Commentary Postprint on the American College of Sports Medicine Consensus Statement on Adult Physical Activity and Overweight and Obesity

Authors: Zhang Ying, Yang Ziyu, Liu Lidi, Liao Xiaoyang, Jia Yu, Shen Can, Yang Rong, Yang Ziyu, Liu Lidi

Date: 2025-08-18T00:00:00+00:00

Abstract

Overweight and obesity are intimately associated with the pathogenesis of numerous chronic diseases. In response to this health crisis, the American College of Sports Medicine published the "Consensus Statement on Physical Activity and Overweight/Obesity in Adults" in 2024, which advocates for incorporating physical activity into the medical management of overweight and obesity in appropriate clinical settings and provides guidance on its application. The consensus specifically highlights: (1) For weight loss and prevention of weight gain, at least 150 min/week of moderate-intensity physical activity may produce the most pronounced effects; (2) High-intensity interval training does not demonstrate superiority over moderate-to-vigorous continuous training regarding physical activity effects on weight regulation; (3) Low-intensity physical activity may serve as an alternative approach provided energy expenditure is maintained; (4) Various exercise modalities exhibit equivalence in weight management; To achieve overall health benefits beyond weight control and fat reduction, the adoption of multiple modes of physical activity is recommended. This consensus underscores the critical importance of physical activity in the prevention, treatment, and management of overweight and obesity. This guideline interpretation aims to conduct an in-depth analysis of the core elements of this consensus statement, provide novel recommendations for preventing and treating overweight/obesity through physical activity in China, and assist primary care physicians in more effectively managing patients with overweight/obesity.

Full Text

Preamble

Interpretation of Guidelines: American College of Sports Medicine' s *Consensus Statement on Physical Activity and Excess Body Weight and Adiposity in Adults*

ZHANG Ying[1], YANG Ziyu[1], *LIU Lidi*[2], LIAO Xiaoyang[1], JIA Yu[1], SHEN Can[1], YANG Rong[1]

[1]General Practice Medical Center/Day Surgery Center, West China Hospital of Sichuan University, Chengdu 610041, Sichuan Province, China
[2]Day Surgery Center, General Practice Medical Center, West China Hospital of Sichuan University, Chengdu 610041, China

Corresponding authors: YANG Ziyu, Attending physician; E-mail: 1206551668@qq.com
LIU Lidi, Attending physician; E-mail: 1661824860@qq.com

Abstract Excess body weight and adiposity are closely related to the pathogenesis of various chronic diseases. To address this health crisis, the American College of Sports Medicine released the *Consensus Statement on Adult Physical Activity and Excess Body Weight and Adiposity* in 2024, advocating for the integration of physical activity into medical treatment for overweight and obesity when clinically appropriate, and providing guidance on its application. The consensus specifically highlights: (1) For weight loss and prevention of weight gain, at least 150 minutes per week of moderate-intensity physical activity may yield the most significant effects; (2) High-intensity interval training is not superior to moderate-to-high-intensity continuous training for weight regulation; (3) Low-intensity physical activity can serve as an alternative provided energy expenditure is maintained; and (4) Various exercise modalities are equivalent for weight management, though multimodal physical activity is recommended for overall health benefits beyond weight control and fat loss. This consensus emphasizes the importance of physical activity in preventing, treating, and managing overweight and obesity. This guideline interpretation aims to analyze the core points of this consensus statement in depth, provide new recommendations for preventing and treating overweight/obesity through physical activity in China, and help primary care physicians manage overweight/obese patients more effectively.

