). Stress, emotional eating and food choices among university students during the COVID-19. *Malaysian Journal of Social Sciences and Humanities*, 6(9), 335-346.
- Hagobian, T. A., & Evero, N. (2013). Exercise and Weight Loss: What Is the Evidence of Sex Differences? *Current Obesity Reports*, 2(1), 86-92. <https://doi.org/10.1007/s13679-012-0035-6>
- Hagobian, T. A., Sharoff, C. G., Stephens, B. R., Wade, G. N., Silva, J. E., Chipkin, S. R., & Braun, B. (2009). Effects of exercise on energy-regulating hormones and appetite in men and women. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 296(2), R233-242. <https://doi.org/10.1152/ajpregu.90671.2008>
- Hasim, M.H., Gunalan, A., Lim, C.T., Lim, Y.S., Cheng, S.H. (2025a). Poor sleep quality, employment status, and female gender as risk factors for overweight and obesity among Malaysian adults. *Sleep Medicine Research*, 16(1):59-66. <https://doi.org/10.17241/smr.2024.02621>
- Hasim, M.H., Gunalan, A., Lim, C.T., Lim, Y.S., Cheng, S.H. (2025b). Exploring biosocial barriers and enablers to weight loss: A qualitative study of a 12-week workplace program for overweight and obese office workers. *BioSocial Health Journal*, 2(3):116-123. <https://doi.org/10.34172/bshj.103>
- Kawano, H., Motegi, F., Ando, T., Gando, Y., Mineta, M., Numao, S., Miyashita, M., Sakamoto, S., & Higuchi, M. (2012). Appetite after rope skipping may differ between males and females. *Obesity Research & Clinical Practice*, 6(2), e121-e127. <https://doi.org/10.1016/j.orcp.2011.07.003>
- Koehler, K., Beckford, S. E., Thayer, E., Martin, A. R., Boron, J. B., & Stevens, J. R. (2021). Exercise Shifts Hypothetical Food Choices toward Greater Amounts and More Immediate Consumption. *Nutrients*, 13(2). <https://doi.org/10.3390/nu13020347>
- Larson-Meyer, D. E., Palm, S., Bansal, A., Austin, K. J., Hart, A. M., & Alexander, B. M. (2012). Influence of running and walking on hormonal regulators of appetite in women. *Journal of Obesity*, 2012, 730409. <https://doi.org/10.1155/2012/730409>
- Liu, X. M., Wang, K., Zhu, Z., & Cao, Z. B. (2022). Compensatory effects of different exercise durations on non-exercise physical activity, appetite, and energy intake in normal weight and overweight adults. *Frontiers in physiology*, 13, 932846. <https://doi.org/10.3389/fphys.2022.932846>

- Martins, C., Stensvold, D., Finlayson, G., Holst, J., Wisloff, U., Kulseng, B., Morgan, L., & King, N. A. (2015). Effect of Moderate- and High-Intensity Acute Exercise on Appetite in Obese Individuals. *Medicine & Science in Sports & Exercise*, 47(1), 40-48. <https://doi.org/10.1249/mss.0000000000000372>
- McNeil, J., Cadieux, S., Finlayson, G., Blundell, J. E., & Doucet, E. (2015). The effects of a single bout of aerobic or resistance exercise on food reward. *Appetite*, 84, 264-270. <https://doi.org/10.1016/j.appet.2014.10.018>
- Metcalfé, R. S., Koumanov, F., Ruffino, J. S., Stokes, K. A., Holman, G. D., Thompson, D., & Vollaard, N. B. J. (2015). Physiological and molecular responses to an acute bout of reduced-exertion high-intensity interval training (REHIT). *European Journal of Applied Physiology*, 115(11), 2321-2334. <https://doi.org/10.1007/s00421-015-3217-6>
- Moshier, S. J., Landau, A. J., Hearon, B. A., Stein, A. T., Greathouse, L., Smits, J. A., & Otto, M. W. (2016). The Development of a Novel Measure to Assess Motives for Compensatory Eating in Response to Exercise: The CEMQ. *Behavioral Medicine*, 42(2), 93-104. <https://doi.org/10.1080/08964289.2014.955077>
- Ng, G.F., Cheng, S.H. (2023). Weight gain, poor mental health and increased sedentary hours among Malaysian adults during the COVID-19 pandemic. *Nutrition and Health*, 31(1):187-96. <https://doi.org/10.1177/02601060231164434>
- Pomerleau, M., Imbeault, P., Parker, T., & Doucet, E. (2004). Effects of exercise intensity on food intake and appetite in women. *American Journal of Clinical Nutrition*, 80(5), 1230-1236. <https://doi.org/10.1093/ajcn/80.5.1230>
- Schubert, M. M., Sabapathy, S., Leveritt, M., & Desbrow, B. (2014). Acute exercise and hormones related to appetite regulation: a meta-analysis. *Sports Medicine*, 44(3), 387-403. <https://doi.org/10.1007/s40279-013-0120-3>
- Shamlan, G., Bech, P., Robertson, M. D., & Collins, A. L. (2017). Acute effects of exercise intensity on subsequent substrate utilisation, appetite, and energy balance in men and women. *Applied Physiology, Nutrition, and Metabolism*, 42(12), 1247-1253. <https://doi.org/10.1139/apnm-2017-0280>
- Ueda, S.-y., Miyamoto, T., Nakahara, H., Shishido, T., Usui, T., Katsura, Y., Yoshikawa, T., & Fujimoto, S. (2013). Effects of exercise training on gut hormone levels after a single bout of exercise in middle-aged Japanese women. *SpringerPlus*, 2(1), 1-9. <https://doi.org/10.1186/2193-1801-2-83>
- Vatansever, S., Tiryaki-Sonmez, R., Yuktasir, B., Yalçın, H., Bugdayci, G., & Willems, M. (2010). Effects of exercise on leptin and acylated ghrelin hormones in trained males. *Journal of Exercise Physiology Online*, 13, 20-30.
- World Health Organization. (2010). A healthy lifestyle - WHO recommendations. <https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations>



© 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY-NC-ND) license (<http://creativecommons.org/licenses/by/4.0/>).