Open Access Full Text Article

CLINICAL TRIAL REPORT

Effect of Acupoint Catgut Embedding on Subjective Appetite in Overweight and Obese Adults with Strong and Moderate Appetite: A Secondary Analysis of a Randomized Clinical Trial

Xin Tang[1,2,*], Gaoyangzi Huang[1,2,*], Qifu Li[1,2], Siwen Zhao[1,2], Ruqin Yang[1,2], Hongyang Wang[1,2], Yuanzheng Deng[1,2], Zili Liu[2], Taipin Guo[1,2], Fanrong Liang[3]

[1]Yunnan Key Laboratory of Integrated Traditional Chinese and Western Medicine for Chronic Disease in Prevention and Treatment, Yunnan University of Chinese Medicine, Kunming, People's Republic of China; [2]School of Second Clinical Medicine/The Second Affiliated Hospital, Yunnan University of Chinese Medicine, Kunming, People's Republic of China; [3]School of Acupuncture and Tuina, Chengdu University of Traditional Chinese Medicine, Chengdu, People's Republic of China

*These authors contributed equally to this work

Correspondence: Taipin Guo, School of Second Clinical Medicine/The Second Affiliated Hospital, Yunnan University of Chinese Medicine, 1076 Yuhua Road, Chenggong District, Kunming City, Yunnan Province, People's Republic of China, Email gtphncs@126.com; Fanrong Liang, School of Acupuncture and Tuina, Chengdu University of Traditional Chinese Medicine, 37 Jinniu District, Chengdu City, Sichuan Province, People's Republic of China, Email acuresearch@126.com

Background: Appetite plays a crucial role in obesity and weight loss outcomes. while conventional therapies reduce appetite, They often have limitations. Acupoint Catgut Embedding (ACE) is widely used for weight loss, but its impact on subjective appetite, especially across different appetite status, remains underexplored.

Objective: To evaluate the differential impact of ACE on the subjective appetite of overweight and obese adults with strong and moderate appetites.

Methods: This secondary analysis used data from a multicenter, double-blind, parallel randomized clinical trial of the ACE intervention. A total of 122 overweight and obese patients aged 18–60 were randomly assigned to the ACE and Non-acupoint Catgut Embedding (NACE) groups, each receiving six sessions over 12 weeks and a 4-week follow-up. Appetite was measured using the Visual Analogue Scale (VAS), and a generalized linear mixed-effects model assessed changes in appetite scores. Bonferroni corrections were applied for multiple comparisons ($P < 0.05$).

Results: Participants with strong appetite in the ACE group showed a significant reduction in appetite VAS score from 7.78 (0.66) at baseline to 5.00 (0.72) at 16 weeks ($P < 0.05$), compared to a reduction from 7.97 (0.93) to 6.54 (1.17) in the NACE group. The adjusted relative rate ratio between the two groups was 0.411 (95% CI, 0.210 to 0.534; $P < 0.05$). In participants with moderate appetite, no significant difference was observed between the two groups ($P > 0.05$). The significant baseline difference in appetite scores between participants with strong and moderate appetite ($P < 0.05$) became non-significant by week 16 ($P > 0.05$).

Conclusion: This study reveals the stratified effect of ACE on appetite, with greater reduction in those with strong appetite and no significant change in those with moderate appetite. This suggests ACE reduces appetite effectively without excessive suppression, supporting its potential as a sustainable obesity management strategy.

Keywords: acupoint catgut embedding, appetite, overweight, obesity, randomized controlled trial

Introduction

Obesity typically results from an energy imbalance caused by excessive caloric intake.[1] Appetite is the body's response to the need for nutrients and energy, directly influencing eating behavior.[2] Differences in appetite between lean and obese individuals extend beyond satiety; obese individuals exhibit a heightened sensitivity to food stimuli and derive more

Received: 20 July 2024
Accepted: 19 November 2024
Published: 29 November 2024

pleasure from eating.[3,4] Previous study has shown that more than 70% of obese or overweight people have factors that increase eating abnormally, and some of them have special ingestion behaviors such as overeating and involuntary eating.[5]

Despite the adverse health effects of increased appetite on overweight and obese individuals, effective treatment options are limited. Current weight loss strategies, including dietary control, pharmacotherapy, and bariatric surgery, have shown some effectiveness in reducing appetite.[6] However, dietary control requires long-term adherence, which is often challenging for patients;[7] pharmacotherapy can lead to many side effects, including nausea, insomnia, and headaches;[8] and bariatric surgery, while effective, is constrained by high safety requirements, high costs, strict indications, and postoperative complications.[9] These limitations have prompted the search for alternative therapeutic approaches.

Currently, various alternative therapies, such as mindfulness-based interventions, behavioral therapies, and acupuncture, are widely used for weight management.[6,10,11] Mindfulness-based interventions and behavioral therapies promote self-regulation by modulating cognitive and emotional aspects of eating behavior.[12,13] However, their effectiveness heavily relies on patient motivation and consistent professional guidance, which limits their practical applicability.[14,15] In contrast, acupuncture offers a low-effort intervention by stimulating specific acupoints associated with hunger and satiety, helping regulate appetite through physiological mechanisms rather than conscious cognitive control.[16] However, acupuncture typically requires frequent treatments over several months, which can be challenging for patient adherence.[17]

Acupoint Catgut Embedding (ACE) is an innovative acupuncture technique that combines traditional acupuncture principles with modern materials.[18] It embeds absorbable catgut into acupoints, where catgut undergoes softening, liquefaction, and absorption, providing prolonged stimulation.[19] Compared with traditional acupuncture, ACE offers stronger and longer-lasting stimulation, requiring fewer sessions and reducing the discomfort from repeated needling. These advantages address the limitations of traditional acupuncture and improve patient compliance.[20] Recent clinical studies have demonstrated ACE's potential in obesity management.[21–23] A network meta-analysis of 35 clinical trials involving 3040 obese patients found that ACE outperformed manual acupuncture, electroacupuncture, and exercise diet therapy in reducing body mass index (BMI), improving waist-to-hip ratio, and promoting weight loss.[24] Despite these promising findings, research on the impact of ACE on subjective appetite remains underexplored. To address this gap, we conducted a preliminary study to quantify and compare the effects of ACE on the subjective appetite of patients with different appetite levels. We tested the hypothesis that the effectiveness of ACE does not differ between adults reporting strong and moderate appetite at baseline.