[**Key words**] Overweight; Obesity; Physical activity; Physical activity mode; Physical activity intensity; American College of Sports Medicine; Guidelines interpretation

---

1. Definition of Overweight and Obesity

The WHO defines obesity as excessive or abnormal fat accumulation that impairs health, while the U.S. Centers for Disease Control defines over-

weight/obesity as body weight exceeding the healthy range for a given height. Both organizations use BMI to further define these terms: BMI 25.0–29.9 kg/m^2 as overweight and BMI $\geq$ 30.0 kg/m^2 as obesity. In China, considering population characteristics, BMI 24.0–27.9 kg/m^2 is defined as overweight and BMI $\geq$ 28.0 kg/m^2 as obesity. ACSM also supports using BMI as an initial screening tool for potential overweight or obesity, though waist circumference may be needed to assess abdominal obesity and body composition, including total and regional adiposity and lean mass components such as bone, muscle, and specific organ mass (e.g., liver, heart). Body composition measurements can be performed when there are concerns that BMI does not accurately reflect health status or when treatment for overweight and obesity may cause reductions in lean mass or bone mass.

---

2. Medical Interventions for Overweight and Obesity

2.1 Pharmacotherapy

Pharmacotherapy primarily mimics nutrient-stimulated hormones (NuSH) that act on receptors for glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide-1 (GLP-1). These NuSH-based therapies can reduce appetite, increase satiety, and slow gastric emptying, thereby facilitating weight loss. Selective GLP-1 receptor agonists such as semaglutide and dual GIP/GLP-1 receptor agonists such as tirzepatide have proven highly effective for weight reduction. However, a potential concern with these NuSH therapies is excessive loss of lean mass, which may negatively impact energy expenditure, musculoskeletal health, and other health outcomes. Most studies on anti-obesity medications have not yet published data on body composition changes.

2.2 Metabolic/Bariatric Surgery

Current guidelines recommend that all individuals with BMI $\geq$ 35 kg/m^2 should consider metabolic and bariatric surgery, as should those with BMI $\geq$ 30 kg/m^2 who have metabolic diseases such as type 2 diabetes. For Asian populations, the threshold for metabolic and bariatric surgery is BMI $\geq$ 27.5 kg/m^2. The European Association for the Study of Obesity concluded that aerobic exercise, resistance exercise, or their combination after metabolic and bariatric surgery can produce an additional 2.5 kg weight loss and prevent declines in muscle strength; however, the effect of resistance exercise in reducing lean mass loss has only been observed in younger individuals. Research shows that supervised aerobic activity compared with unsupervised physical activity in the context of metabolic and bariatric surgery significantly improves cardiorespiratory fitness, insulin sensitivity, and glucose effectiveness. Therefore, beyond considering the impact of physical activity on body weight, other health-related benefits should also be considered in the context of metabolic and bariatric surgery.

The consensus statement notes that anti-obesity medications and metabolic/bariatric surgery are effective treatments for overweight and obesity and related health conditions such as cardiovascular disease and diabetes. Consistent with ACSM' s previous position statements, these interventions should be combined with dietary and physical activity behaviors tailored to individual needs, including both aerobic and resistance exercise. This combination of physical activities will improve cardiorespiratory fitness, muscle strength and function, and muscle mass, potentially mitigating lean mass and muscle loss that may occur during weight reduction. Long-term adherence to physical activity is necessary to maintain these benefits.

---

3. The Role of Physical Activity in Preventing and Treating Overweight/Obesity

Based on previous position papers and the latest research evidence, this consensus indicates that physical activity helps prevent weight and fat gain and reduces the progression of obesity-related health problems. Increased physical activity leads to greater weight loss and fat reduction in a dose-response relationship. Even without concurrent energy-restricted dieting, physical activity alone typically produces modest weight loss of 0.5–3.0 kg. Some specific forms of physical activity may reduce visceral fat and increase muscle mass, though most evidence comes from aerobic and resistance exercise. Physical activity provides additional health benefits for overweight and obese patients even without weight or fat loss, such as reducing risks for cardiovascular disease, diabetes, and cancer. Combining physical activity with energy-restricted dieting yields approximately 20% greater weight loss than dieting alone, with more pronounced effects as physical activity increases, though the impact may diminish with more severe dietary energy restriction.

