Jundishapur J Nat Pharm Prod. 2026 May; 21(2): e170967 https://doi.org/10.5812/jjnpp-170967

Published Online: 2026 July 6 **Research Article**

The Effect of Propolis on Anthropometric Indices and Body Composition in Men with Asthenozoospermia: A Randomized Double-Blind Clinical Trial

Majid Karandish [1, 2], Alihossein Saberi [4], Mohammadreza Dadfar [3], Bizhan Helli [1], Reza Malihi [5, 6, *]

[1] Nutrition and Metabolic Diseases Research Center, Clinical Sciences Research Institute, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[2] Department of Nutrition, School of Allied Medical Sciences, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[3] Department of Urology, Imam Khomeini Hospital, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[4] Department of Medical Genetics, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[5] Nutrition and Metabolic Disease Research Center, Clinical Sciences Research Institute, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[6] Student Research Committee, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

[*] ***Corresponding Author:*** Nutrition and Metabolic Disease Research Center, Clinical Sciences Research Institute, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Email: malihire3@gmail.com

Received: 27 February, 2026; **Revised:** 16 June, 2026; **Accepted:** 17 June, 2026

Abstract

Background: Male infertility represents a significant clinical concern. Obesity adversely affects male fertility, largely through mechanisms related to oxidative stress. Propolis, a bioactive substance produced by bees, has antioxidant and anti-inflammatory properties and has been suggested to exert potential anti-adiposity effects.

Objectives: This study aimed to evaluate the effects of propolis supplementation on anthropometric indices and body composition in men with asthenozoospermia.

Methods: In this 12-week randomized, double-blind, placebo-controlled trial, 60 men diagnosed with asthenozoospermia were randomly allocated to receive either Iranian propolis (1500 mg/day) or a matched placebo. Anthropometric measures, including body weight and waist and hip circumferences, as well as body composition parameters, including fat mass (FM), fat-free mass (FFM), percentage body fat (PBF), and visceral fat area (VFA), were assessed at baseline and after 12 weeks. Assessments were conducted using a three-dimensional body-scanning system in conjunction with bioelectrical impedance analysis.

Results: Twelve weeks of propolis supplementation did not result in significant changes in body weight, body mass index (BMI), or waist-to-hip ratio. However, after adjustment for multiple comparisons, significant improvements in body composition were observed compared with the placebo group. In both per-protocol and intention-to-treat analyses, participants receiving propolis showed a significant increase in FFM and significant reductions in FM, PBF, and VFA (all Benjamini-Hochberg adjusted $P < 0.05$). No significant between-group difference was observed for basal metabolic rate.

Conclusions: Although propolis supplementation did not result in an overall reduction in body weight, it favorably modified body composition in men with asthenozoospermia by reducing adiposity, particularly visceral fat, and increasing lean body mass. These changes may mitigate a known risk factor for male reproductive dysfunction; however, confirmatory studies that assess direct fertility outcomes are warranted.

Keywords: Propolis, Asthenozoospermia, Male Infertility, Body Composition, Visceral Fat

1. Background

According to the World Health Organization, infertility is defined as the failure to achieve pregnancy after at least 1 year of unprotected intercourse. It represents a major medical and social challenge, affecting approximately 10 - 15% of couples worldwide and ranking as the third most serious health problem

How to Cite: Karandish M, Saberi A, Dadfar M, Helli B, Malihi R. The Effect of Propolis on Anthropometric Indices and Body Composition in Men with Asthenozoospermia: A Randomized Double-Blind Clinical Trial. Jundishapur J Nat Pharm Prod. 2026;21(2):e170967. doi: https://doi.org/10.5812/jjnpp-170967

after cardiovascular diseases and cancer (1). In nearly 40% of infertility cases, male-related factors are implicated, with spermatogenic failure being the most common underlying cause (2). One specific manifestation of this condition is asthenozoospermia, which is characterized by reduced sperm motility and accounts for approximately 19% of male infertility cases. This disorder may result from various etiological factors, including varicocele, inflammation, physical and chemical exposures, and endocrine abnormalities (3).

The rapidly increasing global prevalence of obesity is a substantial public health concern and is clearly inversely associated with declining male fertility rates (4). Accumulating evidence indicates that excessive adiposity adversely affects male reproductive function through several interrelated mechanisms, including oxidative stress, apoptosis induction, and disruption of energy metabolism within testicular tissue (5). These pathophysiological alterations collectively contribute to impaired spermatogenesis and reduced sperm quality (6). The parallel rise in obesity prevalence and decline in male fertility observed over recent decades underscores adiposity as a major independent risk factor for compromised reproductive capacity, in addition to its well-established systemic health consequences (7).

Propolis is a resinous, biologically active substance produced by honeybees through the collection of plant exudates, such as saps, resins, and bud secretions, which are subsequently combined with beeswax and endogenous enzymes, including β-glucosidase, from salivary secretions (8). Propolis contains a wide range of phenolic compounds, including catechin, quercetin, and chlorogenic acid, which have demonstrated considerable potential in body weight regulation through multiple biological pathways (9). These bioactive components may contribute to reduced adiposity by increasing energy expenditure, promoting the browning of white adipose tissue, and enhancing lipolytic activity (10). Furthermore, the anti-obesity effects of propolis are mediated through appetite regulation via satiety induction, stimulation of oxidative metabolism, and modulation of adipocyte differentiation and turnover (11). As a rich natural source of these polyphenolic compounds, propolis represents a promising therapeutic candidate for obesity management, particularly given the growing global interest in natural and complementary treatment strategies (12).

2. Objectives

Given the limited clinical evidence regarding the effects of propolis on anthropometric measures and body composition, and in response to recommendations for additional interventional studies, this trial was designed to evaluate the impact of propolis supplementation on these parameters in infertile men diagnosed with asthenozoospermia.

3. Methods

The study population comprised 60 infertile men diagnosed with asthenozoospermia who met the inclusion criteria, defined as total sperm motility below 40% and rapid progressive motility below 32% (13). This randomized, double-blind, placebo-controlled clinical trial was conducted between September 2024 and March 2025 at the Infertility Clinic of Imam Hospital, Ahvaz, Iran.