Methods

Study Design and Setting

This study is a secondary analysis of appetite data from a multicenter, double-blind, parallel randomized clinical trial.[25] The trial aimed to examine the effect of ACE intervention on the subjective appetite of overweight and obese adults with strong and moderate appetites. The trial was registered with the Chinese Clinical Trial Registry (ChiCTR1800016947) and approved by the Ethics Committee of Yunnan Sports Trauma Specialist Hospital (2018CK-001). All participants provided written informed consent. The study adhered to the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines (Supplementary Material 1).

Study Population

The study was conducted from July 2018 to March 2020 at four hospitals in China: the Second Affiliated Hospital of Yunnan University of Chinese Medicine, Kunming Traditional Chinese Medicine Hospital, Yunnan Sports Trauma Specialist Hospital, and Sheng'ai Traditional Chinese Medicine Hospital. Eligibility criteria included: (1) meeting the diagnosis of overweight and obesity, BMI $\geq$ 24 kg/m^2;[26] (2) age between 18–60 years; (3) signing informed consent. Exclusion criteria included: (1) secondary obesity caused by medication or endocrine diseases; (2) light appetite (Appetite Visual Analogue Scale (VAS) at baseline < 4 points); (3) chronic obstructive pulmonary disease, coronary heart disease, liver cirrhosis, nephritis, and other severe organ diseases; (4) severe mental and neurological disorders; (5) allergies to alcohol or catgut; (6) pregnancy, breastfeeding, and childbirth within the past six months; (7) receiving weight loss treatment within the past three months.

Randomization and Blinding

The randomization was computer generated by the Clinical Research Center of Yunnan University of Chinese Medicine. Stratified randomization was performed in the 4 clinical centers. Opaque envelopes with a random number were managed by an independent coordinator. Participants and inspectors were all blinded to the allocation. The acupuncturist performed the catgut embedding after the assistant laid the drapes. Therefore, the acupuncturists were also blinded to the allocation.

Sample Size

The sample size was calculated using G*Power software (version 3.1)[27] based on findings from prior studies,[28] which reported a mean BMI reduction of 1.32 kg/m² in the intervention group and 1.02 kg/m² in the control group, with a standard deviation (SD) of 0.31 kg/m². Accounting for differences in study design, we anticipated a slightly lower BMI reduction of 1.14 kg/m² in the ACE group and 0.9 kg/m² in the NACE group, both with an SD of 0.31 kg/m². Using a two-tailed test, we set the significance level at $\alpha = 0.05$ and statistical power at $1-\beta = 0.95$. The minimum required sample size was calculated as 84 participants (42 per group). Considering the 8% dropout rate, the sample size was adjusted to 92 participants with 46 participants in each group. A total of 137 participants were initially recruited; however, 14 participants were excluded due to recruitment errors. Additionally, one participant with light appetite (outside the scope of this secondary analysis focusing on participants with moderate and strong appetite levels) was excluded. The final sample size was 122, comprising 59 participants in the ACE group and 63 in the NACE group.

Interventions

Before treatment, participants in both groups were placed in a comfortable supine position. For the ACE group, true acupoints were selected based on previous research and classical Traditional Chinese Medicine theory, including Zhongwan (CV12), Tianshu (ST25), Zhangmen (LR13), Pishu (BL20), Weishu (BL21), and Dachangshu (BL25). Standardized techniques for location were used.[29] To ensure rigorous trial design, a sham procedure that mimicked the actual treatment but was inactive was employed. Although standardized protocols for placebo control in acupoint embedding trials are lacking, it is recommended to use non-active points as controls. For this study, non-acupoints located near the true acupoints but outside recognized meridian lines were selected and labeled as NA1–NA6 (see Figure 1 and Table 1). Previous research has shown that non-acupoints do not elicit specific therapeutic effects, making them effective inert controls.[30] Moreover, brain imaging research indicates that stimulation of non-acupoints does not activate the same brain regions as true acupoints, further validating their use as a reliable placebo control.[31]

Assistants marked the locations of acupoints and non-acupoints and performed routine disinfection of the surgical area before placing a sterile drape. A 1–2 cm sterile medical catheter (length depending on the location of the acupoint) was positioned at the end of a trocar, connected to a stylet. The skin was raised slightly with the thumb and index finger of one hand while the other hand performed the puncture. When the required depth was reached, the catgut was implanted into the subcutaneous tissue or muscle layer. After removing the needle, a dry cotton ball was pressed on the puncture site for half a minute to stop bleeding, followed by bandaging to protect the site. Participants were instructed

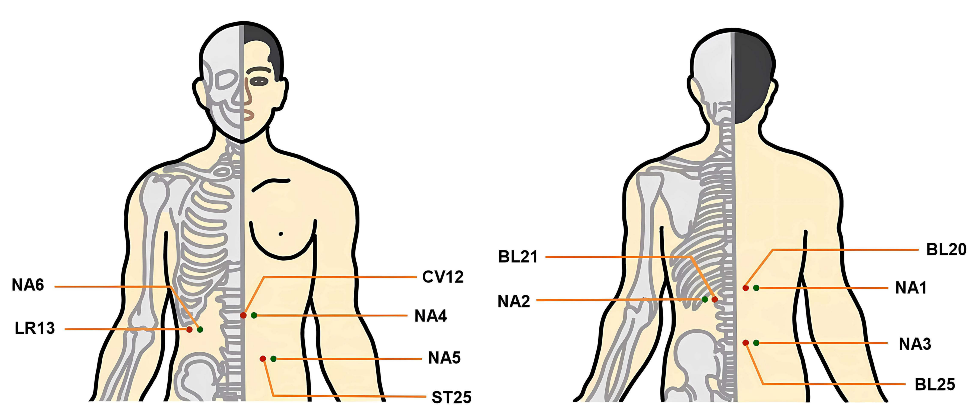

Figure 1 The location of acupoints.

