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Temporal Changes in Anthropometric Circumferences and Bioimpedance-Derived Body Composition During Eight Weeks of Reformer Pilates in Young Women Without Regular Exercise Participation

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ORIGINAL ARTICLE

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Abstract

Background: Evidence on Pilates-related body composition is inconsistent, and few studies track changes during programs. Objective: To assess body mass, bioimpedance-derived body-fat percentage and muscle mass, and seven circumferences at baseline, week 4, and week 8 of supervised Reformer Pilates. Methods: Twenty-two women aged 18–24 years who had not exercised regularly in the previous six months completed an 8-week program (two 50–60-min sessions weekly). Repeated-measures ANOVA with Greenhouse–Geisser correction was used; Holm adjustment covered 10 outcomes, with Bonferroni-adjusted pairwise comparisons and Friedman sensitivity tests. Results: Body mass, body-fat percentage, and muscle mass showed no significant time effects (Holm-adjusted P=.952, 1.000, and 1.000). All seven circumferences showed significant time effects (Holm-adjusted P≤.041). Baseline-to-week-8 reductions ranged from 0.95 cm (arm) to 5.32 cm (abdomen). Abdominal circumference decreased from 83.55±8.35 to 78.23±6.23 cm (adjusted P<.001; partial η^2=.515). No week-4-to-week-8 comparison remained significant. Conclusions: During this uncontrolled program, several circumferences decreased, but body mass and bioimpedance-derived estimates showed no significant time effects. Most detectable circumference differences were evident by week 4.

Keywords: Reformer Pilates, Anthropometry, Body Composition, Bioelectrical Impedance, Young Women, Repeated Measures, Exercise Training.

Düzenli Egzersiz Yapmayan Genç Kadınlarda Sekiz Haftalık Reformer Pilates Sürecinde Antropometrik Çevre Ölçümleri ve Biyoelektrik İmpedansa Dayalı Vücut Kompozisyonundaki Değişimler

Özet

Pilatesin vücut kompozisyonuna etkileri tutarsızdır; süreçteki değişimleri izleyen çalışma sayısı azdır. Amaç: Gözetimli Reformer Pilates boyunca vücut ağırlığı, biyoelektrik impedansla belirlenen vücut yağ yüzdesi ve kas kütlesi ile yedi çevre ölçümünü başlangıçta, 4. ve 8. haftalarda değerlendirmek amaçlanmıştır. Yöntem: Son altı ayda düzenli egzersiz yapmamış, 18–24 yaşlarındaki 22 kadın, haftada iki kez 50–60 dakika süren 8 haftalık programa katılmıştır. Sonuçlar Greenhouse–Geisser düzeltmeli tekrarlı ölçümler ANOVA ile analiz edilmiş; 10 sonuç için Holm, ikili karşılaştırmalar için Bonferroni düzeltmesi uygulanmıştır. Duyarlılık analizlerinde Friedman testi kullanılmıştır. Bulgular: Vücut ağırlığı, vücut yağ yüzdesi ve kas kütlesinde anlamlı zaman etkisi görülmemiştir (Holm-düzeltilmiş P=.952, 1.000 ve 1.000). Yedi çevre ölçümünün tamamında zaman etkisi anlamlıdır (Holm-düzeltilmiş P≤.041). Başlangıçtan 8. haftaya azalmalar kol çevresinde 0,95 cm, karın çevresinde 5,32 cm olmuştur. Karın çevresi 83,55±8,35 cm'den 78,23±6,23 cm'ye düşmüştür (düzeltilmiş P<.001; kısmi η^2=.515). Düzeltme sonrası 4. ve 8. hafta karşılaştırmalarının hiçbiri anlamlı değildir. Sonuç: Kontrol grubu olmayan programda bazı çevre ölçümleri azalırken vücut ağırlığı ve biyoelektrik impedans tahminlerinde anlamlı zaman etkisi saptanmamıştır. Çevre ölçümlerindeki farklılıkların çoğu 4. haftada görülmüştür.

Anahtar Kelimeler: Reformer Pilates, Antropometri, Vücut Kompozisyonu, Biyoelektrik İmpedans, Genç Kadınlar, Tekrarlı Ölçümler, Egzersiz Antrenmanı.

Introduction

Insufficient physical activity remains a major global public-health problem and is more prevalent in women than men. In a pooled analysis of 507 population-based surveys encompassing 5.7 million adults, the global prevalence of insufficient physical activity reached 31.3% in 2022 and remained higher among women (Strain et al., 2024). Young women who do not participate in structured exercise may nevertheless have body mass index (BMI) values within or near the normal-weight range. For this population, exercise programs should therefore be evaluated beyond weight loss alone and should consider multidimensional adaptations that may occur without substantial changes in total body mass.