The consensus points out that gradually increasing physical activity in an appropriate manner to achieve at least 150 minutes per week of moderate-intensity physical activity, or an equivalent dose across different intensities, may yield the most significant effects. Individuals show differential responses to exercise and physical activity in terms of weight changes, with considerable individual variation in the magnitude of weight change. This suggests that personalized recommendations for structured exercise and physical activity may be necessary, and it is important to identify relevant influencing factors to inform how better to achieve individualized recommendations. Another aspect to consider is the potential impact of sedentary behavior on weight status and weight loss. ACSM' s 2019 position statement on sedentary behavior concluded that sedentary behavior is unrelated to weight status. One study combining dietary changes with physical activity reported that changes in sedentary behavior did not predict weight loss, whereas increases in low-intensity and moderate-to-vigorous physical activity were predictive factors for weight loss.

Emerging research areas related to physical activity include the total energy expenditure from moderate-to-vigorous physical activity, which is associated with lower body weight and fat mass regardless of bout duration. A cross-sectional study showed that at least 150 minutes per week of moderate-to-vigorous physical activity, regardless of bout duration, modestly reduces body weight, BMI, and waist circumference; however, decreases in body fat percentage require each bout to last at least 10 minutes. It remains unclear whether accumulating activity bouts shorter than 10 minutes is effective for weight and adiposity changes compared with longer bouts of equal energy expenditure. Another emerging area is the relationship between timing of physical activity and weight and adiposity measures. Engaging in physical activity at a consistent time each day helps maintain activity participation; however, data on whether time of day affects weight and fat outcomes are limited and inconsistent. Some studies suggest afternoon exercise is more effective, others indicate morning exercise is better, and some show no difference between morning and afternoon exercise. A 15-week pilot study showed similar weight loss between morning and evening exercise, though exercising at a consistent time each day, particularly in the morning, may be important for maintaining participation after weight loss. For individuals, the most suitable exercise time may need to consider both health benefits and factors affecting participation, such as occupational and family responsibilities.

---

4. Considerations for Physical Activity Intensity and Patterns

Most studies have reported the effects of moderate-to-vigorous physical activity on weight regulation, including preventing weight gain, promoting weight loss, and maintaining weight loss. Engaging in 200–300 minutes per week of leisure-time physical activity or expending $\geq$ 2,000 kcal per week facilitates more significant long-term weight loss. This activity dose was initially recommended by ACSM and is supported by other clinical and public health guidelines. However, one study showed that prescribing 250 minutes per week of unsupervised physical activity in a comprehensive behavioral weight loss program did not produce significantly greater weight loss than prescribing 150 minutes per week. Therefore, physical activity goals can initially be set to gradually increase to 150 minutes per week of moderate-to-vigorous physical activity, with increases to higher doses as needed for better weight regulation and to achieve additional health benefits that may not be realized with lower doses.

Although less studied, emerging evidence suggests low-intensity physical activity may also have potential benefits for weight regulation. High-intensity interval training (HIIT) offers another approach to consider, but research shows it is not superior to continuous moderate-intensity physical activity in terms of weight or body composition effects. However, HIIT can be an option when there are no contraindications and when preferred by the individual. For those unable

to engage in moderate or vigorous physical activity or with contraindications, low-intensity physical activity is a feasible alternative that can increase energy expenditure. However, to achieve the same energy expenditure as moderate-to-vigorous physical activity, low-intensity activity requires longer duration, and the specific dose of low-intensity physical activity effective for weight regulation and obesity treatment remains unclear.

Controversy persists regarding which physical activity mode is most effective for preventing and treating overweight and obesity. To achieve overall health benefits beyond weight control and fat loss, individuals with overweight and obesity should engage in multiple modes of physical activity rather than a single mode, including: (1) aerobic activity to maintain or improve cardiorespiratory fitness; (2) resistance exercise, which may help increase muscle mass and maintain or enhance muscle strength and function; (3) mind-body exercises such as yoga to improve mobility and balance, enhance kinesthetic awareness, and influence other aspects that contribute to overall health and well-being; and (4) balance training to adapt to changes in weight distribution, facilitate safe movement, and prevent falls. The contributions of different activity modes to body composition, fitness components, and health are illustrated in Figure 1 [Figure 1: see original paper].