Table 1 Location of the Points and the Details Operation of Catgut Embedding

	Acupoints	Location	Operation
ACE Group	Pishu (BL20)	In the upper back region, at the same level of inferior border of the 11th thoracic spine (T11), 1.5 cun lateral to the posterior median line	Slightly oblique needling in the medial direction of the spine to the depth of 0.5–1 cun
	Weishu (BL21)	In the upper back region, at the same level of inferior border of the 12th thoracic spine (T12), 1.5 cun lateral to the posterior median line	
	Dachangshu (BL25)	In the lumbar region, at the same level thoracic spine 4th lumbar spine (L4), 1.5 cun lateral to the posterior median line	
	Zhongwan (CV12)	On the upper abdomen, 4 cun superior to the navel, on the anterior median line	Pinch and lift the skin slightly with the thumb and index finger. Needling at 90 degrees to the depth of 1–1.5 cun
	Tianshu (ST25)	On the left and right abdomen, 2 cun lateral to the navel	
	Zhangmen (LR13)	On the lateral abdomen, inferior to the free extremity of the 11th rib	Pinch and lift the skin slightly with the thumb and index finger. Needling at 15 degrees to the depth of 1 cun
NACE Group	NA1	2 cun outward from the Pishu (BL20)	Pinch and lift the skin slightly with the thumb and index finger. Needling at 45 degrees downward to a depth of 0.5–1 cun
	NA2	2 cun outward from the Weishu (BL21)	
	NA3	2 cun outward from the Dachangshu (BL25)	
	NA4	1.5 cun to the left of the Zhongwan (CV12)	Pinch and lift the skin slightly with the thumb and index finger. Needling at 90 degrees to a depth of 1–1.5 cun
	NA5	1 cun outward from the Tianshu (ST25)	
	NA6	2 cun forward from the Zhangmen (LR13)	Pinch and lift the skin slightly with the thumb and index finger. Needling at 15 degrees to the depth of 1 cun

not to bathe for 24 hours and to keep the embedding area dry. Participants' diet and physical activity were not restricted during treatment and follow-up, and they could continue their usual lifestyle.

The embedding needle used was a No. 8 disposable needle (Jiangxi Glance Medical Equipment Co. Ltd. Production, Nanchang, China). The medical catgut was an absorbable collagen thread, specification 2–0, 2cm*20 (Jiangxi Longteng Biotechnology Co., Ltd., Nanchang, China).

ACE was performed by certified acupuncturists designated at each site, including SWZ, QFL, and six other acupuncturists. The study acupuncturists met national licensing requirements, held medical practitioner certificates, and had a minimum of three years of clinical acupuncture experience. They received standardized training before the commencement of the study.

Outcome

Outcome measurements were performed at baseline, 6 and 12 weeks in the intervention period, and 16 weeks in the follow-up phase. Patients were required to undergo measurements at 8 AM after fasting for 12 hours before each measurement. Appetite was measured using a VAS ranging from 0–10 mm, with higher scores indicating stronger appetite. The VAS is a well-established tool for assessing subjective appetite, widely recognized for its validity, reliability, and reproducibility.[32] In this study, baseline strong appetite was defined as a baseline appetite score of 7–10, and baseline moderate appetite was defined as a baseline appetite score of 4–6. The appetite VAS scale is shown in Figure 2.

Statistical Analysis

Differential intervention effects over time were tested for adults categorized into moderate and strong appetite groups at baseline, using an intention-to-treat principle. Under the assumption of data missing at random, we analyzed the full dataset using mean imputation for missing values. Changes in appetite scores were analyzed using generalized linear mixed-effects models (GLMM) with a Gamma distribution and log link function, appropriate for non-normal outcome data. This model accounts for repeated measurements within individuals by including random intercepts for participants to control for intra-individual variability over time. The following model was used:

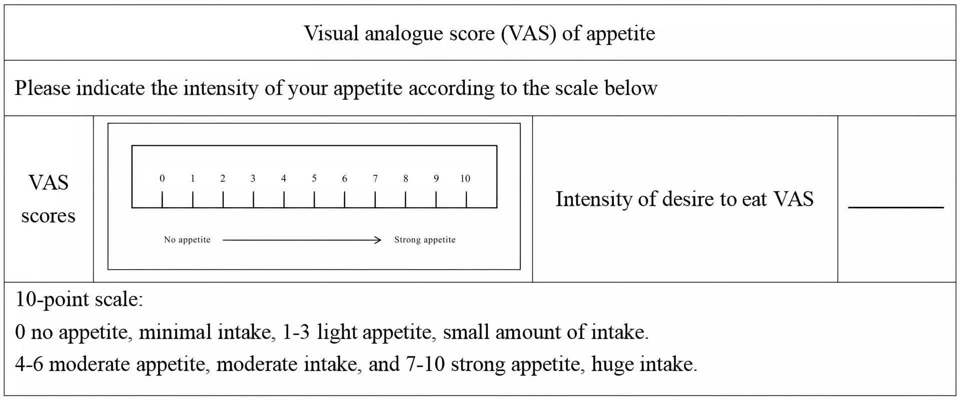

Figure 2 The scale of VAS of appetite.

$$\log(VAS_{it}) = \beta_0 + \beta_1 \cdot \text{Group}_i + \beta_2 \cdot \text{Time}_t + \beta_3 \cdot \text{Appetite Status}_i + \beta_4 \cdot (\text{Group}_i \times \text{Time}_t \times \text{Appetite Status}_i) + \gamma_1 \cdot \text{Age}_i + \gamma_2 \cdot \text{Gender}_i + \gamma_3 \cdot \text{BMI}_i + b_i + \in_{it}$$

(VAS_{it}: VAS score for participant i at time t. β_0: Intercept (overall baseline value), β_1, β_2, β_3: Fixed effects of group, time, and appetite status. $\beta_4 \times(\text{Group}_i \times \text{Time}_t \times \text{Appetite Status}_i)$: Interaction effect of group, time, and appetite status. γ_1, γ_2, γ_3: Covariate effects of age, gender, and BMI. b_i: Random intercept for participant i, accounting for individual variability. $\in_{it}$: Residual error for participant i at time t).