Pilates is a mind-body exercise system emphasizing controlled movement, breathing, trunk stabilization, postural alignment, mobility, and coordinated muscular activation. Reformer Pilates adds a spring-loaded carriage, straps, pulleys, and adjustable resistance, allowing external loading and movement assistance to be modified within the same session. This combination may be particularly suitable for previously non-training adults because movement complexity and resistance can be progressed without requiring high-impact locomotor loading. Pilates-based programs can improve physical-fitness and psychosocial outcomes even when body-size or body-composition responses are modest (Aracı & Baş Aslan, 2024).

Evidence for Pilates-related body-composition change is heterogeneous. A meta-analysis in adults with overweight or obesity found reductions in body weight, BMI, and body-fat percentage but substantial between-study heterogeneity for several outcomes (Wang et al., 2021). In healthy populations, a systematic review concluded that the effect of Pilates on body composition remained uncertain because of inconsistent findings and limited methodological quality (Silva et al., 2022). A second systematic review likewise identified marked heterogeneity in population characteristics, Pilates modalities, intervention doses, and body-composition methods (Pereira et al., 2022). These syntheses indicate that baseline phenotype and measurement method are central to interpretation.

Original intervention studies reinforce this heterogeneity. In inactive adult women, a three-month Pilates program improved flexibility but did not reproduce the body-composition changes observed with a low-load, high-repetition comparison program (Evangelou et al., 2021). In young medical interns with sedentary tendencies, nine weeks of equipment-based Reformer Pilates produced favorable performance and biochemical changes, whereas most body-composition indices remained unchanged and waist circumference was the clearest anthropometric response (Yılmaz et al., 2022). Eight weeks of mat Pilates in Pilates-trained middle-aged women was associated with reductions in several body-composition and circumference indices (Zaras et al., 2023), whereas a 12-week

randomized trial in middle-aged women with obesity found no significant body-composition changes despite improvements in other health-related outcomes (Park et al., 2023).

Reformer-specific evidence also suggests that baseline adiposity and training dose may influence the apparent response. In 22 women without regular exercise participation, four weeks of twice-weekly Reformer Pilates was associated with reductions in several circumferences and body mass/BMI while body-fat percentage did not change significantly (Akpınar Kocakulak & Özdemir, 2024). In a randomized controlled pilot study, eight weeks of twice-weekly Reformer Pilates improved flexibility and functional core strength without significant changes in body-composition indices relative to comparison conditions (Kalkan Balak & Yürük, 2024). By contrast, an eight-week, three-session-per-week randomized trial in women with overweight or obesity reported reductions in body weight, BMI, and body-fat percentage together with increased muscle mass (Gökalp & Kırmızıgil, 2025). Another randomized study reported differential body-composition responses by obesity status (Kabasakal & Delice, 2025).

More recent work further emphasizes that Pilates-related adaptation is multidimensional. Lim et al. (2026) compared prop and apparatus Pilates in postmenopausal women and found improvements in several physiological and fitness outcomes without significant main or interaction effects for body weight, BMI, lean mass, fat mass, body-fat percentage, waist circumference, hip circumference, or waist-to-hip ratio. Onu et al. (2026) also reported age-dependent cardiometabolic and anthropometric responses during a short Pilates program in previously sedentary adult women. Collectively, current evidence does not support assuming that tape-measured dimensions, body mass, and bioimpedance-derived body-composition estimates will change in parallel.

A remaining issue is the temporal pattern of change during short Reformer programs. Most studies rely on pre- and post-intervention measurements, preventing assessment of whether detectable anthropometric differences emerge early and then persist or continue to accumulate across the intervention. This issue is methodologically relevant because circumference measures and bioimpedance-derived estimates represent different constructs and are influenced by different sources of biological and measurement variability. Accordingly, this exploratory single-group repeated-measures study aimed to characterize within-participant trajectories in body mass, bioimpedance-derived body-fat percentage and muscle mass, and seven anthropometric circumferences at baseline, week 4, and week 8 during a supervised Reformer Pilates program in young women without regular exercise participation. A secondary objective was to determine whether detectable circumference differences relative to baseline were already evident by week 4 or continued to increase during weeks 4–8. Because no concurrent non-exercise control group was available, all findings were interpreted as temporal within-participant changes rather than causal intervention effects.

Method

Study design and participants

A priori power analysis conducted using G*Power (version 3.1.9.7; Faul et al., 2007) for a one-way repeated-measures ANOVA indicated that a minimum sample size of 21 participants was required to detect a medium effect size ($f = 0.25$; Cohen, 1988) with 80% power at $\alpha = .05$ (assumed correlation among repeated measures $r = .70$; nonsphericity correction $\varepsilon = .78$; (Koo & Li, 2016). Accordingly, this prospective single-group repeated-measures study included 22 volunteer women enrolled at Karabuk University. Participants were 18–24 years of age and were eligible if they had not participated in a regular structured exercise program during the preceding six months. Eligibility also required absence of an orthopedic, neurological, cardiovascular, or metabolic condition that would preclude Reformer Pilates, willingness to participate, written informed consent, and the ability to attend the 8-week program. Complete measurements were available for all 22 participants at baseline, week 4, and week 8. Because the eligibility criterion concerned participation in structured exercise rather than objectively measured sitting time or total physical activity, participants are described throughout as women without regular exercise participation rather than as objectively classified sedentary individuals.