The exclusion criteria were as follows: allergy to honey and bee products; any known cause of infertility, such as hormonal disorders, obstruction of the epididymal duct, or epididymo-orchitis; substance abuse; alcohol consumption; diabetes mellitus; kidney disease, defined as creatinine levels exceeding twice the upper normal limit; chronic liver disease, defined as transaminase levels exceeding twice the upper normal limit; varicocele; and infectious diseases accompanied by fever and leukocytosis (14).

The study protocol was registered with the Iranian Registry of Clinical Trials (IRCT; registration number IRCT20231123060155N1) and received ethical approval from the Ethics Committee of Ahvaz Jondishapur University of Medical Sciences (ethics approval code: IR.AJUMS.REC.1402.426). The study was conducted in full compliance with the principles of the Declaration of Helsinki. Before participation, all individuals were informed about the study aims, anticipated benefits, and potential health risks, and written informed consent was obtained from all participants before enrollment.

Participants assigned to the propolis group (n = 30) received Iranian propolis at a dose of 500 mg 3 times daily after meals for 12 weeks, whereas participants in the placebo group (n = 30) received visually identical placebo capsules according to the same dosing regimen. The Iranian propolis capsules used in this study were provided by Shahdine Golha Co. (Isfahan, Iran), collected from beehives located in different parts of East Azerbaijan Province during the fall season, and verified by an agricultural organization (15, 16). The daily dose of 1500 mg was selected based on prior clinical trials demonstrating the safety and tolerability of propolis at 1000 - 1500 mg/day and to ensure adequate polyphenol

intake for potential metabolic effects (16). Total phenolic content was determined using the Folin-Ciocalteu method, and total flavonoids were measured using the aluminum chloride colorimetric assay with a spectrophotometer at the quality control laboratory of Shahdine Golha Co. Treatment adherence was evaluated by counting returned capsules, with consumption of more than 90% of the allocated supplements considered indicative of adequate compliance. Mean capsule-count adherence was 97.2% ± 2.5% in the propolis group and 96.8% ± 3.1% in the placebo group (P = 0.61).

For monitoring during the 12-week intervention, all participants were instructed to maintain their usual dietary and physical activity habits. Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ-SF) at baseline and week 12. Dietary intake was evaluated using three 24-hour dietary recalls at baseline and at the end of the study.

Anthropometric assessments were conducted at baseline and at study completion. Participants wore light clothing, were barefoot, and had emptied their bladder before assessment. All measurements were conducted in the morning after an overnight fast of at least 8 hours. In addition, participants were instructed to refrain from strenuous physical activity, alcohol consumption, and sauna use for 24 hours before measurement. Body weight and body composition were measured using a portable, multifrequency bioelectrical impedance analysis (BIA) device (Anea BIA Scale, Model BIA, Iran). Bioelectrical impedance analysis was used to quantify multiple body composition parameters, including intracellular water (ICW), extracellular water (ECW), total body water (TBW), protein mass, mineral mass, FFM, FM, PBF, VFA, and the extracellular-to-total body water ratio (ECW/TBW). During measurements, participants were instructed to remove all metallic objects and place both palms and the soles of their feet directly on the device electrodes, in accordance with the manufacturer's guidelines. In our laboratory, the test-retest reliability of the Anea BIA Scale was assessed in 15 healthy volunteers; the coefficients of variation for FM and VFA were 2.1% and 2.8%, respectively. Standing height was measured without shoes using a stadiometer with a precision of 0.5 cm.

Additional anthropometric indices, including waist circumference, hip circumference, and a Body Shape Index (ABSI), were obtained using a three-dimensional body analyzer (PT-3D FIT, Payatec, Iran) based on time-of-flight technology.

The sample size was determined based on the findings of Gholaminejad et al. (17), using sperm motility as the primary outcome variable. The calculation was performed using MedCalc Statistical Software version 19.6.4, with a power of 95% and a type I error of 5%, yielding 46 cases (23 individuals per group). To account for potential attrition during the study, 30% was added to the calculated sample size, resulting in 30 participants per group. Based on the observed effect sizes and standard deviations, post hoc power calculations indicated that the study had > 80% power ($\alpha = 0.05$) to detect the between-group differences observed for FM, PBF, and VFA.

Permutation block randomization was used in this study. For this two-group clinical trial, block sizes were randomly selected as 4, 6, or 8, ensuring equal allocation to each group within each block. Random sequences were generated using R software. To ensure allocation concealment, sequentially numbered, opaque, sealed envelopes containing the randomization assignment were used. This method prevented knowledge of the assigned group before participant enrollment, thereby minimizing selection bias.

Placebo and propolis capsules were identical in size, color, volume, and fill weight. Both supplements were packaged in identical containers and labeled only as Drug A and Drug B. The person responsible for packaging, who had no role in study implementation or data analysis, determined the coding, ensuring that the content of each code was unknown to all individuals involved in the trial. Throughout the study, the moderators, including the student, supervisors, and consultants, as well as the patients, remained completely unaware of which supplement each patient received.

Statistical analyses were conducted using SPSS software (version 22). Continuous variables are reported as mean ± standard deviation, whereas categorical variables are presented as frequencies and percentages. Data normality was evaluated using the Shapiro-Wilk test. Baseline comparisons between the intervention and control groups were performed using independent-samples t tests for normally distributed variables and the Mann-Whitney U test for variables with non-normal distributions. For each outcome, the final analysis of covariance (ANCOVA) model included only the baseline value of the outcome as a covariate. Age, BMI, and physical activity level (IPAQ-SF) were not included in the final models because they were well balanced between groups at baseline, and their inclusion did not materially alter the results in sensitivity analyses. Within-group changes from baseline to the end of the intervention were analyzed using paired-samples t tests for parametric data and the Wilcoxon signed-rank test

Table 1. Characteristics of the Trial Participants [a]