Group, time, and appetite status were included as fixed effects to assess their influence on intervention outcomes. Additionally, age, gender and BMI were included as covariates to control for potential confounding factors, ensuring the robustness of the model. Although age, gender and BMI did not show statistically significant effects, their inclusion helped mitigate the risk of biased estimates. To assess differential intervention effects over time, we incorporated an interaction term for time × group × appetite status. Post-hoc pairwise comparisons with Bonferroni corrections were applied to identify significant differences between the ACE and NACE groups at each time point. Statistical significance was set at $P < 0.05$ (two-tailed). All data analyses were performed using SPSS version 28.0 (IBM Corp., Chicago, IL, USA).

Results

Participants and Baseline Characteristics

A total of 186 participants entered the baseline period, and 137 participants were randomized, aged 18 to 65 years. A total of 122 participants (one participant was excluded due to a baseline appetite score of less than 4) were included in the ITT population (Figure 3). The mean (SD) age of participants was 36.11 (9.60) years, and 99 participants (81.1%) were female. 59 participants (48.4%) were randomly assigned to the ACE group, while 63 participants (51.6%) were assigned to the Non-acupoint Catgut Embedding (NACE) group. There were no differences in demographic characteristics between the two groups, as shown in Table 2. During the 12-week treatment and 4-week follow-up, 118 participants (96.72%) had complete appetite data.

Appetite Outcome

Figure 4 and Table 3 depict the effects of the intervention on the outcome using interaction plots with marginal estimated values. In participants who reported strong appetite at baseline, the ACE group observed a decrease in the mean appetite VAS score from 7.78 (0.66) at baseline to 5.00 (0.72) at 16 weeks. Meanwhile, the NACE group observed a decrease in the mean appetite VAS score from 7.97 (0.93) at baseline to 6.54 (1.17), as shown in Table 4. In participants who reported moderate appetite at baseline, the ACE group observed a decrease in the mean appetite score from 5.70 (0.61) to 4.5 (0.81), while the NACE group observed a decrease from 5.56 (0.57) to 5.23 (0.99).

Among participants with a strong appetite at baseline, a significant interaction between time and intervention was observed, with a 54.5% reduction in appetite scores at 12 weeks and a 58.9% reduction at 16 weeks in the ACE group compared to the NACE group (adjusted relative rate ratios [ARRR], 0.455 [95% CI, 0.293 to 0.707] at 12 weeks; 0.411 [95%

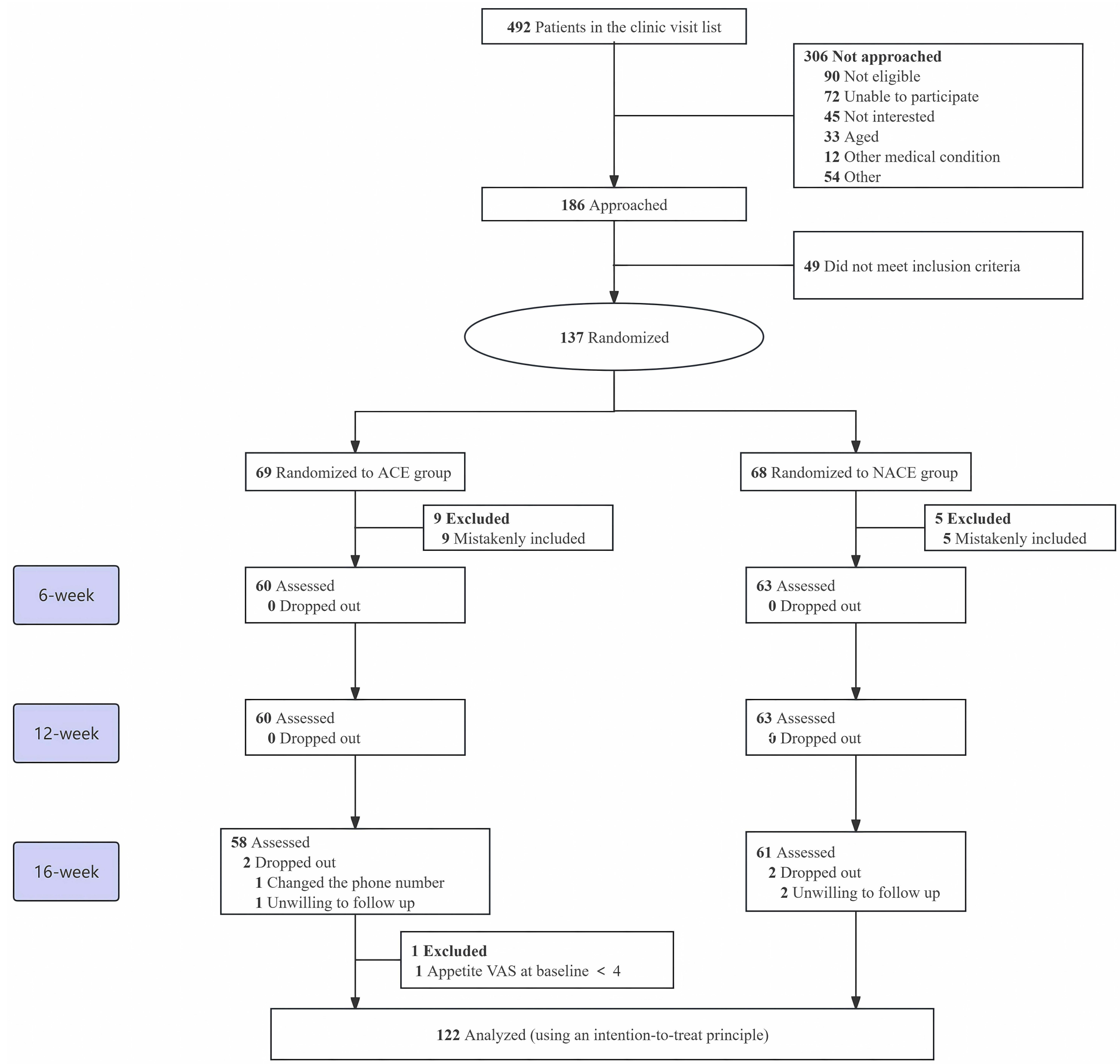

Figure 3 Study flow diagram.

