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Concurrent Exercise Training Adaptations Over 16 Weeks in Sedentary, Middle-Aged Adults With and Without Post-Exercise Peanut Butter Consumption

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Abstract

International Journal of Exercise Science 19(2): 2013, 2026. Maximizing training adaptations in athletes requires complex coordination of training and nutrition; however, beneficial health adaptations in middle-aged adults might not require the same complexity. Simple exercise and nutrition strategies might provide meaningful health benefits with minimal burden. Health guidelines recommend concurrent aerobic and resistance exercise several times per week. Middle-aged adults who meet these recommendations might benefit from an inexpensive, readily available post-exercise snack to support cardiorespiratory and strength adaptations. Peanuts are an accessible food source that contain protein and carbohydrates and might provide this. The purpose of this study was to determine whether post-exercise consumption of peanut butter could improve training adaptations in middle-aged adults. We hypothesized that adding peanut butter as a post-exercise nutrition source would improve lean mass, strength, and cardiorespiratory fitness to a greater extent than a carbohydrate-based snack. Seventeen adults (30–55 years), randomized to receive a peanut-containing smoothie (NUT) or an isocaloric, non-peanut carbohydrate-based smoothie (CON) after each workout, completed a 16-week concurrent training program. Body composition, cardiorespiratory fitness, and strength were assessed pre- and post-training. Total lean mass increased 4% with training (p= 0.008), however gains did not differ by group (CON 43.7 ± 6.7 kg to 45.5 ± 7.1 kg and NUT 43.6 ± 11.3 kg to 45.4 ± 13.5 kg; p= 0.97). Similarly, all strength measures improved but did not differ between groups. VO□ peak increased (CON 30.6 ± 2.8 ml/kg/min to 34.6 ± 6.6 ml/kg/min and NUT 29.7 ± 5.5 ml/kg/min to 32.0 ± 8.0 ml/kg*min; p= 0.02) and exercise tolerance improved (p< 0.001), with no group differences. Fat mass did not change. These results suggest peanut butter neither augments nor detracts from training-induced improvements in strength, lean mass, or cardiorespiratory fitness.

Keywords: Strength, nutrition, aging, cardiorespiratory fitness.

Introduction

Public health entities, including the American College of Sports Medicine (ACSM) and the American Heart Association (AHA), recognize beneficial physiologic adaptations to exercise training and provide recommendations for physical activity to decrease morbidity and premature mortality.[1] These recommendations include concurrent exercise training, resistance training twice per week, and aerobic exercise multiple times per week to accumulate 75 minutes of vigorous aerobic exercise or 150 minutes of moderate aerobic exercise. Meeting these recommendations improves cardiorespiratory fitness, increases muscle mass and strength, and decreases cardiovascular and metabolic disease risk.[2–5] Unfortunately, only 24% of adults in the

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United States meet the recommendations, and the number who do sharply declines after the age of 34, with lack of time cited as the reason for low physical activity levels.[6,7] Since training adaptations increasing longevity and functional independence into elder years occur even in those individuals who do not begin exercise programs until older ages, middle-age is an important time to establish consistent physical activity habits.[3,8]

Nutrition is an important factor in supporting exercise training adaptations, yet much of the existing literature emphasizes optimization of individual macronutrients and meal timing, often in the context of athletic performance. Carbohydrate and protein are essential to maximize beneficial adaptations like increasing muscle glycogen stores or increasing protein synthesis to increase muscle mass.[9,10] While these approaches are relevant for athletic performance optimization, they might not reflect the needs of the average, healthy, middle-aged adult engaging in exercise consistent with public health recommendations to improve overall health across a broad range of outcomes, from cardiovascular and metabolic health to muscle function.

In this context, whole foods studies are important to consider for overall health. While not specifically optimized for performance, whole foods supply the macronutrients needed for beneficial adaptations. The micronutrients they contain are also important dietary components that might be capable of enhancing the beneficial adaptations the macronutrients provide. For instance, protein from foods was determined to be as effective as whey protein at improving exercise performance and cardiometabolic health in overweight men and women in a 16-week concurrent exercise training program.[11] Similarly, increases in strength were augmented with whole-food protein consumption in a 12-week study in older adults.[12] Identifying whole foods that are inexpensive and accessible, but also capable of providing the building blocks for beneficial training adaptations, could lessen the barriers to entry into fitness and sports nutrition-related health.