Variables	Intervention(N = 30)	Control(N = 30)	P-Value
Education level			0.150
Less than high school	8 (26.7)	7 (23.3)	
High school diploma	12 (40.0)	6 (20.0)	
Bachelor's degree or higher	10 (33.3)	17 (56.7)	
Job			0.141
Unemployed and self-employed	11 (36.7)	11 (36.7)	
Indoor/Office-based	8 (26.7)	14 (46.7)	
Outdoor/Field-based	11 (36.7)	5 (16.7)	
Smoke			0.308
Never smoke	22 (73.3)	24 (80.0)	
Current or ex-smoker	8 (26.7)	6 (20.0)	
Age	36.28 ± 5.54	34.51 ± 5.17	0.218
Infertility duration	5.36 ± 3.88	4.59 ± 2.82	0.393
Height	173.53 ± 6.41	175.00 ± 5.23	0.349
Weight	86.33 ± 13.67	87.51 ± 12.76	0.738
BMI	28.77 ± 5.15	28.59 ± 4.023	0.882

[a] Values are expressed as No. (%) or mean ± SD.

for nonparametric data. To account for multiple testing of the seven prespecified secondary body composition outcomes (FM, PBF, VFA, FFM, basal metabolic rate, TBW, and ECW/TBW), the Benjamini-Hochberg false discovery rate (FDR) correction was applied; both raw and adjusted q values are reported where applicable. A two-sided P value < 0.05 was considered statistically significant (Table 1).

4. Results

Sixty participants were randomized (n = 30 per group) to receive propolis or placebo for 12 weeks. Of the 60 randomized participants, 57 completed the 12-week intervention (propolis: n = 28; placebo: n = 29). Three participants (2 in the propolis group and 1 in the placebo group) withdrew for personal reasons unrelated to the intervention; their baseline data were carried forward for the intention-to-treat analysis (Figure 1). Baseline demographic and clinical characteristics are summarized in Table 2. There were no statistically significant between-group differences in education level, occupational status, or smoking behavior (P > 0.05). Furthermore, the mean age of participants (36.28 ± 5.54 years in the intervention group vs. 34.51 ± 5.17 years in the placebo group) and the mean duration of infertility (5.36 ± 3.88 vs. 4.59 ± 2.82 years, respectively) were comparable between groups (P > 0.05). Baseline anthropometric measures, including height, body weight, and BMI, also did not differ significantly between the two groups (P > 0.05; Table 2).

Dietary intake data are presented in Supplementary Table S1. No statistically significant between-group differences were observed in total energy or macronutrient intake at baseline or after 12 weeks.

Table 2 presents the mean ± standard deviation of anthropometric and body composition indices before and after the intervention in both groups. After applying the Benjamini-Hochberg FDR correction to the seven prespecified secondary body composition outcomes, only the between-group differences in VFA, FM, and PBF remained statistically significant. For VFA, the adjusted between-group difference was -7.6 cm^2 (95% CI, -12.1 to -3.1; Cohen d = 0.61; q = 0.009); for FM, -0.92 kg (95% CI, -1.71 to -0.13; Cohen d = 0.42; q = 0.039); and for PBF, -1.05% (95% CI, -2.01 to -0.10; Cohen d = 0.39; q = 0.043). No other outcome, including basal metabolic rate, remained significant after adjustment for multiplicity.

Independent-samples t tests showed no significant between-group differences in baseline values for the studied variables. After 12 weeks of intervention, within-group analyses indicated that the propolis group experienced a significant increase in FFM (P = 0.006) and significant reductions in FM (raw P = 0.024), PBF (raw P = 0.014), and VFA (raw P = 0.011). Basal metabolic rate did not differ significantly between groups at week 12 (ANCOVA-adjusted P = 0.675).

In the intention-to-treat analysis (n = 60) with baseline observation carried forward, the adjusted