---

5. Dietary Intervention Recommendations

The consensus statement notes that dietary intervention is crucial for weight management. Portion control strategies help prevent weight gain and may achieve weight loss by reducing energy intake. Increasing portion size at a single meal leads to higher daily caloric intake, with doubling portion size increasing energy intake per eating occasion by 35%. Reducing portion sizes decreases energy intake, with smaller portions reducing weight gain by approximately 0.6 kg compared with larger portions. Clinical guidelines recommend reducing daily caloric intake by 500–1,000 kcal combined with exercise to achieve 0.45–0.90 kg per week of weight loss, though actual results are often lower than expected.

Research shows that for individuals with BMI > 30 kg/m^2, intermittent fasting (whether time-restricted or alternate-day fasting) does not demonstrate superior weight loss compared with low-calorie diets, though combining exercise during fasting periods may enhance improvements in cardiometabolic indicators (e.g., blood lipids, inflammation) and liver health, with attention needed to hypoglycemia risk. Different dietary patterns (e.g., ketogenic diet) can all produce weight loss with no difference in lean mass preservation, and single-food interventions have limited effects.

Future challenges and considerations for dietary interventions in weight management include mechanistic research to reveal physiological and neural mechanisms (e.g., appetite hormones, food reward systems) underlying energy compensation from exercise and diet. Technological innovation should focus on developing dy-

namic monitoring tools (e.g., wearable devices + artificial intelligence) for real-time feedback on intake and expenditure to optimize intervention adjustments. Policy initiatives should advocate for the food industry to reduce default portion sizes and strengthen institutionalized collaboration among multidisciplinary teams in weight management. Future efforts must address core issues of individualized intervention, multidisciplinary integration, and long-term maintenance to achieve more effective weight management.

---

6. Regulation of Energy Intake and Eating Behavior by Physical Activity

Research indicates that exercise-induced weight loss is typically lower than expected based on objective measurements of exercise-induced energy expenditure, with changes in energy intake considered the primary pathway compensating for the energy deficit created by exercise. Regarding acute exercise effects, a single bout of aerobic exercise does not increase hunger or energy intake within 24 hours, and high-intensity exercise (>70% VO_2max) temporarily suppresses post-exercise hunger, though hunger changes synchronize with gastrointestinal hormone concentrations. Exercise intensity, duration, sex, and obesity status may modulate appetite responses but do not significantly affect acute energy intake compensation. Regarding medium- to long-term exercise effects, after 7–14 days of intervention, energy intake begins to match increased exercise-induced energy expenditure, with approximately 30% of exercise-induced energy expenditure compensated through increased energy intake. Long-term exercise training studies show similar partial compensation phenomena.

Notably, the effects of exercise training on appetite regulation are complex and show significant individual variation. Exercise may increase fasting hunger while enhancing postprandial satiety and improving food reward responses and eating behavior traits (especially during weight loss) to offset increased energy intake. Individuals habitually engaging in high levels of physical activity may exist in a "regulated zone" of appetite with enhanced appetite control sensitivity, coupling energy intake and expenditure more tightly.

The primary challenges facing exercise-induced weight loss include energy compensation mechanisms, individual variation, and the complexity of appetite regulation. Future research must further explore how to optimize exercise protocols to maximize weight loss effects.