Ethical approval

The study was reviewed by the Karabük University Non-Interventional Clinical Research Ethics Committee and was approved unanimously on 6 May 2026 (Decision No. 2026/2895; document No. E-77192459-050.99-514654). All participants provided written informed consent before study procedures.

Reformer Pilates intervention

The Reformer Pilates program was delivered twice weekly for 8 weeks. Each supervised session lasted approximately 50–60 min and was led by a certified Pilates instructor. Sessions comprised warm-up, a main exercise phase, and cool-down/stretching. Progression was organized across three phases by increasing spring resistance, movement complexity, postural challenge, continuity of transitions, and muscular time under tension. During weeks 6–8, progression included moderate-to-high spring resistance, more multiplanar and whole-body movements, standing or balance-challenging positions, smoother transitions, and reduced rest intervals. Perceived exertion progressed from Borg RPE 9–11 during adaptation to 13–14 during the final phase. The intervention is summarized in Table 1. Exact Reformer manufacturer/model, spring-color settings, attendance/adherence data, and intervention-fidelity metrics were not preserved in the source documentation and are therefore not reconstructed retrospectively.

Table 1

Progression of the 8-week Reformer Pilates intervention.

Training phase	Primary aim	Exercise content	Resistance/intensity	Sets × repetitions
Weeks 1–2: adaptation	Teach movement patterns, neutral spine awareness, and core activation	Footwork, pelvic tilt, breathing exercises, modified hundred, frog, short leg circles, basic arm exercises	Low spring resistance; Borg RPE 9–11; slow and controlled	2 × 8–10
Weeks 3–5: development	Increase core stability and muscular endurance	Short spine, elephant, knee stretches, mermaid, scooter, side-lying leg exercises, arm-strap exercises	Moderate spring resistance; Borg RPE 11–13	2–3 × 10–12
Weeks 6–8: progression	Increase dynamic stability, balance, and neuromuscular control	Long stretch, side splits, advanced leg circles, hundred, standing balance exercises	Moderate-to-high spring resistance; Borg RPE 13–14; more continuous transitions	3 × 10–12

Anthropometry and body composition

Height was recorded using a stadiometer with participants barefoot or wearing socks, standing upright with heels together and the head in a standardized upright position. Body mass, body-fat percentage, and muscle mass were obtained using an InBody bioelectrical-impedance analyzer. The exact model number and full premeasurement standardization protocol were not preserved in the source documentation. Circumference measurements were recorded in centimeters for the chest, waist, abdomen, hip, upper-hip region, leg, and arm. The archived records did not specify the exact anatomical landmarks, tape characteristics, replicate-measurement procedure, assessor blinding, or intra-/inter-rater reliability. These details were not reconstructed after data collection. Because current methodological guidance emphasizes explicit reporting of device configuration and standardized premeasurement conditions for bioimpedance assessment, the unavailable information is treated as a central limitation of measurement reproducibility rather than as a minor reporting omission (Ward, 2019; Prado et al., 2026).

Statistical analysis

Continuous data are presented as mean ± standard deviation (SD). Baseline BMI was calculated as body mass (kg)/height (m^2). Each outcome was analyzed across baseline, week 4, and

week 8 using a one-factor repeated-measures ANOVA. To provide a consistent and conservative treatment of sphericity, Greenhouse–Geisser-adjusted degrees of freedom and P values are reported for every outcome. Partial eta-squared (ηp^2) is reported as the omnibus effect-size estimate. Because 10 outcomes were tested, the family of omnibus P values was additionally adjusted using Holm's sequential procedure. For outcomes with a Holm-adjusted omnibus $P<.05$, paired comparisons were performed for baseline versus week 4, baseline versus week 8, and week 4 versus week 8; P values were Bonferroni-adjusted across the three comparisons, and 98.33% confidence intervals are presented so that interval coverage corresponds to the Bonferroni familywise alpha of .05 within each outcome. Because several change-score distributions departed from normality, Friedman tests with Wilcoxon signed-rank follow-up comparisons were performed as sensitivity analyses. Statistical significance was set at two-sided $P<.05$. No missing values were present in the three-time-point dataset. The analysis is interpreted primarily through effect estimates, confidence intervals, and multiplicity-adjusted inference; nonsignificant results are not interpreted as proof of equivalence or absence of biologically meaningful change.

Reporting approach

Reporting of this nonrandomized intervention evaluation was structured with reference to the TREND statement, and intervention description was organized with reference to the TIDieR framework where applicable (Des Jarlais et al., 2004; Hoffmann et al., 2014). Items that were not preserved in the source records are reported transparently as limitations rather than reconstructed retrospectively.