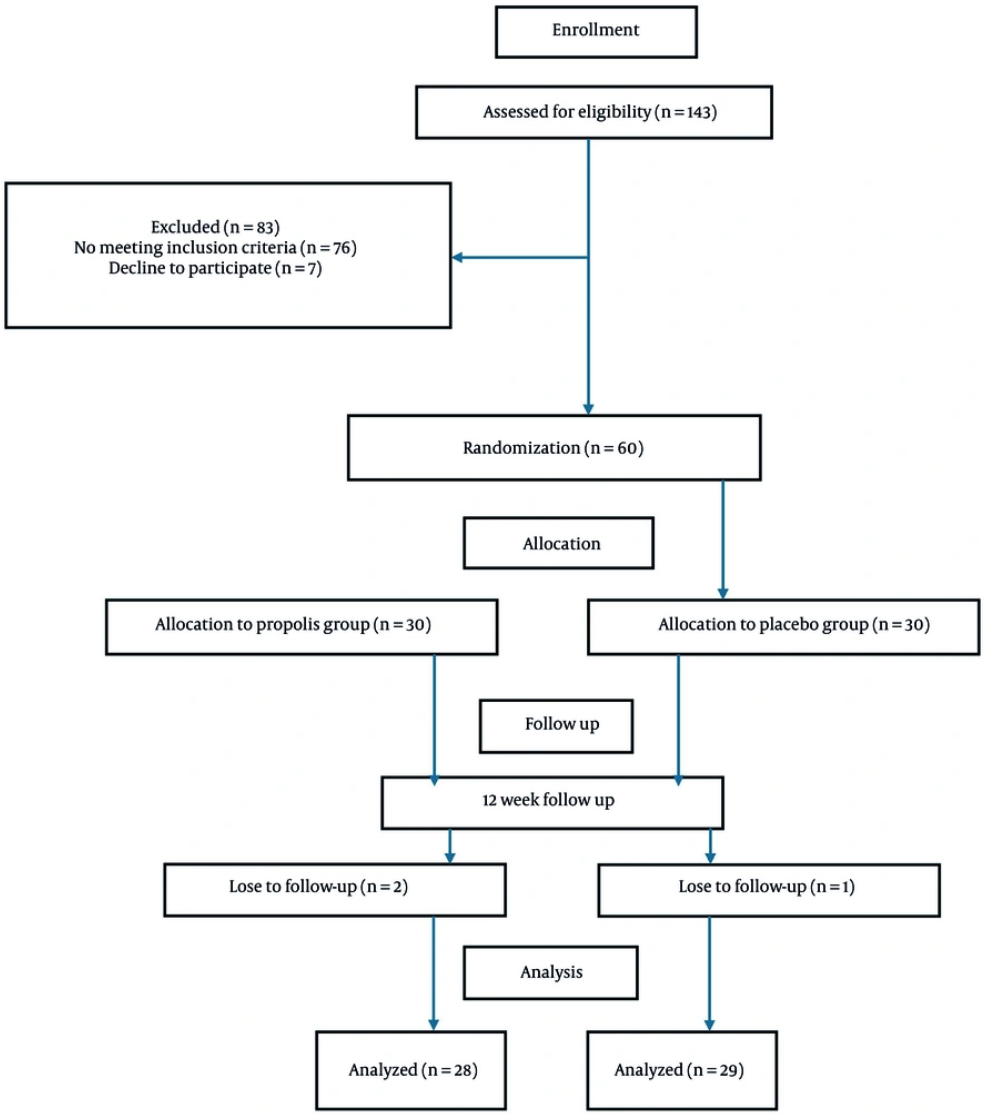

Figure 1. Consort flow chart of patients' enrollment and follow-up

between-group differences were as follows: FM, -0.92 kg (95% CI, -1.71 to -0.13; P = 0.022); PBF, -1.05% (95% CI, -2.01 to -0.10; P = 0.037); and VFA, -7.6 cm^2 (95% CI, -12.1 to -3.1; P = 0.004), confirming the robustness of the per-protocol findings.

After Benjamini-Hochberg FDR correction across the seven prespecified secondary body composition outcomes, only FM, PBF, and VFA retained statistical significance ($q < 0.05$). The adjusted mean differences, 95% CIs, and effect sizes (Cohen d) for these variables are reported in the Results text.

5. Discussion

The global rise in obesity, driven by modern lifestyle patterns and environmental changes, has become a major public health concern (18), and accumulating evidence links excess adiposity, particularly visceral fat, to impaired male reproductive function and asthenozoospermia (19). Despite growing interest in

natural anti-obesity agents, clinical evidence regarding the effects of propolis on body composition remains limited, with most data derived from preclinical models (11). The present randomized, double-blind, placebo-controlled trial was designed to evaluate the effects of 12-week propolis supplementation (1500 mg/day) on anthropometric indices and body composition in men with asthenozoospermia.

Our primary finding was that propolis did not lead to significant reductions in overall body weight, BMI, waist circumference, or waist-to-hip ratio. This finding is consistent with several previous clinical trials (16, 22, 23) and two recent meta-analyses (20, 21), which did not detect meaningful effects of propolis on gross anthropometric measures. However, detailed body composition analysis revealed a favorable shift in tissue partitioning: participants receiving propolis exhibited a significant decrease in FM, PBF, and VFA, along with a significant within-group increase in FFM. After controlling for multiple comparisons using the Benjamini-Hochberg procedure, these between-group differences remained statistically significant. These changes occurred in the absence of any prescribed dietary or exercise intervention, and body weight remained stable in both groups, indicating true body recomposition rather than simple weight loss. This pattern is consistent with recent findings by Kanazashi et al., who reported reductions in absolute and relative fat mass and an increase in relative lean body mass in elderly women supplemented with Brazilian propolis (24).

The observed reduction in VFA, with an adjusted between-group difference of approximately -7.6 cm^2, is of particular interest given the well-documented association between visceral adiposity, systemic inflammation, and adverse reproductive hormonal profiles (25, 26). Because no minimal clinically important difference has been established for FM or VFA in infertile men, the clinical relevance of these changes cannot be definitively asserted. However, the observed improvements exceeded the typical measurement error of the BIA device used and are consistent with a favorable metabolic shift.

The within-group increase in basal metabolic rate previously reported has been removed from the Results because the between-group comparisons were nonsignificant (ANCOVA P = 0.675; change score P = 0.495). Therefore, basal metabolic rate is not considered a beneficial effect of propolis.

Several mechanisms have been proposed in preclinical studies to explain the potential fat-loss-promoting effects of propolis, including Artepillin C-induced browning of white adipose tissue (27, 33), AMPK-mediated enhancement of lipid catabolism in skeletal muscle (28, 29), and modulation of the gut microbiome toward a less obesogenic profile (30-32). Propolis constituents such as caffeic acid phenethyl ester may also suppress adipogenesis by downregulating PPARγ and SREBP-1 (34, 35), while concurrently attenuating obesity-associated inflammation through activation of the Nrf2 pathway and inhibition of IKKε/TBK1 signaling (36-39). However, none of these molecular or microbial pathways were directly measured in the present study; therefore, the discussion of mechanisms is speculative and intended only to provide biological context for the observed body composition changes. Future studies incorporating molecular and omics endpoints are needed to validate these pathways.

Notably, the propolis used in this trial was poplar-type propolis, collected from East Azerbaijan Province and chemically characterized, with total phenolic content and flavonoid levels falling within the typical ranges for temperate-region propolis (8, 15). Because propolis composition varies widely by geographical origin and botanical source, our findings should not be directly extrapolated to chemically distinct types, such as Brazilian green propolis or Chinese propolis, without independent verification (9, 11).

An important consideration is that the present report represents a secondary analysis of a parent trial in which the primary outcome was sperm motility, as stated in the IRCT registration. The sample size was prospectively calculated for that primary endpoint (17) and was not formally powered for individual body composition variables. Nevertheless, post hoc power calculations indicated > 80% power for the significant between-group differences in FM, PBF, and VFA. All anthropometric and body composition results reported here should be interpreted as exploratory. The Benjamini-Hochberg correction was applied, and the key findings for FM, PBF, and VFA remained significant; however, confirmatory studies with body composition as the primary outcome are warranted.

Dietary intake and physical activity were monitored using three 24-hour dietary recalls and the IPAQ-SF, respectively, and remained stable across the intervention period. Dietary data are provided in Supplementary Table S1. The absence of weight change indirectly supports the notion that major behavioral confounders were not operating. Nevertheless, subtle uncontrolled variations cannot be entirely ruled out, and future trials should incorporate more intensive dietary control or objective activity monitoring.

5.1. Limitations

Several limitations should be considered. This was a secondary analysis of a parent trial powered for sperm motility; therefore, the body composition findings are exploratory and were corrected for multiple comparisons using the Benjamini-Hochberg procedure. Body composition was assessed using BIA and three-dimensional scanning rather than reference imaging methods; in particular, BIA-derived VFA is not a validated substitute for CT or MRI. Blinding integrity was not formally tested, but because both supplements were provided as identical capsules swallowed whole without chewing, taste and odor differences were effectively masked, making unblinding unlikely. Adherence was monitored by capsule count and self-report without an objective biomarker. An intention-to-treat analysis using baseline observation carried forward was performed and confirmed the per-protocol findings. Mechanistic pathways were not measured, and the results are specific to Iranian men with asthenozoospermia from a single center, limiting generalizability. Finally, although comprehensive reproductive outcomes were collected in the parent trial, they are reported separately; therefore, the present paper does not establish a direct link between body composition changes and fertility improvement.