---

7. Population and Individual-Specific Considerations

Overweight and obesity have become public health issues affecting broad populations across different life stages (children, adolescents, young adults, middle-aged, older adults), biological sex and gender identity, race, ethnicity, and so-

cioeconomic strata, and also exist among individuals with physical disabilities, mobility limitations, or intellectual and developmental disabilities. Geographic factors (e.g., urban-rural differences) may further exacerbate the problem. Physical activity has positive effects on weight regulation and health outcomes for all populations, but sustainable exercise protocols must be tailored to group characteristics. The consensus statement emphasizes that healthcare providers must recognize how social determinants of health affect overweight/obesity and opportunities for physical activity, incorporating individual identity characteristics (e.g., age, developmental stage, gender identity, race, socioeconomic status) into personalized interventions while addressing systemic barriers (e.g., urban-rural exercise environments, economic accessibility, cultural preferences). For individuals with physical disabilities or developmental disorders, adapted activity programs must be provided, focusing on functional training and professional support, with cost-sensitive approaches to ensure facility accessibility. Additionally, healthcare providers should identify factors that may limit exercise participation, including clinical intolerance, physiological deconditioning, or subjective tolerance differences, to ensure intervention safety and feasibility. Future breakthroughs are needed in precision, equity, adaptability, and interdisciplinary integration to achieve more effective overweight/obesity prevention and treatment.

---

8. Future Research Directions

ACSM's *Consensus Statement on Physical Activity and Excess Body Weight and Adiposity in Adults* updates previous recommendations and further emphasizes the central role of physical activity in weight and body composition regulation, proposing future research directions (see Table 1) to improve scientific evidence supporting clinical and public health intervention strategies.

Table 1. Areas for Future Research in Each of the Topical Areas

Topical Area	Key Research Directions
Clinical medical interventions for overweight and obesity	• Define physical activity doses (duration, frequency, intensity) that produce multiple health benefits (including weight and body composition improvements) and their combined application with anti-obesity medications or metabolic/bariatric surgery • Investigate differential effects of combining different exercise modes with medical interventions for obesity treatment • Study individual variation in response to exercise combined with weight loss therapy

Topical Area	Key Research Directions
Role of physical activity in preventing and treating overweight/obesity	• Investigate whether specific strategies are needed for anti-obesity medications or metabolic/bariatric surgery to effectively improve initial participation and long-term adherence to physical activity interventions • Explore factors influencing effects of different exercise modes, doses, intensities, and timing on weight, body composition, and other health outcomes in overweight/obese populations • Conduct prospective RCTs analyzing effects of single exercise bout duration on weight, body composition, and other health indicators under equal total energy expenditure • Conduct prospective RCTs examining effects of exercise timing (morning vs. evening) on weight, body composition, and other health indicators under equal total energy expenditure • Conduct studies with supervised exercise or objective activity measurement to quantify and verify whether prescribed exercise mode, dose, intensity, bout duration, and timing are achieved
Considerations for physical activity intensity	• Investigate effects of low-intensity vs. moderate-to-high-intensity physical activity (with equal energy expenditure) on weight, body composition, and other health indicators in overweight/obese populations • Explore whether physical activity intensity affects participation and adherence in overweight/obese populations and related individual factors (e.g., body image dissatisfaction, emotional responses)
Considerations for physical activity patterns	• Investigate differential effects of different exercise modes (with equal energy expenditure) on weight, body composition, and other health indicators • Compare multimodal vs. single-mode exercise interventions on weight, body composition, and other health indicators • Examine whether the sequence of adding different exercise modes in interventions produces differential effects

Topical Area	Key Research Directions
Dietary considerations	• Evaluate feasibility and effectiveness of precision nutrition recommendations by studying individual variation in weight loss responses to different dietary interventions • Investigate whether specific dietary patterns provide health benefits beyond weight loss and fat reduction
Regulation of energy intake and eating behavior by physical activity	• Current research focuses on appetite regulation effects of increased exercise, while specific appetite effects of sedentary behavior and experimental physical activity restriction remain poorly understood • Long-term exercise training studies integrating metabolic physiological adaptations with psychological/behavioral responses are needed to understand how homeostatic mechanisms, hedonic eating mechanisms, and environmental factors shape compensatory eating behavior • Parsing individual variation in exercise-induced appetite responses and weight loss sensitivity remains central to developing compensatory eating interventions, requiring study designs and statistical methods that distinguish between- and within-individual variation and assessing reproducibility and plasticity of such variation
Population and individual-specific considerations	• Optimize exercise dose, intensity, and mode for populations and individuals to improve effectiveness for weight regulation, obesity treatment, and obesity-related disease management • Identify factors causing participation differences across groups and individuals to develop targeted, inclusive intervention strategies • Reveal biological characteristics, behavioral patterns, and environmental factors underlying heterogeneous intervention effects at group and individual levels