Peanuts (including peanut butter made from whole peanuts) are one such candidate food. Peanuts are not often considered as an exercise snack, likely due to their higher fat content. 100 grams of peanuts is over 2500 kJ, containing ~49 grams of fat, but also ~16 grams of carbohydrate and ~26 grams of protein.[13] However, the protein and carbohydrate content might still provide the necessary composition for exercise training adaptations, and their other health benefits are well documented. Peanuts have proven beneficial to lessen cardiovascular disease risk and improve metabolic health and body composition. In both randomized, controlled trials and large prospective cohort studies, peanut consumption decreased cardiovascular disease risk, likely through changes in improved blood lipid profiles and lower oxidative stress, in the same order of magnitude that would be expected by exercise training.[14,15] Similarly, metabolic disease risk is lessened when peanuts are a component of the diet.[16] This lower metabolic risk could be due to improved glucose/insulin regulation or increased satiety leading to lower consumption of other, more calorie-dense, but less nutrient-rich foods throughout the day. Even in the case of individuals who consume excess calories in the form of peanuts, expected increases in body fat mass do not occur,[17] providing further evidence for positive metabolic outcomes with peanut consumption.

Despite the potential interaction of the health benefits of peanuts and physical activity, only recently has research focused on peanut consumption as a means to improve exercise-related outcomes. Existing studies primarily focus on resistance training. Older adults engaged in resistance training for 6 or 10 weeks, with peanut consumption.[18,19] Participants had small, but clinically significant increases in leg muscle size and strength compared to non-peanut-consuming participants.[18] Young, adult females did not have similar robust benefits with peanut consumption in a 10-week resistance training study, however there was a trend for increased lean mass.[19]

Research on aerobic exercise and peanut consumption is limited. Peanut consumption improves a single bout of moderate intensity, endurance performance.[20] However, the study design did not allow determination of the role of peanuts in the adaptations. The peanut group was the only group that consumed any calories in the previous 12 hours, which might have led to the improvement in performance. A decrease in oxidative stress was observed in the peanut group.[20]

Given the limited research examining peanut consumption in the context of exercise training, their potential impact on long-term adaptations to concurrent aerobic and resistance exercise remains unclear. While peanuts might not provide an optimal nutritional stimulus for performance-focused athletes, the exercise patterns of middle-aged adults hoping for improved health outcomes are likely not dependent on precise macronutrient optimization. Instead, practical and accessible nutrition strategies that provide sufficient energy and key macronutrients may be more relevant. In this context, peanuts may represent a viable whole-food option to support exercise training by supplying adequate carbohydrate and protein for individuals meeting public health physical activity recommendations of the ACSM and AHA.

Therefore, the purpose of this randomized, placebo-controlled trial was to determine whether consumption of peanut butter post-exercise further improved adaptations to concurrent aerobic and resistance training in middle-aged adults. We hypothesized that adding peanut butter as a post-exercise nutrition source would improve muscle strength, lean mass, cardiorespiratory fitness, and exercise tolerance to a greater extent than a standard carbohydrate-based snack.

Methods

Participants

Volunteers were recruited from the surrounding region. The minimum number of participants needed was calculated using a priori power analysis (Gpower version 3.1.9.7) for a desired power level of 0.80, alpha level of 0.05, and effect size based on strength differences between groups from a similar, previous study and determined to be ~12 per group.[21] Participants were 30–55 years old, healthy, had no exercise training in the previous 6 months, were not currently attempting to gain or lose weight, and did not require physician clearance prior to beginning an exercise program. Volunteers were excluded for neurological or musculoskeletal disorders, uncontrolled hypertension, unstable or exercise-induced angina pectoris, diabetes mellitus, any other medical condition that would interfere with testing or training; androgen (e.g., testosterone) or anabolic (e.g., growth hormone) therapy, food allergy to any nuts, or body mass index ≥ 32. Prior to any data collection, all participants were informed about the general purpose of the study (how post-workout nutrition affects exercise training adaptations), the procedures, and they signed an informed consent. This study was approved by the University Institutional Review Board (IRB# SP23_20) in accordance with the ethical standards set by the Helsinki Declaration. This research was carried out fully in accordance with the ethical standards of the *International Journal of Exercise Science*.[22]

Protocol

Health History & In-Person Pre-Screening: After signing informed consent, research participants completed a comprehensive health history questionnaire and resting blood pressure measurement. Participants with a resting blood pressure greater than 180/120, or those who disclosed health information or recent exercise training history that made them ineligible for the study, were not allowed to partake in the study.