5.2. Conclusions

Twelve weeks of propolis supplementation at 1500 mg/day did not reduce overall body weight but led to statistically significant, FDR-corrected improvements in body composition, including reductions in FM, PBF, and VFA, with a concomitant increase in FFM. These changes, which were robust in both per-protocol and intention-to-treat analyses, may represent a favorable shift in metabolic risk. However, because the direct link to fertility was not examined in this report and the clinical importance of the observed effect sizes remains to be established, the findings should be considered hypothesis-generating. Further trials with body composition as the primary outcome, validation of visceral fat measurement against reference imaging, and concurrent evaluation of reproductive endpoints are required to determine the therapeutic utility of propolis in infertile men.

Acknowledgements

This study was conducted as part of the Ph.D. dissertation of Reza Malihi and received approval from the Nutrition and Metabolic Diseases Research Center, Clinical Research Institute, Ahvaz Jundishapur University of Medical Sciences (grant No. NRC-0211). The authors gratefully acknowledge all participants for their valuable cooperation and contribution to this research.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

Footnotes

AI Use Disclosure: The authors declare that no generative AI tools were used in the creation of this article.

Authors' Contribution: Study concept and design: M. K. and R. M.; Acquisition of data: R. M. and M. D.; Analysis and interpretation of data: R. M. and M. K.; Drafting of the manuscript: R. M., M. K., and B. H.; Critical revision of the manuscript for important intellectual content: M. K., B. H., and A. S.; Statistical analysis: R. M. and M. K.; Administrative, technical, and material support: A. S. and R. M.; Study supervision: M. K.

Clinical Trial Registration Code: Clinical Trial Code: IRCT20231123060155N1 (Link: https://en.irct.ir/trial/76052)

Conflict of Interests Statement: The authors do not declare any conflicts of interests for this study.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication. The data are not publicly available due to privacy and ethics.

Ethical Approval: This study is approved under the ethical approval code ofIR.AJUMS.REC.1402.426 (webpage of ethical approval code is: https://ethics.research.ac.ir/EthicsProposalView.php?id=412404)

Funding/Support: This study was conducted as part of the Ph.D. dissertation of Reza Malihi and received approval from the Nutrition and Metabolic Diseases Research Center, Clinical Research Institute, Ahvaz Jundishapur University of Medical Sciences (grant No. NRC-0211).

Informed Consent: Informed consent was obtained from all participants.