Topical Area	Key Research Directions
Intervention strategies to promote physical activity participation and maintenance	• Explore intervention pathways to improve affective exercise experiences in overweight/obese populations, including: modifying exercise formats (non-weight-bearing, interval training, self-selected intensity, size-adapted equipment); changing cognitive appraisal (gamification, autonomy support); optimizing physical (temperature/humidity) and social environments (social support, eliminating psychological threats) • Study how psychosocial factors (e.g., body image dissatisfaction, affective responses to intensity) influence exercise prescription development to reduce sedentary time and improve health outcomes through personalized programs • Conduct prospective studies evaluating effective strategies for promoting participation and maintenance (digital tools, behavioral tracking, interpersonal support, medical follow-up, professional guidance), analyzing mechanisms for reducing sedentary behavior

9. Conclusion and Implications for China

China has the largest number of overweight and obese individuals globally, and obesity rates continue to rise. To achieve the Healthy China 2030 goals, China has already released guidelines including the *Physical Activity Guidelines for Chinese Population (2021)*, *Physical Activity Guidelines for Chinese Children and Adolescents*, *Physical Activity Guidelines for Older Adults*, and the *Chinese Expert Consensus on Exercise Prescription (2023)*. Continued research should be strengthened to provide evidence for localized obesity prevention and treatment measures. Furthermore, ACSM' s advocacy for inclusive approaches to promote population-wide physical activity participation has important implications for China: on one hand, urban planning and public fitness facilities must be optimized to provide convenient and accessible exercise environments for diverse populations; on the other hand, physical education for children and adolescents should be emphasized to cultivate lifelong exercise habits. In general practice, individualized exercise prescriptions can be combined with traditional Chinese fitness practices (e.g., Baduanjin, Tai Chi, square dancing) and coordinated with dietary management to build a comprehensive overweight/obesity prevention and control system suitable for Chinese populations, thereby achieving multi-level health promotion from clinical to community settings and pre-

venting obesity and its complications.

Author Contributions: ZHANG Ying and YANG Ziyu conceived the article, drafted and revised the manuscript, and take overall responsibility; LIU Lidi, JIA Yu, SHEN Can, and YANG Rong provided guidance and revision; LIU Lidi conducted feasibility analysis, participated in revision, and supervised quality control and final review.

Conflict of Interest Statement: The authors declare no conflicts of interest.

ORCID IDs:
LIU Lidi: https://orcid.org/0009-0009-8608-181X
YANG Ziyu: https://orcid.org/0000-0001-6153-5613

References

[1] ELMALEH-SACHS A, SCHWARTZ J L, BRAMANTE C T, et al. Obesity management in adults: a review[J]. JAMA, 2023, 330(20): 2000-2015. DOI: 10.1001/jama.2023.19897.

[2] CHEN K, SHEN Z W, GU W J, et al. Prevalence of obesity and associated complications in China: a cross-sectional, real-world study in 15.8 million adults[J]. Diabetes Obes Metab, 2023, 25(11): 3390-3399. DOI: 10.1111/dom.15238.

[3] SUN X M, YAN A F, SHI Z M, et al. Health consequences of obesity and projected future obesity health burden in China[J]. Obesity (Silver Spring), 2022, 30(9): 1724-1751. DOI: 10.1002/oby.23472.