CI, 0.210 to 0.534] at 16 weeks; both $P < 0.05$), as shown in Table 3. In contrast, among those with moderate appetite at baseline, no significant differences in appetite score changes were observed at either 12 or 16 weeks ($P > 0.05$). At 12 weeks, intervention effects differed significantly between participants with strong and moderate appetite (ARRR, 0.455 [95% CI, 0.293 to 0.707] vs 0.674 [95% CI, 0.408 to 1.115]; P for group interaction = 0.000). By 16 weeks, this interaction effect was no longer significant (ARRR, 0.411 [95% CI, 0.210 to 0.534] vs 0.608 [95% CI, 0.359 to 1.031]; P for group interaction = 0.114).

Table 5 presents the P values for differences in estimated marginal means (Standard Error [SE]) of appetite scores between participants with strong and moderate appetite statuses at each time point, separately within the ACE and NACE groups. In the ACE group, a significant difference in appetite scores was observed between participants with strong and moderate appetites at baseline ($P < 0.05$), but this difference was no longer significant by week 16 ($P > 0.05$). In the NACE group, appetite scores remained significantly different between participants with strong and moderate appetites at all time points ($P < 0.05$).

Table 2 Baseline Participant Characteristics

Characteristics	Overall, N = 122	ACE Group, N=59	NACE Group, N=63	*P* Value
Age at the Baseline, Mean (SD)	36.11 (9.60)	36.15 (10.16)	36.08 (9.12)	0.967
Gender, N (%)				0.385
Male	23 (81.1)	13 (22.0)	53 (84.1)	
Female	99 (18.9)	46 (78.0)	10 (15.9)	
BMI, Mean (SD)	28.63 (3.26)	28.69 (2.96)	28.59 (3.54)	0.867
Appetite VAS at baseline, N (%)				0.617
Moderate Appetite (4–6 points)	53 (43.4)	27 (45.8)	26 (41.3)	
Strong Appetite (7–10 points)	69 (56.6)	32 (54.2)	37 (58.7)	

Note: The data without cases which been incorrectly included.
Abbreviations: ACE, acupoint catgut embedding; NACE, non-acupoints catgut embedding; BMI, body mass index; VAS, visual analogue score.

Discussion

In this secondary analysis, we found that ACE intervention has a regulatory effect on subjective appetite in overweight and obese individuals, suggesting that this intervention can promote changes in appetite. This finding aligns with previous studies on acupuncture-based interventions, which reported reductions in appetite and improvements in weight management outcomes.[33–35] By stratifying participants according to baseline appetite levels, this study provides new insights into the differential effects of ACE that may not have been captured by studies focusing solely on mean outcomes. Specifically, obese and overweight adults with strong baseline appetite in the ACE group showed a sustained reduction in subjective appetite scores, while those with moderate appetite did not exhibit significant changes. By week 16, the significant differences in baseline appetite scores became non-significant, possibly due to ACE intervention balancing appetite without excessively suppressing it.

Our findings suggest that ACE has potential as an alternative approach for appetite regulation. Beyond weight management, ACE may also be beneficial for treating appetite-related disorders such as binge eating disorder and metabolic syndrome.[36,37] In addition, a key advantage of ACE is its ability to adaptively modulate appetite, enhancing satiety without completely suppressing hunger. This balanced regulation promotes healthy eating behaviors, which are essential for long-term weight control, and reduces the risk of compensatory behaviors, such as binge eating, which could undermine weight loss efforts.[38,39]

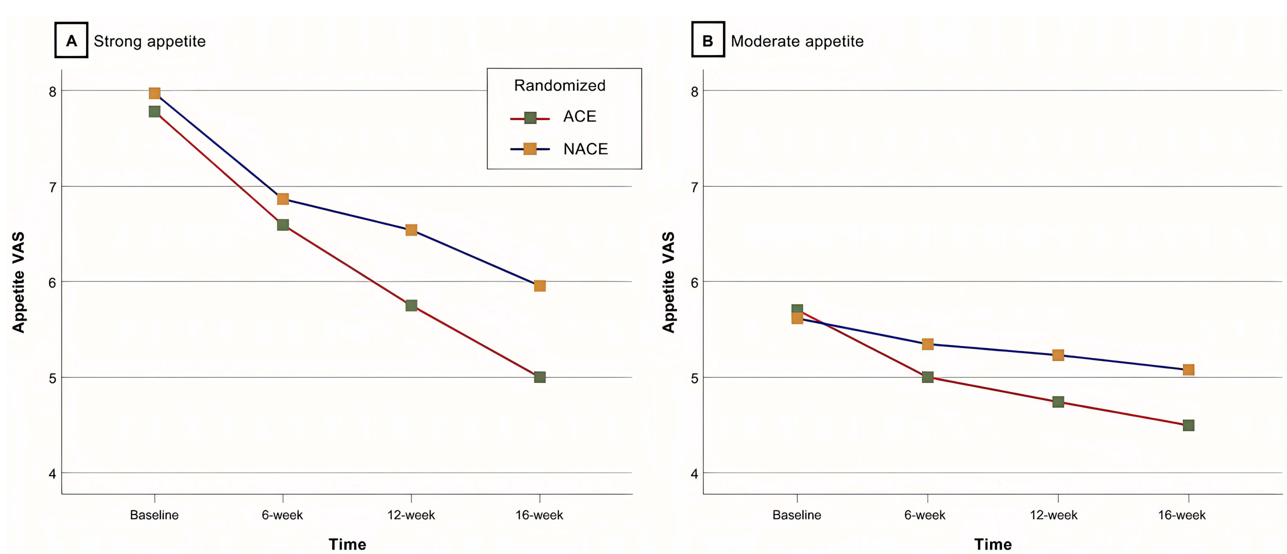

Figure 4 Intervention effects on appetite VAS score at different time points stratified by appetite VAS score at baseline. (**A**) Strong appetite: Appetite VAS scores decreased from baseline to 16 weeks in both groups, with a sharper decline in the ACE group (red line) compared with the NACE group (blue line). (**B**) Moderate appetite: Appetite VAS scores also decreased, though less steeply compared with strong appetite. The ACE group again showed a greater reduction compared with the NACE group.