References

1. Fatima W, Akhtar AM, Hanif A, Gilani A, Farooq SMY. Predicted risk factors associated with secondary infertility in women: univariate and multivariate logistic regression analyses. *Frontiers in Medicine*. 2024;**10**. 1327568. [PubMed ID: 38590911]. [PubMed Central ID: PMC11000415]. https://doi.org/10.3389/fmed.2023.1327568.
2. Barone B, Amicuzi U, Tammaro S, Olivetta M, Stizzo M, Musone M, et al. Male Infertility: A Comprehensive Review of Urological Causes and Contemporary Management. *Journal of Clinical Medicine*. 2026;**15**(1):397. [PubMed ID: 41517646]. [PubMed Central ID: PMC12787072]. https://doi.org/10.3390/jcm15010397.
3. Abd Elrahman MM, El makawy AI, Hassanane MS, Alam SS, Hassan NHA, Amer MK. Assessment of correlation between asthenozoospermia and mitochondrial DNA mutations in Egyptian infertile men. *J Genet Eng Biotechnol*. 2021;**19**(1). 11. [PubMed ID: 33459881]. [PubMed Central ID: PMC7813956]. https://doi.org/10.1186/s43141-020-00111-0.
4. Service CA, Puri D, Al Azzawi S, Hsieh TC, Patel DP. The impact of obesity and metabolic health on male fertility: a systematic review. *Fertility and Sterility*. 2023;**120**(6):1098-1111. [PubMed ID: 37839720]. https://doi.org/10.1016/j.fertnstert.2023.10.017.
5. Chaudhuri GR, Das A, Kesh SB, Bhattacharya K, Dutta S, Sengupta P, et al. Obesity and male infertility: multifaceted reproductive disruption. *Middle East Fertility Society Journal*. 2022;**27**(1). 8. https://doi.org/10.1186/s43043-022-00099-2.
6. Rabijewski M. Male-specific consequences of obesity-functional hypogonadism and fertility disorders. *Endokrynologia Polska*. 2023;**74**(5):480-489. [PubMed ID: 37779374]. https://doi.org/10.5603/ep.95626.
7. Ameratunga D, Gebeh A, Amoako A. Obesity and male infertility. *Best Practice & Research Clinical Obstetrics & Gynaecology*. 2023;**90**. 102393. [PubMed ID: 37572397]. https://doi.org/10.1016/j.bpobgyn.2023.102393.
8. Zabaiou N, Fouache A, Trousson A, Baron S, Zellagui A, Lahouel M, et al. Biological properties of propolis extracts: Something new from an ancient product. *Chemistry and Physics of Lipids*. 2017;**207**(Pt B):214-222. [PubMed ID: 28411017]. https://doi.org/10.1016/j.chemphyslip.2017.04.005.
9. Tek NA, Şentüre ŞA, Ersoy N. Is propolis a potential anti-obesogenic agent for obesity? *Current Nutrition Reports*. 2024;**13**(2):186-193. [PubMed ID: 38436884]. [PubMed Central ID: PMC11133030]. https://doi.org/10.1007/s13668-024-00524-0.
10. Megantara I, Karisa P, Pakpahan WI, Sylviana N, Goenawan H. Molecular mechanisms of propolis in adipogenesis, lipid metabolism and white adipose tissue Browning: a systematic review of preclinical studies. *Adipocyte*. 2025;**14**(1). 2576894. [PubMed ID: 41108373]. [PubMed Central ID: PMC12536616]. https://doi.org/10.1080/21623945.2025.2576894.
11. Zhu L, Zhang J, Yang H, Li G, Li H, Deng Z, et al. Propolis polyphenols: A review on the composition and anti-obesity mechanism of different types of propolis polyphenols. *Frontiers in Nutrition*. 2023;**10**. 1066789. [PubMed ID: 37063322]. [PubMed Central ID: PMC10102383]. https://doi.org/10.3389/fnut.2023.1066789.
12. Abdelfattah DSE, Fouad MA, Elmeshad AN, El-Nabarawi MA, Elhabal SF. Anti-obesity effect of combining white kidney bean extract, propolis ethanolic extract and crpi3 on Sprague-Dawley rats fed a high-fat diet. *Nutrients*. 2024;**16**(2):310. [PubMed ID: 38276548]. [PubMed Central ID: PMC10818276]. https://doi.org/10.3390/nu16020310.
13. Cooper TG, Noonan E, von Eckardstein S, Auger J, Baker HW, Behre HM, et al. World Health Organization reference values for human semen characteristics. *Human Reproduction Update*. 2010;**16**(3):231-245. [PubMed ID: 19934213]. https://doi.org/10.1093/humupd/dmp048.
14. Maghsoumi-Norouzabad L, Zare Javid A, Mansoori A, Dadfar M, Serajian A. The effects of Vitamin D3 supplementation on Spermatogram and endocrine factors in asthenozoospermia infertile men: a randomized, triple blind, placebo-controlled clinical trial. *Reproductive Biology and Endocrinology*. 2021;**19**(1). 102. [PubMed ID: 34225767]. [PubMed Central ID: PMC8256550]. https://doi.org/10.1186/s12958-021-00789-y.
15. Bankova V. Chemical diversity of propolis and the problem of standardization. *J Ethnopharmacol*. 2005;**100**(1 - 2):114-117. [PubMed ID: 15993016]. https://doi.org/10.1016/j.jep.2005.05.004.
16. Zakerkish M, Jenabi M, Zaeemzadeh N, Hemmati AA, Neisi N. The effect of Iranian propolis on glucose metabolism, lipid profile, insulin resistance, renal function and inflammatory biomarkers in patients with type 2 diabetes mellitus: A randomized double-blind clinical trial. *Scientific Reports*. 2019;**9**(1). 7289. [PubMed ID: 31086222]. [PubMed Central ID: PMC6514000]. https://doi.org/10.1038/s41598-019-43838-8.
17. Gholaminejad F, Javadi M, Karami AA, Alizadeh F, Kavianpour M, Khadem Haghighian H. Propolis Supplementation Effects on Semen Parameters, Oxidative Stress, Inflammatory Biomarkers and Reproductive Hormones in Infertile Men with Asthenozoospermia; A Randomized Clinical Trial. *International Journal of Medical Laboratory*. 2019;**6**(1):21-32. https://doi.org/10.18502/ijml.v6i1.504.
18. Khusun H. Compressed Modernization and Nutrition Transition: Implications for Diet Quality and Disease. *Global Perspective on the Relationship Between Dietary Habits and Health*. 2025. https://doi.org/10.5772/intechopen.1010887.
19. Jiao J, Xu P, Wang X, Xing Z, Dong S, Li G, et al. Enterotypes in asthenospermia patients with obesity. *Scientific Reports*. 2022;**12**(1). 16993. [PubMed ID: 36216963]. [PubMed Central ID: PMC9550853]. https://doi.org/10.1038/s41598-022-20574-0.
20. Aliakbarian M, Jazinaki MS, Bahari H, Rashidmayvan M, Golafrouz H, Khodashahi R, et al. Effects of Propolis Consumption on Liver Enzymes and Obesity Indices in Adults: A Systematic Review and Dose-Response Meta-Analysis. *Current Developments in Nutrition*. 2024;**8**(9). 104438. [PubMed ID: 39296926]. [PubMed Central ID: PMC11407979]. https://doi.org/10.1016/j.cdnut.2024.104438.
21. Salehi-Sahlabadi A, Chhabra M, Rahmani J, Momeni A, Karam G, Nattagh-Eshtivani E, et al. The effect of propolis on anthropometric indices and lipid profile: a systematic review and meta-analysis of randomized controlled trials. *Journal of Diabetes & Metabolic Disorders*. 2020;**19**(2):1835-1843. [PubMed ID: 33520864]. [PubMed Central ID: PMC7843794]. https://doi.org/10.1007/s40200-020-00604-2.
22. Soleimani D, Rezaie M, Rajabzadeh F, Gholizadeh Navashenaq J, Abbaspour M, Miryan M, et al. Protective effects of propolis on hepatic steatosis and fibrosis among patients with nonalcoholic fatty liver disease (NAFLD) evaluated by real-time two-dimensional shear wave elastography: A randomized clinical trial. *Phytotherapy Research*. 2021;**35**(3):1669-1679. [PubMed ID: 33166032]. https://doi.org/10.1002/ptr.6937.
23. Mujica V, Orrego R, Pérez J, Romero P, Ovalle P, Zúñiga-Hernández J, et al. The Role of Propolis in Oxidative Stress and Lipid Metabolism: A Randomized Controlled Trial. *Evidence-Based Complementary and Alternative Medicine*. 2017;**2017**(1). 4272940. [PubMed ID: 28539963]. [PubMed Central ID: PMC5429932]. https://doi.org/10.1155/2017/4272940.
24. Kanazashi M, Iida T, Nakanishi R, Tanaka M, Ikeda H, Takamiya N, et al. Brazilian Propolis Intake Decreases Body Fat Mass and Oxidative Stress in Community-Dwelling Elderly Females: A Randomized Placebo-Controlled Trial. *Nutrients*. 2023;**15**(2):364. [PubMed ID:

36678234]. [PubMed Central ID: PMC9861743]. https://doi.org/10.3390/nu15020364.