[4] JAKICIC J M, APOVIAN C M, BARR-ANDERSON D J, et al. Physical activity and excess body weight and adiposity for adults. American college of sports medicine consensus statement[J]. Med Sci Sports Exerc, 2024, 56(10): 2076-2091. DOI: 10.1249/MSS.0000000000003520.

[6] WILDING J P H, BATTERHAM R L, CALANNA S, et al. Once-weekly semaglutide in adults with overweight or obesity[J]. N Engl J Med, 2021, 384(11): 989-1002. DOI: 10.1056/NEJMoa2032183.

[7] WADDEN T A, CHAO A M, MOORE M, et al. The role of lifestyle modification with second-generation anti-obesity medications: comparisons, questions, and clinical opportunities[J]. Curr Obes Rep, 2023, 12(4): 453-473. DOI: 10.1007/s13679-023-00534-z.

[8] BOUCHONVILLE M F, VILLAREAL D T. Sarcopenic obesity: how do we treat it?[J]. Curr Opin Endocrinol Diabetes Obes, 2013, 20(5): 412-419. DOI: 10.1097/01.med.0000433071.11466.7f.

[9] JOBANPUTRA R, SARGEANT J A, ALMAQHAWI A, et al. The effects of weight-lowering pharmacotherapies on physical activity, function and fitness:

a systematic review and meta-analysis of randomized controlled trials[J]. Obes Rev, 2023, 24(4): e13553. DOI: 10.1111/obr.13553.

[10] EISENBERG D, SHIKORA S A, AARTS E, et al. 2022 American society for metabolic and bariatric surgery (ASMBS) and international federation for the surgery of obesity and metabolic disorders (IFSO): indications for metabolic and bariatric surgery[J]. Surg Obes Relat Dis, 2022, 18(12): 1345-1356. DOI: 10.1016/j.soard.2022.08.013.

[11] COEN P M, TANNER C J, HELBLING N L, et al. Clinical trial demonstrates exercise following bariatric surgery improves insulin sensitivity[J]. J Clin Invest, 2015, 125(1): 248-257. DOI: 10.1172/JCI78016.

[12] BOND D S, MANUEL K M, WU Y, et al. Exercise for counteracting weight recurrence after bariatric surgery: a systematic review and meta-analysis of randomized controlled trials[J]. Surg Obes Relat Dis, 2023, 19(6): 641-650. DOI: 10.1016/j.soard.2022.12.029.

[13] CARNERO E A, DUBIS G S, HAMES K C, et al. Randomized trial reveals that physical activity and energy expenditure are associated with weight and body composition after RYGB[J]. Obesity (Silver Spring), 2017, 25(7): 1206-1216. DOI: 10.1002/oby.21864.

[14] JAKICIC J M, POWELL K E, CAMPBELL W W, et al. Physical activity and the prevention of weight gain in adults: a systematic review[J]. Med Sci Sports Exerc, 2019, 51(6): 1262-1269. DOI: 10.1249/MSS.0000000000001938.

[15] WASHBURN R A, SZABO-REED A N, GORCZYCA A M, et al. A randomized trial evaluating exercise for the prevention of weight regain[J]. Obesity (Silver Spring), 2021, 29(1): 62-70. DOI: 10.1002/oby.23022.

[16] DONNELLY J E, BLAIR S N, JAKICIC J M, et al. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults[J]. Med Sci Sports Exerc, 2009, 41(2): 459-471. DOI: 10.1249/MSS.0b013e3181949333.

[17] SARZYNSKI M A, RICE T K, DESPRÉS J P, et al. The HERITAGE family study: a review of the effects of exercise training on cardiometabolic health, with insights into molecular transducers[J]. Med Sci Sports Exerc, 2022, 54(5S): S1-S43. DOI: 10.1249/MSS.0000000000002859.

[18] JAKICIC J M, KING W C, MARCUS M D, et al. Short-term weight loss with diet and physical activity in young adults: The IDEA study[J]. Obesity (Silver Spring), 2015, 23(12): 2385-2397. DOI: 10.1002/oby.21241.