Table 3 Intervention Effects Stratified by Appetite VAS at Baseline

Outcome (Time × Intervention)	Intervention Effects (N=122)[a]		*P* value for Group Interaction[b]
	ARRR (95% CI)	*P* value	
Appetite score at 6 weeks			
Strong Appetite Moderate Appetite	0.787 (0.537, 1.155) 0.751 (0.482, 1.160)	0.225 0.201	0.000
Appetite score at 12 weeks			
Strong Appetite Moderate Appetite	0.455 (0.293, 0.707) 0.674 (0.408, 1.115)	0.001 0.124	0.000
Appetite score at 16 weeks			
Strong Appetite Moderate Appetite	0.411 (0.210, 0.534) 0.608 (0.359, 1.031)	0.000 0.065	0.114

Note: [a] The intervention effect compares the difference in changes in appetite scores at different time points, and all models include the interaction between the intervention and strong versus moderate appetite, adjusted for baseline demographic characteristics, including age, gender, and BMI. [b] Strong appetite vs moderate appetite.
Abbreviation: ARRR, adjusted relative rate ratio.

Table 4 Observed Outcomes at All Assessment Occasions

Group	Characteristic	Baseline		6-week		12-week		16-week	
		ACE	NACE	ACE	NACE	ACE	NACE	ACE	NACE
		n=59	N=63	n=59	N=63	n=59	N=63	n=59	N=63
Strong Appetite (n=69)[a]	Appetite VAS								
	Mean (SD)	7.78 (0.66)	7.97 (0.93)	6.59 (0.88)	6.86 (1.06)	5.75 (1.08)	5.96 (1.12)	5.00 (0.72)	6.54 (1.17)
	(Missing)	0	0	0	0	0	0	2	0
Moderate Appetite (n=53)[a]	Appetite VAS								
	Mean (SD)	5.70 (0.61)	5.56 (0.57)	5.00 (0.73)	5.35 (0.75)	4.74 (0.76)	5.08 (0.89)	4.5 (0.81)	5.23 (0.99)
	(Missing)	0	0	0	0	0	0	0	2

Note: [a] Moderate appetite is defined as a baseline appetite score of 4–6, and strong appetite is defined as a baseline appetite score of 7–10.
Abbreviations: ACE, acupoint catgut embedding; NACE, non-acupoints catgut embedding; BMI, body mass index; VAS, visual analogue score.

Table 5 Appetite Score Comparison Between Strong and Moderate Appetite Status at Each Time Point

Time Point	Appetite Status	ACE Group		NACE Group	
		Estimated Marginal Mean (SE)[a]	P-value for Group Difference[b]	Estimated Marginal Mean (SE)[a]	P-value for Group Difference[b]
Baseline	Strong Appetite	7.81 (0.17)	0.000	7.97 (0.26)	0.000
	Moderate Appetite	5.72 (0.14)		5.61 (0.22)	
6-week	Strong Appetite	6.58 (0.15)	0.000	6.82 (0.17)	0.000
	Moderate Appetite	5.00 (0.13)		5.35 (0.16)	
12-week	Strong Appetite	5.72 (0.17)	0.000	6.48 (0.18)	0.000
	Moderate Appetite	4.74 (0.15)		5.20 (0.17)	
16-week	Strong Appetite	4.91 (0.13)	0.101	5.92 (0.18)	0.001
	Moderate Appetite	4.60 (0.13)		5.07 (0.18)	

Notes: [a] Estimated Marginal Mean (SE) represents the estimated marginal means and standard errors of appetite scores for participants with strong and moderate appetite status at each time point, based on the generalized linear mixed model. [b] P-value for group difference indicates the statistical significance of the difference between strong and moderate appetite status within each group (ACE or NACE) at each respective time point.
Abbreviations: ACE, acupoint catgut embedding; NACE, non-acupoints catgut embedding.

The mechanism by which ACE regulates appetite remains unclear. As an evolved form of acupuncture, ACE is based on the efficacy of acupoints and shares similar mechanisms with acupuncture.[18] Prior studies have shown that acupuncture activates vagal afferents, which enhance satiety perception and regulate appetite.[40] This vagal activation allows for timely detection of gastric distension and changes in gut hormone levels, transmitting satiety signals to the central nervous system. Subsequently, this triggers the release of anorexigenic peptides, such as pro-opiomelanocortin (POMC), to terminate feeding behavior.[41,42] Prolonged excessive energy intake in individuals with obesity can impair these mechanisms, reducing vagal excitability and increasing the expression of orexigenic peptides such as neuropeptide Y (NPY), leading to disrupted appetite control and energy imbalance.[43] By activating the vagus nerve, acupuncture may help restore the balance between anorexigenic and orexigenic signals, thereby improving appetite control. Acupuncture has also been shown to regulate dopaminergic pathways from the ventral tegmental area (VTA) to the nucleus accumbens, and serotonergic pathways from the dorsal raphe nucleus to the VTA.[44] These pathways are essential components of the reward system, which plays a key role in regulating food intake.[45] In individuals with obesity, these pathways are often disrupted, resulting in heightened sensitivity to food-related pleasure, excessive eating, and compulsive eating behaviors.[46] By modulating these pathways, acupuncture may help reduce the reward-driven urge to overeat and restore normal appetite control. With embedded sutures providing prolonged acupoint stimulation, ACE may enhance these regulatory effects, resulting in more stable appetite control over time. These potential mechanisms may help explain our findings, the sustained reductions in appetite observed among participants with strong baseline appetite following ACE intervention. In contrast, participants with moderate appetite showed no significant changes, suggesting that ACE helps balance appetite rather than simply suppress it. Future studies should further explore these pathways to better understand the mechanisms involved and enhance the clinical use of ACE for appetite management.

This study has several limitations. The small sample size and secondary nature of the analysis limit the generalizability of our findings. Additionally, the study focused only on participants with moderate and strong appetite, excluding those with light appetite. Future research should include a larger and more diverse sample to validate these findings and explore the impact of ACE across different appetite states. Longer follow-up periods are also necessary to assess the sustainability of ACE's effects. Furthermore, mechanistic studies are essential to better understand the pathways involved and inform strategies for effective clinical use of ACE.