25. Lv X, Jiang YT, Zhang XY, Li LL, Zhang HG, Liu RZ. Associations of sex hormone levels with body mass index (BMI) in men: a cross-sectional study using quantile regression analysis. *Asian Journal of Andrology*. 2023;**25**(1):98-102. [PubMed ID: 35439874]. [PubMed Central ID: PMC9933972]. https://doi.org/10.4103/aja202212.
26. Turan E, Öztekin Ü. Relationship between visceral adiposity index and male infertility. *Andrologia*. 2020;**52**(4). e13548. [PubMed ID: 32100901]. https://doi.org/10.1111/and.13548.
27. Nishikawa S, Aoyama H, Kamiya M, Higuchi J, Kato A, Soga M, et al. Artepillin C, a typical Brazilian propolis-derived component, induces brown-like adipocyte formation in C3H10T1/2 cells, primary inguinal white adipose tissue-derived adipocytes, and mice. *PLoS One*. 2016;**11**(9). e0162512. [PubMed ID: 27598888]. [PubMed Central ID: PMC5012562]. https://doi.org/10.1371/journal.pone.0162512.
28. Ueda M, Hayashibara K, Ashida H. Propolis extract promotes translocation of glucose transporter 4 and glucose uptake through both PI3K and AMPK dependent pathways in skeletal muscle. *BioFactors*. 2013;**39**(4):457-466. [PubMed ID: 23355380]. https://doi.org/10.1002/biof.1085.
29. Day EA, Ford RJ, Steinberg GR. AMPK as a therapeutic target for treating metabolic diseases. *Trends in Endocrinology & Metabolism*. 2017;**28**(8):545-560. [PubMed ID: 28647324]. https://doi.org/10.1016/j.tem.2017.05.004.
30. Zheng Y, Wu Y, Tao L, Chen X, Jones TJ, Wang K, et al. Chinese propolis prevents obesity and metabolism syndromes induced by a high fat diet and accompanied by an altered gut microbiota structure in mice. *Nutrients*. 2020;**12**(4):959. [PubMed ID: 32235581]. [PubMed Central ID: PMC7230861]. https://doi.org/10.3390/nu12040959.
31. Zhong XC, Liu YM, Gao XX, Krausz KW, Niu B, Gonzalez FJ, et al. Caffeic acid phenethyl ester suppresses intestinal FXR signaling and ameliorates nonalcoholic fatty liver disease by inhibiting bacterial bile salt hydrolase activity. *Acta Pharmacologica Sinica*. 2023;**44**(1):145-156. [PubMed ID: 35655096]. [PubMed Central ID: PMC9813015]. https://doi.org/10.1038/s41401-022-00921-7.
32. Roquetto AR, Monteiro NES, Moura CS, Toreti VC, de Pace F, Santos AD, et al. Green propolis modulates gut microbiota, reduces endotoxemia and expression of TLR4 pathway in mice fed a high-fat diet. *Food Research International*. 2015;**76**(Pt 3):796-803. [PubMed ID: 28455065]. https://doi.org/10.1016/j.foodres.2015.07.026.
33. Nishikawa S, Hydo T, Aoyama H, Miyata R, Kumazawa S, Tsuda T. Artepillin C, a key component of Brazilian propolis, induces thermogenesis in inguinal white adipose tissue of mice through a creatine-metabolism-related thermogenic pathway. *Journal of Agricultural and Food Chemistry*. 2020;**68**(4):1007-1014. [PubMed ID: 31914311]. https://doi.org/10.1021/acs.jafc.9b07080.
34. Shin SH, Seo SG, Min S, Yang H, Lee E, Son JE, et al. Caffeic acid phenethyl ester, a major component of propolis, suppresses high fat diet-induced obesity through inhibiting adipogenesis at the mitotic clonal expansion stage. *Journal of Agricultural and Food Chemistry*. 2014;**62**(19):4306-4312. [PubMed ID: 24611533]. https://doi.org/10.1021/jf405088f.
35. Juman S, Yasui N, Okuda H, Ueda A, Negishi H, Miki T, et al. Caffeic acid phenethyl ester inhibits differentiation to adipocytes in 3T3-L1 mouse fibroblasts. *Biological and Pharmaceutical Bulletin*. 2010;**33**(9):1484-1488. [PubMed ID: 20823561]. https://doi.org/10.1248/bpb.33.1484.
36. Cardinault N, Tourniaire F, Astier J, Couturier C, Perrin E, Dalifard J, et al. Poplar propolis ethanolic extract reduces body weight gain and glucose metabolism disruption in high fat diet fed mice. *Molecular Nutrition & Food Research*. 2020;**64**(18). 2000275. [PubMed ID: 32729164]. https://doi.org/10.1002/mnfr.202000275.
37. Amir Siddiqui M, Badruddeen, Akhtar J, Uddin S, Chandrashekharan SM, Ahmad M, et al. Chrysin modulates protein kinase IKKε/TBK1, insulin sensitivity and hepatic fatty infiltration in diet induced obese mice. *Drug Development Research*. 2022;**83**(1):194-207. [PubMed ID: 34350600]. https://doi.org/10.1002/ddr.21859.
38. Iio A, Ohguchi K, Inoue H, Maruyama H, Araki Y, Nozawa Y, et al. Ethanolic extracts of Brazilian red propolis promote adipocyte differentiation through PPARγ activation. *Phytomedicine*. 2010;**17**(12):974-979. [PubMed ID: 20382515]. https://doi.org/10.1016/j.phymed.2010.03.001.
39. Vanella L, Tibullo D, Godos J, Pluchinotta FR, Di Giacomo C, Sorrenti V, et al. Caffeic Acid Phenethyl Ester Regulates PPAR's Levels in Stem Cells Derived Adipocytes. *PPAR Research*. 2016;**2016**(1):7359521. [PubMed ID: 26904104]. [PubMed Central ID: PMC4745343]. https://doi.org/10.1155/2016/7359521.