Study Design: Participants exercised 4 days per week (2 days/week resistance, 2 days/week aerobic). After baseline testing, but prior to initiating training, each was randomly assigned to consume either a peanut-based snack (NUT) or an isocaloric, non-peanut carbohydrate-based snack (CON) immediately after each exercise session. A comprehensive cardiorespiratory and muscular strength assessment was conducted before training (Pre), after 8 weeks (Mid), and after 16 weeks (Post) of training (See Figure 1).

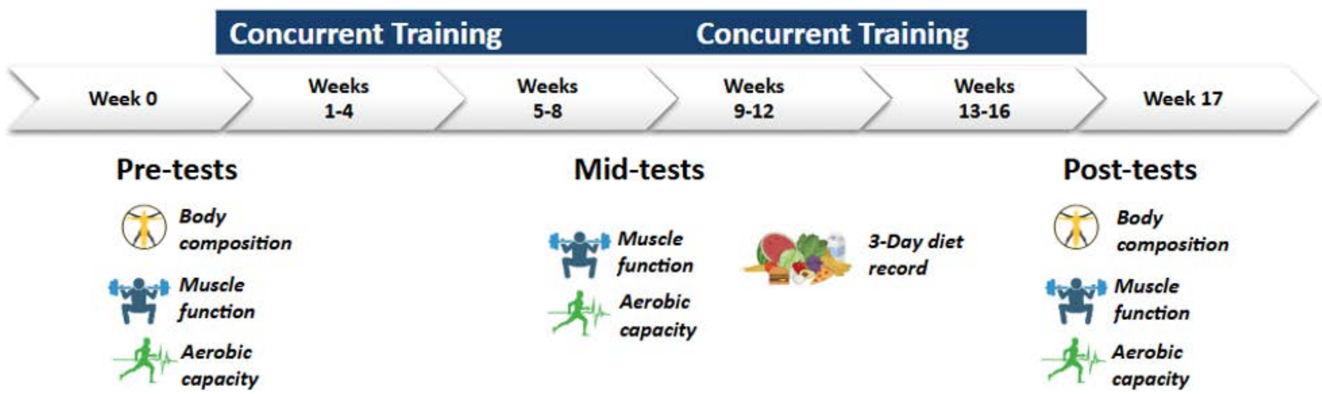

Figure 1. Research timeline overview.

Body Composition: Dual-energy X-ray absorptiometry (DXA, Lunar Prodigy with enCORE software version 18, GE Healthcare, Madison, WI, USA) was used to estimate percent body fat, total body fat mass, lean mass, and bone mass. Scans were performed prior to exercise testing and training and after completion of the 16-week training program.

Exercise Tests: Assessments took place over three days each separated by 48 hours. These tests, described below, occurred prior to training, after 8 weeks of training, and after 16 weeks of training. The first testing day's measurements included a maximal oxygen consumption test, a 20-minute rest, and then the grip strength and isometric knee extension tests. On the second testing day, participants completed a treadmill time to exhaustion test. On the third testing day, participants completed 1-repetition maximum testing (1-RM).

Cardiorespiratory fitness was assessed on a motorized treadmill (4Front, Woodway, Waukesha, WI, USA) by measuring participants' maximal oxygen consumption (VO_2 peak) in accordance with field standards.[23] Respiratory gases were collected and analyzed continuously by a face mask and two-way non-rebreathing valve (Hans Rudolph 2700, Shawnee, KS, USA) connected to a metabolic cart (ParvoMedics TrueOne2400, Salt Lake City, UT, USA) during a standardized, graded exercise test to exhaustion with one-minute stages. Heart rate was measured continuously throughout the test (Polar H10, Polar Electro Oy, Kempele, Finland). A treadmill running time-to-exhaustion test was administered at least 48 hours after the VO_2 peak test. Participants walked or ran on the treadmill at the same speed and grade as during their second-to-last completed stage of the pre-training VO_2 peak test and continued until they could no longer maintain the pace.