Results

Participant characteristics and data completeness

All 22 participants contributed complete observations at baseline, week 4, and week 8. Mean age was 22.64 ± 1.65 years (range 18–24), mean height was 166.68 ± 4.85 cm, and baseline BMI was 21.26 ± 2.13 kg/m² (range 17.01–24.96 kg/m²). Baseline characteristics are summarized in Table 2. Because the BMI range included values below 18.5 kg/m², the sample should not be characterized as uniformly normal weight.

Table 2

Baseline Participant Characteristics (n=22).

Characteristic	Mean ± SD	Range
Age (years)	22.64 ± 1.65	18–24
Height (cm)	166.68 ± 4.85	159–175
Baseline BMI (kg/m²)	21.26 ± 2.13	17.01–24.96

Body-composition outcomes

No statistically significant time effect was detected for body mass, body-fat percentage, or muscle mass (Table 3). After Greenhouse–Geisser correction, the corresponding P values were .317,

.850, and .684, respectively, and all three remained nonsignificant after Holm adjustment across the 10 omnibus outcomes (Holm-adjusted P=.952, 1.000, and 1.000). Mean body mass was 59.21 ± 7.46 kg at baseline and 59.42 ± 7.44 kg at week 8; body-fat percentage was 26.57 ± 6.57% and 26.48 ± 6.26%, respectively; and muscle mass was 40.92 ± 3.16 and 41.13 ± 2.58 kg. These estimates did not provide evidence of a time effect, but the nonsignificant tests should not be interpreted as equivalence.

Anthropometric circumference outcomes

Time effects were detected for all seven circumference outcomes and remained statistically significant after Holm correction across the full family of 10 outcomes (Table 3). The largest omnibus partial η^2 was observed for abdominal circumference, F(1.39,29.22)=22.26, P<.001, Holm-adjusted P<.001, ηp^2=.515. Significant time effects were also retained for chest, waist, hip, upper-hip, leg, and arm circumferences.

From baseline to week 8, mean reductions were 1.98 cm for chest, 2.16 cm for waist, 5.32 cm for abdomen, 1.23 cm for hip, 1.39 cm for the upper-hip region, 2.25 cm for leg, and 0.95 cm for arm circumference. Baseline-to-week-4 differences were significant for chest, waist, abdomen, upper-hip, and leg; hip and arm met the adjusted criterion only for baseline-to-week-8 comparisons. No week-4-to-week-8 pairwise comparison was significant after Bonferroni correction (Table 4). Thus, the data do not provide evidence of an additional statistically detectable reduction during the second four-week period; they should not be interpreted as proving a biological plateau.

Table 3

Repeated-Measures Results for Body-Composition and Circumference Outcomes (n=22).

Outcome	Baseline	Week 4	Week 8	F (GG-adjusted df)	P_GG	P_Holm	ηp^2
Body mass (kg)	59.21 ± 7.46	59.05 ± 7.37	59.42 ± 7.44	1.17 (1.74, 36.60)	.317	.952	.053
Body fat (%)	26.57 ± 6.57	26.36 ± 6.67	26.48 ± 6.26	0.07 (1.29, 27.01)	.850	1.000	.003
Muscle mass (kg)	40.92 ± 3.16	41.02 ± 2.35	41.13 ± 2.58	0.27 (1.41, 29.69)	.684	1.000	.013
Chest circumference (cm)	88.70 ± 4.40	87.36 ± 4.18	86.73 ± 4.17	6.29 (1.47, 30.90)	.010	.041	.230
Waist circumference (cm)	73.16 ± 5.13	70.80 ± 4.19	71.00 ± 4.16	12.16 (1.94, 40.68)	<.001	<.001	.367
Abdominal circumference (cm)	83.55 ± 8.35	79.48 ± 7.29	78.23 ± 6.23	22.26 (1.39, 29.22)	<.001	<.001	.515
Hip circumference (cm)	98.36 ± 6.65	97.34 ± 5.82	97.14 ± 5.77	5.62 (1.88, 39.49)	.008	.041	.211
Upper-hip circumference (cm)	95.52 ± 5.73	94.32 ± 5.58	94.14 ± 5.26	11.19 (1.84, 38.58)	<.001	.001	.348
Leg circumference (cm)	55.27 ± 4.86	53.50 ± 4.08	53.02 ± 3.39	16.30 (1.31, 27.58)	<.001	.001	.437
Arm circumference (cm)	25.00 ± 2.51	24.43 ± 1.81	24.05 ± 1.77	8.35 (1.37, 28.76)	.004	.022	.284

Values are mean ± SD. GG=Greenhouse–Geisser. P_GG is the Greenhouse–Geisser-adjusted omnibus P value; P_Holm is Holm-adjusted across the 10 omnibus outcome tests. ηp^2=partial eta-squared.