Conclusion

In a secondary analysis of this randomized clinical trial, ACE significantly reduced appetite scores in overweight and obese individuals with high baseline appetite, while those with moderate appetite showed no significant change. These findings suggest that ACE effectively reduces appetite without over-suppressing it. This balanced regulation fosters healthy eating behaviors, making ACE a promising strategy for sustainable, long-term obesity management. However, further research is needed to validate these findings across more diverse populations and explore the long-term sustainability of ACE. Mechanistic studies are especially required to clarify the neural and metabolic pathways involved, thereby strengthening the theoretical basis for ACE as an effective approach to appetite management.

Data Sharing Statement

Data will be available upon request from the corresponding author.

Ethics and Consent Statements

This study was conducted in strict adherence to the Helsinki Declaration of Principles. The trial was registered with the Chinese Clinical Trial Registry (ChiCTR1800016947) and approved by the Ethics Committee of Yunnan Sports Trauma Specialist Hospital (2018CK-001). Informed consent was obtained from all patients to be included in the study.

Acknowledgments

We would like to express our sincere gratitude to the Yunnan Sports Trauma Specialist Hospital for providing supervision and support during the original data collection process, which laid the foundation for the reanalysis reported in this study.

Funding

This work was funded by the National Natural Science Foundation of China (82260964), the "Liang Fanrong Expert Workstation" of Yunnan Province-Yunnan Provincial Science and Technology Plan Project (202305AF150072), the Youth Special of Yunnan Province Ten-thousand Plan (YNWR-QNBJ-2019-257). The funding bodies do not play any role in the design of the study, collection, analysis, or writing manuscripts.

Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Han SJ, Lee SH. Nontraditional risk factors for obesity in modern society. *J Obesity Metab Syndrome*. 2021;30(2):93–103. doi:10.7570/jomes21004
2. Hall KD, Guo J. Obesity energetics: body weight regulation and the effects of diet composition. *Gastroenterology*. 2017;152(7):1718–1727.e3. doi:10.1053/j.gastro.2017.01.052
3. Dalton M, Hollingworth S, Blundell J, et al. Weak satiety responsiveness is a reliable trait associated with hedonic risk factors for overeating among women. *Nutrients*. 2015;7(9):7421–7436. doi:10.3390/nu7095345
4. Stice E, Spoor S, Bohon C, et al. Relation of reward from food intake and anticipated food intake to obesity: a functional magnetic resonance imaging study. *J Abnormal Psychol*. 2008;117(4):924–935. doi:10.1037/a0013600
5. Miranda-Olivos R, Agüera Z, Granero R, et al. The role of food addiction and lifetime substance use on eating disorder treatment outcomes. *Nutrients*. 2023;15(13):2919. doi:10.3390/nu15132919
6. Kheniser K, Saxon DR, Kashyap SR. Long-term weight loss strategies for obesity. *J Clin Endocrinol Metab*. 2021;106(7):1854–1866. doi:10.1210/clinem/dgab091
7. Mastellos N, Gunn LH, Felix LM, et al. Transtheoretical model stages of change for dietary and physical exercise modification in weight loss management for overweight and obese adults. *Cochrane Database Syst Rev*. 2014;2014(2):Cd008066. doi:10.1002/14651858.CD008066.pub3
8. Krentz AJ, Fujioka K, Hompesch M. Evolution of pharmacological obesity treatments: focus on adverse side-effect profiles. *Diab Obes Metab*. 2016;18(6):558–570. doi:10.1111/dom.12657
9. Arterburn DE, Telem DA, Kushner RF, et al. Benefits and risks of bariatric surgery in adults: a review. *JAMA*. 2020;324(9):879–887. doi:10.1001/jama.2020.12567
10. Lua PL, Roslim NA, Ahmad A, et al. Complementary and alternative therapies for weight loss: a narrative review. *J Evid Based Integr Med*. 2021;26:2515690x211043738. doi:10.1177/2515690x211043738
11. Dunn C, Haubenreiser M, Johnson M, et al. Mindfulness approaches and weight loss, weight maintenance, and weight regain. *Curr Obes Rep*. 2018;7:37–49. doi:10.1007/s13679-018-0299-6
12. Zergani MJ, Taghdisi MH, Seirafi M, et al. Mindfulness-based eating awareness training versus itself plus implementation intention model: a randomized clinical trial. *Eat Weight Disord*. 2024;29:53. doi:10.1007/s40519-024-01677-1
13. Wilfley DE, Kolko RP, Kass AE. Cognitive-behavioral therapy for weight management and eating disorders in children and adolescents. *Child Adolesc Psychiatr Clin N Am*. 2011;20:271–285. doi:10.1016/j.chc.2011.01.002
14. Sosa-Cordobés E, Ramos-Pichardo JD, Sánchez-Ramos JL, et al. How effective are mindfulness-based interventions for reducing stress and weight? A systematic review and meta-analysis. *Int J Environ Res Public Health*. 2022;20:20. doi:10.3390/ijerph20010446
15. Teixeira PJ, Marques MM. Health behavior change for obesity management. *Obes Facts*. 2017;10:666–673. doi:10.1159/000484933
16. Yang S, Zhou Y, Wang Y, et al. Mechanism of acupuncture intervention on obesity based on appetite regulation. *Acta Medicinae Universitatis Scientiae et Technologiae Huazhong*. 2021;50:544–547.
17. Zhang L, Zhang R. Issues and countermeasures of acupuncture for weight loss. *J Liaoning Univ of Tradit Chin Med*. 2009;11:136–137. doi:10.13194/j.jlunivtcm.2009.10.138.zhanglm.071
18. Jingtian X, Xiaobin G. Literature review in origin and development of catgut implantation therapy. *J Tradit Chin Med Lit*. 2016;34(06):19–22.
19. Kazemi AH, Adel-Mehraban MS, Jamali Dastjerdi M, et al. A comprehensive practical review of acupoint embedding as a semi-permanent acupuncture: a mini review. *Medicine*. 2024;103:e38314. doi:10.1097/md.0000000000038314
20. Jiali W, Lily L, Zhechao L, et al. Acupoint catgut embedding versus acupuncture for simple obesity: a systematic review and meta-analysis of randomized controlled trials. *J Tradit Chin Med*. 2022;42:839–847. doi:10.19852/j.cnki.jtcm.2022.06.001
21. Yan M, Zhu M, Quan F, et al. Subcutaneous acupoint catgut embedding for the treatment of abdominal obesity: a randomized controlled trial. *Zhongguo Zhen Jiu*. 2024:1–14. doi:10.13703/j.0255-2930.20240517-k0005.
22. Yuan J, Liu J, Ni J, et al. Different frequency of acupoint thread-embedding for overweight/obesity of spleen deficiency and dampness retention: a randomized controlled trial. *Zhongguo Zhen Jiu*. 2023;43:1229–1234. doi:10.13703/j.0255-2930.20230219-k0001
23. Yue JH, Li XL, Zhang YY, et al. Comparing verum and sham acupoint catgut embedding for adults with obesity: a systematic review and meta-analysis of randomized clinical trials. *Medicine*. 2024; 103:e36653. doi:10.1097/md.0000000000036653.
24. Wang ZY, Li XY, Gou XJ, et al. Network meta-analysis of acupoint catgut embedding in treatment of simple obesity. *Evid Based Complement Alternat Med*. 2022;2022:6408073. doi:10.1155/2022/6408073
25. Xinghe Z, Qifu LI, Rong YI, et al. Effect of catgut embedding at acupoints versus non-acupoints in abdominal obesity: a randomized clinical trial. *J tradit Chin med*. 2023;43(4):780–786. doi:10.19852/j.cnki.jtcm.20230608.002
26. Chen C, Lu FC. The guidelines for prevention and control of overweight and obesity in Chinese adults. *Biomed Environ Sci*. 2004;17 Suppl:1–36.
27. Faul F, Erdfelder E, Buchner A, et al. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav Res Methods*. 2009;41:1149–1160. doi:10.3758/brm.41.4.1149