Table 2. Characteristics of the Trial Participants and Between Group Comparison of Pre- and Post-Intervention for Anthropometric and Body Composition Indices [a]

Variables and Time Points	Intervention (n = 28)	Control (n = 29)	P-Vblue (Cetween)
Physical activity (MET-min/wk)			
Baseline	1649.036 ± 1382.289	1575.069 ± 1351.692	0.839 [b]
12 weeks	1738.607 ± 1260.196	1518.172 ± 1254.675	0.068 [c]
Change	89.57 ± 359.75	-56.9 ± 328.41	0.114 [d]
P value	0.199	0.359	
Weight (kg)			
Baseline	86.332 ± 13.669	87.51 ± 12.762	0.738 [b]
12 weeks	85.739 ± 13.422	87.81 ± 12.947	0.105 [c]
Change	-0.59 ± 2.58	0.3 ± 1.41	0.109 [d]
P value	0.235	0.261	
Waist-to-hip ratio			
Baseline	0.871 ± 0.056	0.868 ± 0.056	0.756 [b]
12 weeks	0.844 ± 0.159	0.865 ± 0.055	0.416 [c]
Change	-0.03 ± 0.15	0.003 ± 0.01	0.412 [d]
P value	0.327	0.227	
A Body Shape Index			
Baseline	0.758 ± 0.033	0.756 ± 0.029	0.682 [b]
12 weeks	0.761 ± 0.036	0.756 ± 0.031	0.446 [c]
Change	0.003 ± 0.01	0.00 ± 0.01	0.447 [d]
P value	0.253	0.953	
Waist (cm)			
Baseline	94.35 ± 10.152	93.646 ± 9.023	0.938 [b]
12 weeks	94.025 ± 10.489	93.55 ± 9.483	0.617 [c]
Change	-0.33 ± 1.76	-0.11 ± 1.76	0.641 [d]
P value	0.336	0.792	
Abdomen (cm)			
Baseline	102.607 ± 11.725	101.008 ± 10.293	0.749 [b]
12 weeks	102.196 ± 12.507	100.513 ± 10.205	0.929 [c]
Change	-0.41 ± 2.01	-0.5 ± 2.45	0.891 [d]
P value	0.288	0.332	
Hip (cm)			
Baseline	108.182 ± 8.043	107.146 ± 6.349	0.915 [b]
12 weeks	107.971 ± 8.252	107.296 ± 6.495	0.431 [c]
Change	-0.21 ± 1.78	0.15 ± 1.41	0.427 [d]
P value	0.535	0.607	
Basal metabolic rate			
Baseline	1640.461 ± 125.762	1603.785 ± 332.281	0.586 [b]
12 weeks	1654.936 ± 118.502	1659.448 ± 132.713	0.675 [c]
Change	14.48 ± 36.99	55.66 ± 315.02	0.495 [d]
P value	0.048	0.349	
Intracellular fluid (L)			
Baseline	26.932 ± 2.641	27.372 ± 2.724	0.538 [b]
12 weeks	27.044 ± 2.579	27.353 ± 2.787	0.248 [c]
Change	0.11 ± 0.38	-0.02 ± 0.43	0.227 [d]
P value	0.134	0.806	
Extracellular fluid (L)			
Baseline	16.2 ± 1.617	16.466 ± 1.751	0.555 [b]
12 weeks	16.228 ± 1.572	16.419 ± 1.77	0.341 [c]
Change	0.03 ± 0.25	-0.05 ± 0.29	0.304 [d]
P value	0.564	0.391	
Total body water (L)			
Baseline	43.125 ± 4.257	43.835 ± 4.471	0.542 [b]
12 weeks	43.446 ± 4.418	44.206 ± 5.178	0.933 [c]
Change	0.32 ± 1.18	0.37 ± 2.46	0.921 [d]
P value	0.161	0.423	
Fat-free mass (kg)			
Baseline	58.482 ± 5.398	59.576 ± 6.382	0.488 [b]
12 weeks	58.945 ± 5.389	59.70 ± 6.389	0.161 [c]
Change	0.46 ± 0.82	0.12 ± 0.83	0.143 [d]
P value	0.006	0.443	
Protein (kg)			
Baseline	11.639 ± 1.14	11.817 ± 1.18	0.565 [b]
12 weeks	11.676 ± 1.116	11.808 ± 1.209	0.365 [c]
Change	0.04 ± 0.19	-0.01 ± 0.17	0.343 [d]
P value	0.322	0.768	
Mineral (kg)			
Baseline	4.014 ± 0.474	4.097 ± 0.514	0.533 [b]
12 weeks	4.03 ± 0.477	4.082 ± 0.493	0.390 [c]
Change	0.02 ± 0.11	-0.01 ± 0.12	0.329 [d]
P value	0.438	0.538	

Variables and Time Points	Intervention (n = 28)	Control (n = 29)	P-Vblue (Cetween)
Fat mass (kg)			
Baseline	27.95 ± 11.647	27.931 ± 9.113	0.995 [b]
12 weeks	26.915 ± 11.669	28.024 ± 9.163	0.027 [c]
Change	-1.04 ± 2.3	0.071 ± 1.3	0.026 [d]
P value	0.024	0.703	
Body fat percentage (%)			
Baseline	31.214 ± 8.701	31.321 ± 6.569	0.959 [b]
12 weeks	30.23 ± 9.202	31.275 ± 6.439	0.032 [c]
Change	-0.98 ± 1.99	-0.054 ± 1.08	0.030 [d]
P value	0.014	0.822	
Body mass index			
Baseline	28.768 ± 5.149	28.586 ± 4.023	0.882 [b]
12 weeks	28.59 ± 5.245	28.689 ± 3.997	0.116 [c]
Change	-0.18 ± 0.82	0.10 ± 0.45	0.113 [d]
P value	0.260	0.230	
Visceral fat area (cm^2)			
Baseline	122.271 ± 50.995	122.879 ± 42.607	0.961 [b]
12 weeks	117.271 ± 50.961	125.376 ± 42.576	0.003 [c]
Change	-5.00 ± 9.69	2.50 ± 8.32	0.003 [d]
P value	0.011	0.118	0.961 [b]
ECW/TBW			
Baseline	0.376 ± 0.005	0.376 ± 0.004	0.892 [b]
12 weeks	0.374 ± 0.008	0.372 ± 0.017	0.668 [c]
Change	0.002 ± 0.01	0.004 ± 0.02	0.655 [d]
P value	0.164	0.251	

[a] Abbreviations: ECW/TBW, extracellular-to-total body water ratio; MET, metabolic equivalent of task.

[b] Between-group differences at baseline; P values were calculated using the independent-samples t test.

[c] Between-group differences after the intervention; P values were derived from analysis of covariance (ANCOVA), adjusting only for the baseline value of the respective outcome.

[d] Within-group differences; P values were calculated using the paired-samples t test.