Table 4

Bonferroni-Adjusted Paired Comparisons for Circumference Outcomes with Significant Omnibus Time Effects.

Outcome	Comparison	Mean reduction, cm [98.33% CI]	Adjusted P
Chest	Baseline vs week 4	1.34 [0.39, 2.29]	.004
	Baseline vs week 8	1.98 [0.23, 3.73]	.023
	Week 4 vs week 8	0.64 [-0.98, 2.25]	.953
Waist	Baseline vs week 4	2.36 [1.03, 3.70]	<.001
	Baseline vs week 8	2.16 [0.66, 3.66]	.004
	Week 4 vs week 8	-0.20 [-1.51, 1.10]	1.000
Abdomen	Baseline vs week 4	4.07 [1.87, 6.26]	<.001
	Baseline vs week 8	5.32 [2.61, 8.03]	<.001
	Week 4 vs week 8	1.25 [-0.15, 2.65]	.090
Hip	Baseline vs week 4	1.02 [-0.00, 2.05]	.051
	Baseline vs week 8	1.23 [0.10, 2.35]	.030
	Week 4 vs week 8	0.20 [-0.70, 1.10]	1.000
Upper-hip	Baseline vs week 4	1.20 [0.26, 2.14]	.009
	Baseline vs week 8	1.39 [0.65, 2.12]	<.001
	Week 4 vs week 8	0.18 [-0.61, 0.98]	1.000
Leg	Baseline vs week 4	1.77 [1.03, 2.52]	<.001
	Baseline vs week 8	2.25 [0.84, 3.66]	.001
	Week 4 vs week 8	0.48 [-0.51, 1.46]	.664
Arm	Baseline vs week 4	0.57 [-0.04, 1.18]	.075
	Baseline vs week 8	0.95 [0.18, 1.72]	.012
	Week 4 vs week 8	0.39 [-0.01, 0.78]	.054

Mean reductions are expressed as the first time point minus the second; positive values therefore indicate a smaller circumference at the later time point. Confidence intervals use 98.33% coverage to match Bonferroni adjustment across three pairwise comparisons within each outcome.

Sensitivity analysis

Friedman sensitivity analyses produced the same classification of outcomes as the primary repeated-measures analyses: body mass, body-fat percentage, and muscle mass were nonsignificant, whereas all seven circumference outcomes showed significant overall time effects. Bonferroni-adjusted Wilcoxon follow-up comparisons likewise supported the principal baseline-to-week-8 circumference findings. This concordance reduces concern that the main pattern was driven solely by the parametric model specification, although it does not address the design- and measurement-level limitations.