28. Abdi H, Zhao B, Darbandi M, et al. The effects of body acupuncture on obesity: anthropometric parameters, lipid profile, and inflammatory and immunologic markers. *Sci World J*. 2012;2012:603539. doi:10.1100/2012/603539
29. Pacific WROft W. *WHO standard acupuncture point locations in the western pacific region*. Manila:World Health Organization; 2008.
30. Choi EM, Jiang F, Longhurst JC. Point specificity in acupuncture. *Chin Med*. 2012;7:4. doi:10.1186/1749-8546-7-4
31. Campbell A. Point specificity of acupuncture in the light of recent clinical and imaging studies. *Acupunct Med*. 2006;24:118–122. doi:10.1136/aim.24.3.118
32. Flint A, Raben A, Blundell JE, et al. Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *Int J Obes Relat Metab Disord*. 2000;24:38–48. doi:10.1038/sj.ijo.0801083
33. Tseng CC, Tseng A, Tseng J, et al. Effect of laser acupuncture on anthropometric measurements and appetite sensations in obese subjects. *Evid Based Complement Alternat Med*. 2016;2016:9365326. doi:10.1155/2016/9365326
34. Rerksuppaphol L. Efficacy of auricular acupressure combined with transcutaneous electrical acupoint stimulation for weight reduction in obese women. *J Med Assoc Thai*. 2012;95 Suppl 12:S32–39.
35. Yao H, Chen JX, Zhang ZQ, et al. Effect of acupuncture therapy on appetite of obesity patients. *Zhen Ci Yan Jiu*. 2012;37:497–501.
36. Yang X, He B, Sun S, et al. Clinical effect of acupoint thread-embedding therapy at different intervalsin the intervention of metabolic syndrome. *Zhen Ci Yan Jiu*. 2020;45:62–65+73. doi:10.13702/j.1000-0607.180681
37. Li H, Ruan Z, Zhang C. Clinical experience of yunzhong tiaoshen method of catgut lmplantationat acupoint for treatment of binge eating disorder. *Chin J Ethnomed Ethnopharm*. 2023;32:57–60.
38. Yuan TY, Bouzari N, Bains A, et al. Weight-control compensatory behaviors patterns and correlates: a scoping review. *Frontiers in Psychology*. 2024;15. doi:10.3389/fpsyg.2024.1383662
39. Stice E, Rohde P, Shaw H, et al. Weight suppression increases odds for future onset of anorexia nervosa, bulimia nervosa, and purging disorder, but not binge eating disorder. *Am J Clin Nutr*. 2020;112:941–947. doi:10.1093/ajcn/nqaa146
40. Wang MN, Zhai MX, Wang YT, et al. Mechanism of acupuncture in treating obesity: advances and prospects. *Am J Chin Med*. 2024;52:1–33. doi:10.1142/s0192415x24500010
41. Harvey T, Rios M. The role of BDNF and TrkB in the central control of energy and glucose balance: an update. *Biomolecules*. 2024;14(4):424. doi:10.3390/biom14040424
42. Page AJ, Li H. Meal-sensing signaling pathways in functional dyspepsia. *Front Systems Neurosci*. 2018;12:10. doi:10.3389/fnsys.2018.00010
43. Benite-Ribeiro SA, Putt DA, Soares-Filho MC, et al. The link between hypothalamic epigenetic modifications and long-term feeding control. *Appetite*. 2016;107:445–453. doi:10.1016/j.appet.2016.08.111
44. Yan L, Liang Z, Yanjing Z, et al. Effects of electroacupuncture on central dopaminergic neuron in morphine addicted rats. *Acad J Shanghai Univ of Tradit Chin Med*. 2017;31(06):86–90. doi:10.16306/j.1008-861x.2017.06.020
45. Barrett P, Mercer JG, Morgan PJ. Preclinical models for obesity research. *Dis Models Mech*. 2016;9(11):1245–1255. doi:10.1242/dmm.026443
46. Xiao Y, Liu D, Cline MA, et al. Chronic stress, epigenetics, and adipose tissue metabolism in the obese state. *Nutr Metab*. 2020;17(1):88. doi:10.1186/s12986-020-00513-4