Muscle function measures were performed using established methods.[24] Dynamic, bilateral 1-RM strength on the leg press, knee extension, bench press, and overhead press were determined. Unilateral knee extension isometric maximum voluntary contraction (MVC) strength of each leg was assessed via a load cell attached to a fixed knee extension dynamometer (Model SGA, Interface, Scottsdale, AZ, USA) interfaced with analysis software (AcqKnowledge Biopac Systems Inc, Goleta, CA, USA). At least three trials were performed per participant with 90 seconds of rest between trials. Participants, in a seated position with their knees at 90 degrees, pushed against a leg pad as hard as possible. Maximal isometric torque was measured when no increase was seen from the previous trial after at least 3 trials. Isometric grip strength of both hands was determined at each timepoint (Handgrip dynamometer, PowerLab with LabChart Software, AD Instruments, Dunedin, New Zealand). In a seated position, with feet flat on the floor, and elbow at a 90-degree angle by their side, participants were instructed to squeeze the dynamometer as hard as possible. At least 3 trials were performed with 90 seconds of rest between trials. Once grip strength no longer increased from the previous attempt, the maximal force was recorded.

Exercise Training: The concurrent program was designed based on effective concurrent and resistance training protocols.[25,26] Aerobic exercise training occurred twice per week with at least 48 hours between sessions, with one session each week supervised in the laboratory fitness center by a trainer. Sessions were logged using wrist-based activity and heart rate sensors (participant-owned) or by a supplied heart rate monitor (Polar H10, Polar Electro Oy, Kempele, Finland). Participants were instructed to complete at least 75 minutes of a vigorous-intensity activity or 150 minutes of moderate-intensity activity of their choice (walking/running, cycling, swimming, etc.) over the two sessions (60–85% of heart rate reserve).

Resistance training occurred twice per week with at least 48 hours between sessions, and all resistance training sessions were supervised by a researcher in the fitness center. Eleven exercises (bench press, seated row, leg press, seated leg curl, shoulder press, assisted pull-ups, knee extension, seated calf raises, hip abduction, hip adduction, and abdominal crunches) were completed in each session. Sessions for weeks 1-4 and 9-12 consisted of a 3-set circuit of 8–12 repetitions per exercise, with the goal of completing at least 8 repetitions, but with enough resistance that no more than 12 repetitions could be completed per set. Sessions for weeks 5-8 and 13-16 consisted of the same 3-set circuit, but with increased resistance such that no more than 8 repetitions could be completed before fatigue. Mass lifted for each exercise was increased when participants could complete the maximum number of repetitions per set without fatiguing. Participants who did not complete at least 85% of sessions each 4-weeks were removed from the study.

Peanut Nutrition Supplement: Immediately following each exercise session, participants consumed a 250-350 ml smoothie. Smoothies contained 35.2 kJ (8.4 kcal) per kilogram of the participant's lean mass. Participants randomized to the peanut consumption group had smoothies that included peanut butter (JIF Natural, J.M. Smucker Company, Orrville, OH, USA), organic oat milk powder (Hoosier Hill Farm, Fort Wayne, IN, USA), rice milk (Zimmermann Sport Nutrition, Neu-Olm, Germany), and flavored sucrose packets of their choice for palatability (e.g., chocolate or berry: Nestle, Vevey Switzerland). A placebo smoothie (also 35.2 kJ/kg lean mass) containing all ingredients except peanut butter was provided to control group participants. Each week, ingredients to mix the smoothies were provided to all participants for their once-per-week unsupervised exercise session.

Nutritional Analysis: Each participant was instructed to record dietary intake using a 3-day diet record between weeks 9 and 12 of training. Participants logged two weekdays and one weekend day. Data from diet records were analyzed with diet analysis software (NutritionistPro 8.1, Axxya Systems, Woodinville, WA, USA) to determine differences in dietary intake between groups.