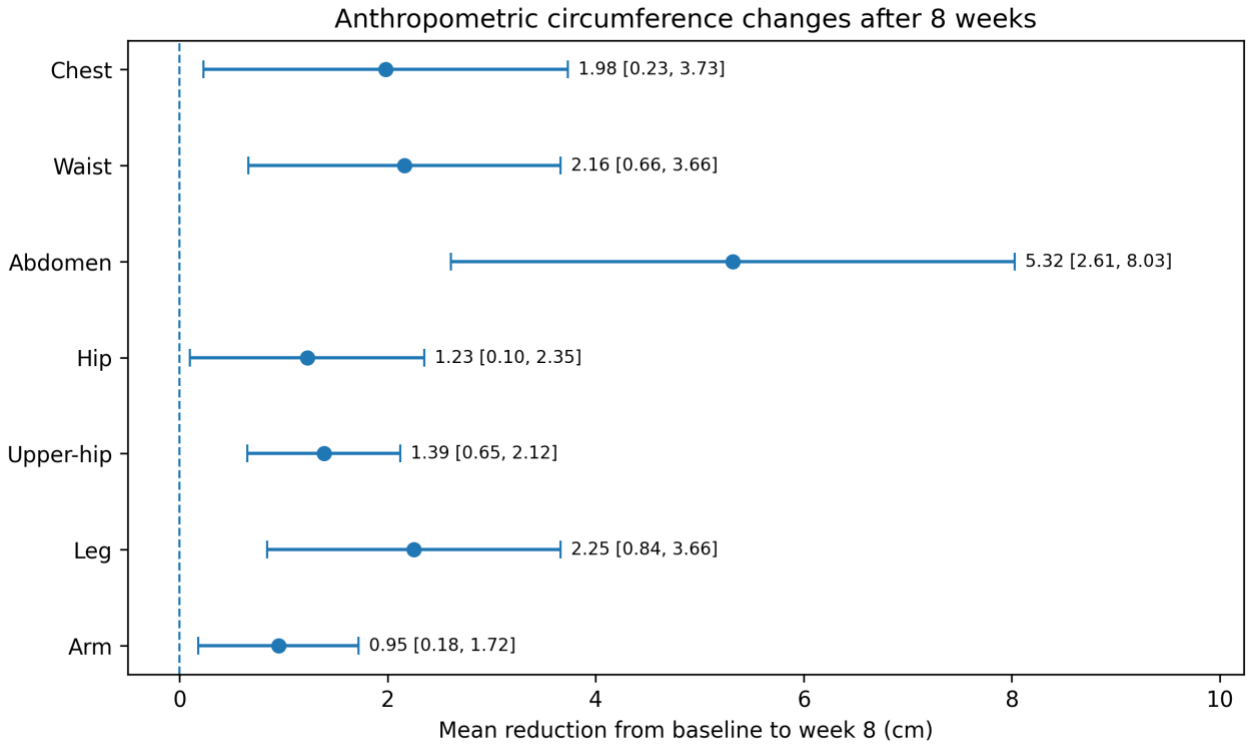


Figure 1. Baseline-to-week-8 changes in anthropometric circumferences.

Points represent mean paired reductions (baseline minus week 8) and error bars represent Bonferroni-compatible 98.33% confidence intervals. Positive values indicate smaller circumference at week 8. The dashed vertical line at zero represents no change. Inferential conclusions are based on the multiplicity-adjusted analyses in Tables 3 and 4.

Discussion

The principal finding was a dissociation between global bioimpedance-derived body-composition measures and tape-measured circumferences across the 8-week observation period. Body mass, body-fat percentage, and muscle mass showed no statistically significant time effects, whereas all seven circumference outcomes decreased over time and remained significant after Holm correction. The largest baseline-to-week-8 difference was observed for abdominal circumference (5.32 cm), which also had the largest omnibus partial η^2 (.515). Importantly, the study design does not permit attribution of these differences to Reformer Pilates alone; the results describe temporal within-participant patterns observed during an intervention period.

The absence of statistically detectable change in global body-composition outcomes is consistent with evidence showing variable responses in healthy or relatively lean populations. Silva et al. (2022) concluded that body-composition effects of Pilates in healthy individuals remain uncertain, whereas Wang et al. (2021) found clearer pooled effects in adults with overweight or obesity. In individual trials, Yılmaz et al. (2022), Kalkan Balak and Yürük (2024), Park et al. (2023), and Lim et al. (2026) reported limited or absent changes in several body-composition indices despite improvements in other domains. By contrast, Gökalp and Kırmızıgil (2025) reported favorable

changes in women with overweight or obesity after a higher weekly Reformer dose. The present sample had a mean baseline BMI of 21.26 kg/m² and received approximately 100–120 min of supervised training per week, which may have limited the scope for large changes in total body mass or global adiposity. This explanation remains speculative because diet, habitual physical activity, and energy balance were not monitored.

The circumference findings are broadly compatible with Reformer-specific research in previously non-training women. Akpınar Kocakulak and Özdemir (2024) reported reductions in multiple circumferences after four weeks of twice-weekly Reformer Pilates despite no significant change in body-fat percentage, and Yılmaz et al. (2022) identified waist circumference as a prominent anthropometric response despite limited change in global body-composition indices. In the present dataset, five circumference outcomes were already lower at week 4 than at baseline after multiplicity adjustment, whereas hip and arm met the adjusted criterion only at week 8. This pattern suggests that detectable differences relative to baseline can emerge early in some anatomical regions, but it does not establish that the intervention caused the change.

No week-4-to-week-8 pairwise comparison reached the Bonferroni-adjusted criterion. Several means continued numerically in the same direction, most notably abdominal circumference, but the additional differences were not statistically detectable under the prespecified multiplicity framework. The most defensible interpretation is therefore that much of the detectable difference relative to baseline was already present by week 4 and remained evident at week 8 for several measures. The results do not support a continuous month-by-month dose-response claim, nor do they prove that a true physiological plateau occurred after week 4.

The divergence between circumference and bioimpedance outcomes is biologically plausible but cannot be resolved with the available measurements. Reformer Pilates repeatedly challenges trunk stabilization, pelvic control, breathing coordination, postural alignment, and muscle activation. These adaptations could influence external body geometry or measurement position without representing equivalent regional adipose-tissue loss. Tape-measured circumference reflects adipose tissue, muscle, skeletal alignment, abdominal contents, respiratory phase, hydration, and measurement technique. Bioimpedance likewise provides indirect body-compartment estimates and is sensitive to device characteristics and premeasurement standardization (Ward, 2019; Prado et al., 2026). The current study did not quantify posture, regional tissue thickness, muscle architecture, or hydration, so mechanistic explanations remain hypotheses rather than demonstrated pathways.

Accordingly, reductions in abdominal or limb circumference should not be described as 'spot reduction' or regional fat loss. This caution is particularly important because the exact circumference landmarks, replicate-measurement procedures, tape characteristics, assessor reliability, and full bioimpedance protocol were not preserved in the source documentation, and the absence of this

information has direct, quantifiable consequences for how confidently the present findings can be interpreted.