[19] JACKSON R E, LANG W, ROGERS R J, et al. Accumulated physical activity and the association with obesity, fitness, and cardiometabolic risk factors in healthy adults[J]. Obesity (Silver Spring), 2024, 32(1): 23-31. DOI: 10.1002/oby.23890.

[20] BLANKENSHIP J M, ROSENBERG R C, RYNDERS C A, et al. Examining the role of exercise timing in weight management: a review[J]. Int J Sports Med, 2021, 42(11): 967-978. DOI: 10.1055/a-1485-1293.

[21] CREASY S A, WAYLAND L, PANTER S L, et al. Effect of morning and evening exercise on energy balance: a pilot study[J]. Nutrients, 2022, 14(4): 816. DOI: 10.3390/nu14040816.

[22] CAMPBELL W W, KRAUS W E, POWELL K E, et al. High-intensity interval training for cardiometabolic disease prevention[J]. Med Sci Sports Exerc, 2019, 51(6): 1220-1226. DOI: 10.1249/MSS.0000000000001934.

[23] SHEEN F, HARDMAN C A, ROBINSON E. Plate-clearing tendencies and portion size are independently associated with main meal food intake in women: a laboratory study[J]. Appetite, 2018, 127: 223-229. DOI: 10.1016/j.appet.2018.04.020.

[24] ROBINSON E, MCFARLAND-LESSER I, PATEL Z, et al. Downsizing food: a systematic review and meta-analysis examining the effect of reducing served food portion sizes on daily energy intake and body weight[J]. Br J Nutr, 2023, 129(5): 888-903. DOI: 10.1017/S0007114522000903.

[25] JENSEN M D, RYAN D H, APOVIAN C M, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society[J]. Circulation, 2014, 129(25 Suppl 2): S102-S138. DOI: 10.1161/01.cir.0000437739.71477.ee.

[26] SILVERII G A, CRESCI B, BENVENUTI F, et al. Effectiveness of intermittent fasting for weight loss in individuals with obesity: a meta-analysis of randomized controlled trials[J]. Nutr Metab Cardiovasc Dis, 2023, 33(8): 1481-1489. DOI: 10.1016/j.numecd.2023.05.005.

[27] PATIKORN C, SAIDOUNG P, PHAM T, et al. Effects of ketogenic diet on health outcomes: an umbrella review of meta-analyses of randomized clinical trials[J]. BMC Med, 2023, 21(1): 196. DOI: 10.1186/s12916-023-02874-y.

[28] SCHUBERT M M, SABAPATHY S, LEVERITT M, et al. Acute exercise and hormones related to appetite regulation: a meta-analysis[J]. Sports Med, 2014, 44(3): 387-403. DOI: 10.1007/s40279-013-0120-3.

[30] STUBBS R J, SEPP A, HUGHES D A, et al. The effect of graded levels of exercise on energy intake and balance in free-living men, consuming their normal diet[J]. Eur J Clin Nutr, 2002, 56(2): 129-140. DOI: 10.1038/sj.ejcn.1601295.

[31] BEAULIEU K, BLUNDELL J E, VAN BAAK M A, et al. Effect of exercise training interventions on energy intake and appetite control in adults with overweight or obesity: a systematic review and meta-analysis[J]. Obes Rev, 2021, 22(Suppl 4): e13251. DOI: 10.1111/obr.13251.

[32] WANG Y F, BEYDOUN M A, MIN J, et al. Has the prevalence of overweight, obesity and central obesity levelled off in the United States? Trends, patterns, disparities, and future projections for the obesity epidemic[J]. Int J Epidemiol, 2020, 49(3): 810-823. DOI: 10.1093/ije/dyz273.

(Received: May 21, 2025; Revised: June 27, 2025)
(This article was edited by ZOU Lin)

Note: Figure translations are in progress. See original paper for figures.