Statistical Analysis

Descriptive statistics (mean ± SD) were calculated for all dependent variables. Welch's independent *t-tests* were used to compare groups on demographic characteristics after randomization and on diet composition. A two-way, repeated measures ANOVA was used to examine the effects of time, pre-training vs. mid-point, vs. post-training (PRE, MID, POST) and group (NUT v. CON) on body composition, VO_2 peak, TTE, and 1-RM strength measures, including interaction effects between time and group. Holm post-hoc analysis was used for pairwise comparisons to identify specific differences between timepoints based on groups. A probability level of $p \leq 0.05$ denoted statistical significance. Effect sizes were calculated using Cohen's *d* or partial eta-squared, η_p^2. Cohen's d was interpreted as ~0.2 = small effect, ~0.5 = moderate effect, and ≥ 0.8 = large effect, and η_p^2 as 0.01 = small effect, 0.06 medium effect, and 0.14 large effect. Statistical analyses were performed using Jeffreys' Amazing Statistical Package (JASP).

Results

Thirty-five participants consented and were enrolled in the study. Five participants failed the final screening (abnormal blood pressure or provided evidence of medication use, or recent exercise training), so 30 participants were randomized to a group and started training. Seventeen completed all exercise training and testing time points (Figure 2) for an attrition rate over the 16 weeks of ~43%.

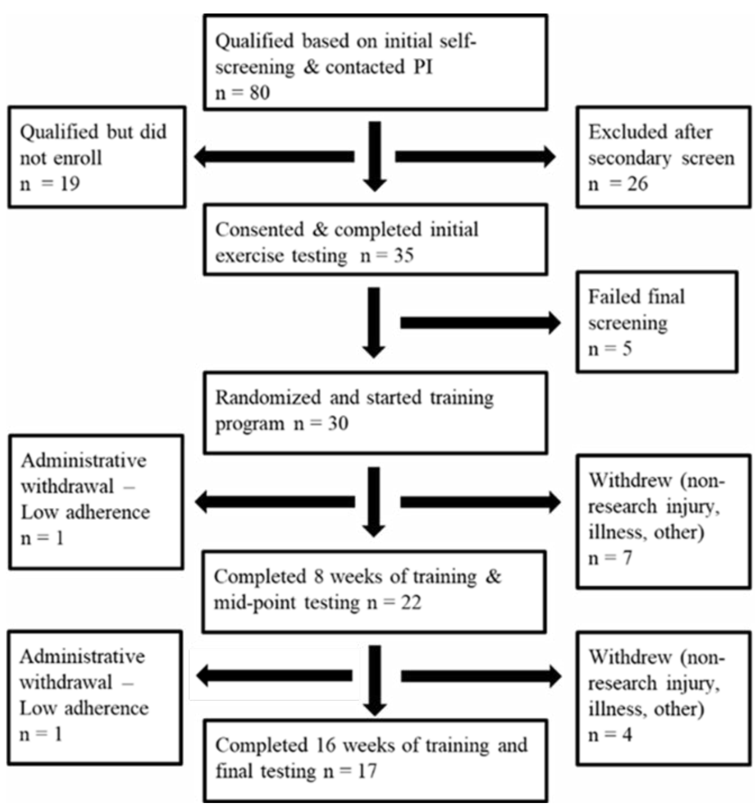

Figure 2. CONSORT diagram depicting research volunteer flow.

Of the 17 participants, ten (Male = 4, Female = 6) had been randomly assigned to the NUT group, and seven (Male = 3, Female = 4) had been randomly assigned to the matched, non-peanut nutrition CON group. No significant differences in demographic characteristics existed between groups prior to the onset of training (Table 1).

Table 1. Participant Demographics (Pre-Training). Mean ± Standard Deviation. No significant differences between groups.