For the circumference outcomes, published technical-error-of-measurement (TEM) data from trained fieldworkers in a large, quality-controlled anthropometric survey indicate a %TEM of approximately 2.4%–2.9% for waist circumference even under standardized conditions (Nel et al., 2024), corresponding to roughly 1.7–2.2 cm of expected measurement error at the mean waist circumference observed in the present sample. The baseline-to-week-8 reduction in waist circumference (2.16 cm) falls within this plausible measurement-error range, so this specific finding cannot be confidently distinguished from assessor- or protocol-related variability given that replicate measurements and assessor reliability were not documented here. The same reasoning applies, with even greater caution, to the smaller reductions observed for arm (0.95 cm), hip (1.23 cm), and upper-hip (1.39 cm) circumference, all of comparable or smaller magnitude than this benchmark. Abdomen-specific TEM data were not available, but using waist TEM as an approximate benchmark for trunk circumferences, the abdominal circumference reduction (5.32 cm) exceeds this expected measurement-error range by a factor of roughly two to three, making it comparatively more likely to reflect a real change in external body dimensions rather than measurement noise alone — although it still cannot be attributed specifically to adipose-tissue loss given the unmeasured contributions of posture, respiratory phase, and gastrointestinal content.

For the bioimpedance outcomes, the interpretive problem is different but equally important. Under tightly standardized laboratory conditions, multi-frequency bioimpedance devices can achieve very high test–retest reliability for body-fat percentage (intraclass correlation ≥ .998) (Looney et al., 2024), but high reliability does not imply high validity: the same analysis reported a mean bias of approximately −4.0 ± 2.8 percentage points for bioimpedance-derived body-fat percentage relative to dual-energy X-ray absorptiometry, and a recent commentary explicitly warns that consistent BIA readings can still be a "hidden driver of clinical misclassification" when electrode placement, body posture, and premeasurement protocol are not standardized across assessments (Potter et al., 2026). Because the present study used a single instrument across all three time points, a stable, device-specific systematic bias would be expected to cancel out when comparing within-participant change over time; the more consequential threat here is that premeasurement conditions — hydration, recent food or fluid intake, and timing relative to exercise — were not standardized across the baseline, week-4, and week-8 visits, introducing measurement noise that could vary unpredictably between assessments rather than as a constant offset. Given that the observed mean changes in body-fat percentage (0.09 percentage points) and muscle mass (0.21 kg) were an order of magnitude smaller than the reliability and bias figures reported for comparable multi-frequency devices even under standardized conditions, the nonsignificant time effects for these outcomes should be interpreted as

inconclusive with respect to true physiological stability rather than as evidence that no meaningful change occurred; the present protocol was very unlikely to have sufficient measurement precision to detect a change of the magnitude that would be biologically plausible over 8 weeks in this population.

The statistical approach improves interpretability but cannot compensate for these design constraints. Omnibus P values were Holm-adjusted across 10 outcomes, pairwise comparisons were Bonferroni-adjusted, adjusted confidence intervals were reported, and nonparametric sensitivity analyses reproduced the same overall classification. These procedures reduce the risk that the pattern reflects uncorrected multiplicity or a single parametric specification. Nevertheless, robust within-participant statistical change remains distinct from a controlled intervention effect.

Several limitations are central to interpretation. First, the absence of a concurrent non-exercise control group prevents separation of intervention-associated change from secular variation, dietary or activity changes, menstrual-cycle-related fluctuation, regression to the mean, measurement familiarization, or assessor drift. Second, although the achieved sample (n = 22) slightly exceeded the minimum indicated by the a priori power analysis (n = 21; see Methods), the sample was small and was drawn from a single university population, which limits precision for smaller-than-medium effects and constrains external validity to similar young, previously non-training populations. Third, participation in structured exercise rather than objectively measured physical activity was used for eligibility; therefore, the cohort cannot be assumed to meet a standardized sedentary-behavior definition. Fourth, several plausible confounding variables were not documented as controlled variables, and each could have influenced the observed pattern of results independently of the Reformer Pilates intervention itself. Free-living physical activity and dietary intake were not monitored, so any concurrent reduction in energy intake or increase in incidental daily activity outside the supervised sessions cannot be distinguished from a training effect; conversely, recent evidence indicates that structured exercise training can trigger substantial energy compensation through reduced resting energy expenditure, improved movement economy, and reductions in metabolically active organ volume that limits weight loss even when reported dietary intake is unchanged (Knaan et al., 2026), which offers a physiologically plausible, unmeasured explanation for the absence of a body-mass time effect in the present sample. Hydration status and time of day were not standardized before bioimpedance or circumference assessment, and both are known to shift fluid distribution and tissue tension acutely, so between-visit differences in fluid intake, recent caffeine or alcohol use, or assessment timing could introduce measurement noise unrelated to true tissue change. Menstrual-cycle phase was not recorded at any assessment. Although two recent controlled studies in eumenorrheic women without hormonal contraception found that bioimpedance and plethysmography-derived body-composition estimates menstrual cycle phase (Schröder et al., 2025; Stein-Brüggemann et al., 2025), those findings do not eliminate the possibility of cycle-related

influence on tape-measured abdominal or waist circumference specifically, which neither study examined and which is biologically plausible given cyclical fluid retention; the absence of cycle-phase data in the present study therefore leaves this source of variability unquantified rather than ruled out. Finally, timing of assessment relative to the most recent Reformer Pilates session was not documented, and acute post-exercise fluid shifts and localized muscle swelling can transiently alter both circumference and bioimpedance readings for up to 24–48 h after resistance-type loading; if assessments were not consistently scheduled relative to the preceding session across the three time points, this could have contributed to, rather than solely reflected, the circumference reductions attributed here to the intervention. Fifth, attendance/adherence, intervention fidelity, and adverse events were not available in the source records. Sixth, the exact InBody model and complete premeasurement standardization protocol were not preserved. Finally, the anatomical landmarks, replicate measurements, tape characteristics, assessor blinding, and intra-/inter-rater reliability for circumference measurements were not documented. Because the positive findings were circumference based, these measurement limitations are central rather than peripheral.

The study nevertheless has features that support cautious interpretation. Three repeated assessment points permit temporal characterization beyond a simple pre/post contrast; complete data were available for all participants; multiplicity was addressed at both omnibus and pairwise levels; effect sizes and confidence intervals were reported; and a nonparametric sensitivity analysis was used. Future studies should use randomized controlled designs, prospectively defined primary outcomes, preregistered analysis plans, adequately powered samples, standardized bioimpedance protocols, prespecified and reliability-tested anthropometric landmarks, and monitoring of diet, menstrual-cycle phase, habitual physical activity, hydration, session adherence, and adverse events. When regional body-composition change is a primary endpoint, DXA, ultrasound, or other validated imaging-based approaches are preferable to inferring tissue-specific change from circumference alone.

In practical terms, these exploratory findings indicate that visible or tape-measured changes in external body dimensions may not parallel scale weight or bioimpedance-derived fat and muscle estimates during a short Reformer Pilates program. That observation supports multidimensional assessment, but it should not be used to claim regional fat loss or a causal body-shaping effect. Controlled, well-standardized studies are required before such interpretations can be made.

Conclusion

Across an 8-week, twice-weekly Reformer Pilates program in 22 young women without regular exercise participation, body mass and bioimpedance-derived body-fat and muscle-mass estimates showed no statistically significant time effects, whereas several tape-measured body circumferences were lower at follow-up. The largest difference was observed for abdominal circumference, and most detectable differences relative to baseline were already evident by week 4.

Because the study lacked a concurrent control group and key standardization and reliability information for the anthropometric measurements was unavailable, these findings should be interpreted as exploratory within-participant temporal patterns rather than causal effects of Reformer Pilates or evidence of regional fat loss.

From a practical standpoint, these findings have several implications for exercise professionals and researchers working with young, previously non-training women. First, because circumference-based change was detectable while scale weight and bioimpedance-derived estimates were not, instructors and clinicians should calibrate client expectations accordingly: the absence of measurable change in body mass or bioimpedance indices during a short Reformer Pilates program does not mean the program produced no physically apparent effect, and conversely, a reduction in tape-measured circumference should not be presented to clients as evidence of regional fat loss or "spot reduction." Multidimensional outcome reporting — combining scale weight, bioimpedance estimates, and standardized circumferences — therefore offers a more complete and realistic picture of program-related change than any single measure alone. Second, because most detectable circumference differences were already present by week 4, practitioners monitoring client progress in similarly structured programs may reasonably schedule an interim anthropometric assessment at the program midpoint rather than waiting until completion, allowing earlier feedback without implying that the remaining weeks are ineffective. Third, unchanged bioimpedance and body-mass indices have not precluded other favorable adaptations in related Reformer Pilates research, including reductions in musculoskeletal pain and improved sleep quality (Şahan et al., 2025) and gains in cognitive performance (Özeren et al., 2024); body composition should therefore not be treated as the sole criterion for judging program value in lean, previously non-training populations, and functional, psychosocial, and cognitive outcomes may be equally relevant for this group. Finally, the measurement-related limitations identified here reinforce the need for standardized anthropometric protocols in future Reformer Pilates research: consistent, prespecified landmarks and measurement positions materially affect circumference values and their comparability over time (Benet et al., 2026), and their absence from the present study's source records limits the precision with which the observed reductions can be attributed to true tissue-level change rather than measurement variability. Controlled trials that combine standardized anthropometry with imaging-based body-composition methods and multidimensional outcome sets are needed before Reformer Pilates programs of this dose and duration can be recommended for body-shaping purposes in young, lean women.

Ethics Committee Approval

Ethics committee: Karabük University Rectorate, Non-Interventional Clinical Research Ethics Committee

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Author Contributions

All authors contributed equally to every stage of the study.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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