	CON	NUT
n (M:F)	7 (3:4)	10 (4:6)
Age (years)	41.1 ± 7.8	41.6 ± 5.9
Height (m)	1.65 ± 0.07	1.66 ± 0.12
Body Mass (kg)	71.2 ± 8.5	72.5 ± 19.9
Lean Mass (kg)	43.8 ± 6.7	43.7 ± 11.3
% Fat	36.0 ± 4.7	36.4 ± 4.9
VO_2Peak (ml/kg*min)	30.6 ± 2.8	29.7 ± 5.5

Adherence & Nutritional Analysis

Total scheduled training days for the 16 weeks were 544; 136 supervised aerobic, 136 at home aerobic and 272 supervised resistance. Participants who completed all 16 weeks of the study had an adherence rate for resistance training sessions of 96%, with participants completing 260 of 272 expected sessions. There was an adherence rate of 89% for aerobic sessions, with participants completing 241 of 272 expected sessions (including supervised and self-reported at-home). Mean duration of aerobic exercise was 39.9 ± 22.0 minutes. Mean heart rate during supervised and self-reported at-home aerobic sessions was 140.8 ± 14.1 beats per minute (~65% of heart rate reserve).

The post-exercise nutrition was consumed after all supervised sessions, and was self-reported as greater than 95% consumed after at home sessions. The mean composition of CON smoothie was 1740 kJ (416 kcal), 3.1 grams fat, 92.4 grams carbohydrate, and 3.6 grams protein. The mean composition of the NUT smoothie was 1695 kJ (405 kcal), 23.0 grams fat, 40.8 grams carbohydrate, and 12.2 grams of protein. Analysis of the 3-day diet record indicated no differences between groups in total energy consumption, NUT 123.0 ± 58.0 kJ/kg vs. CON 109.6 ± 59.0 kJ/kg (t(12.92) = 0.46, p= 0.65, d= 0.23) or protein consumption NUT 1.03 ± 0.50 g/kg vs CON 1.16 ± 0.60 g/kg (t(11.45) = 0.47, p= 0.65, d= 0.24).

Body Composition Results

Results of the body composition analysis are visualized in Figure 3. Lean mass of participants who completed the 16-week exercise training program (n = 17) increased significantly by 3.9% ($F_{(1,15)}$ = 9.29, p= 0.008, η_p^2 = 0.38) with no differences between the CON and NUT groups ($F_{(1,15)}$ = 0.01, p= 0.972, $\eta_p^2 < 0.001$). There was no significant interaction between group and training status. Body fat percentage was not significantly different due to training ($F_{(1,15)}$ = 1.694, p= 0.213, η_p^2 = 0.003), and there was no interaction between training status and group ($F_{(1,15)}$ = 0.81, p= 0.38, η_p^2 = 0.001).

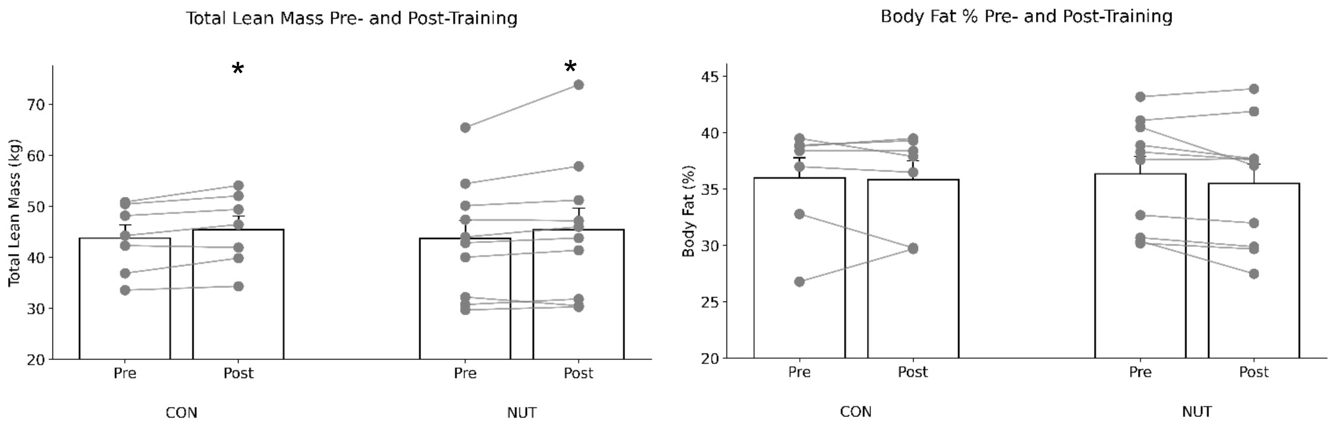

Figure 3. Total lean mass and body fat percentage before (Pre) and after (Post) 16-weeks of exercise training with consumption of a peanut (NUT) smoothie or an isocaloric, non-peanut containing carbohydrate-based smoothie (CON). * Indicates the final timepoint for the group (p< 0.05). No significant differences between groups.

Cardiorespiratory Fitness and Exercise Tolerance Results

Pre-training, mid-point, and final time point cardiorespiratory fitness tests are shown in Figure 4. The maximal oxygen consumption test (VO_2peak) indicated that cardiorespiratory fitness increased by 10.5% (30.0 ml/kg*min to 33.1 ml/kg*min) after 16 weeks of training ($F_{(2,30)}$ = 4.28, p= 0.02, η_p^2 = 0.22). There was no interaction of VO_2peak and training timepoint between groups, and CON and NUT groups were not significantly different.

A main effect of training on time to exhaustion (TTE) ($F_{(2,28)}$ = 20.29, p< 0.001, η_p^2 = 0.59) indicated that exercise tolerance improved due to training after 16 weeks. TTE improved due to training by 98% in the CON group and 152% in the NUT group. No significant interaction occurred between training and group, however post-hoc analysis of the main effect showed the NUT group significantly improved TTE by the mid-point (p= 0.02) and further improved TTE at the final time after training compared to initial (p< 0.001). The control group mid-point TTE was not significantly higher than the pre-training TTE (p= 0.26) but was significantly higher by the post-training time point (p= 0.04).

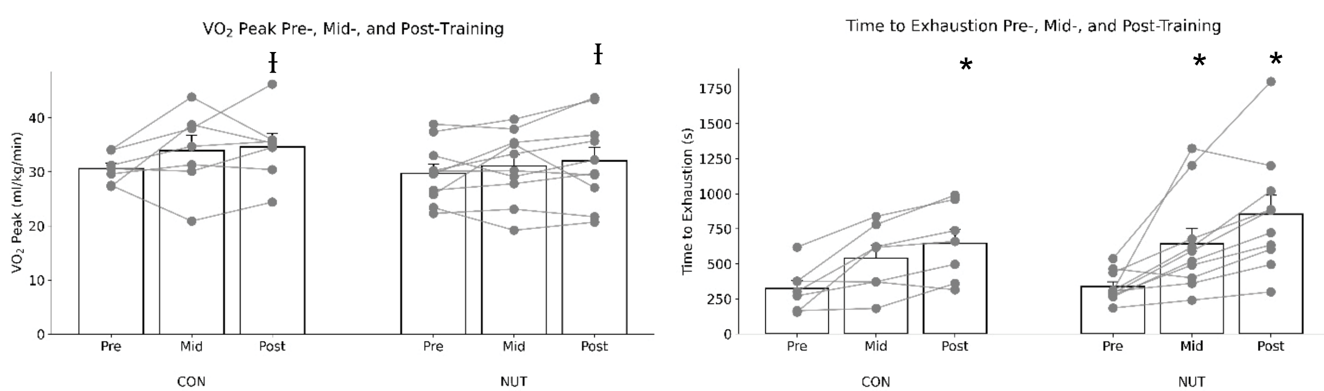

Figure 4. Cardiorespiratory fitness measures pre-training (Pre), after 8-weeks (Mid) and after (Post) of exercise training between NUT and CON nutrition groups. * Indicates the timepoint is significantly different from the initial timepoint. □ indicates combined groups significantly different from initial timepoint (p< 0.05). No significant differences between groups.

Strength Testing Results

Pre-training, mid-point, and final time point 1-RM strength tests, including bench press, shoulder press, leg press, and knee extension, are visualized in Figure 5. No significant differences were observed in left or right grip strength over the course of the study (Data not shown). Strength significantly improved after training in all other measures in both groups. There was a significant main effect of training on bench press ($F_{(2,30)}$ = 62.2, p< 0.001, η_p^2 = 0.81) and leg press ($F_{(2,30)}$ = 46.2, p< 0.001, η_p^2 = 0.76). Post-hoc comparisons showed that bench press and leg press each increased significantly in the NUT group after 8-weeks of training (p= 0.001) and also significantly improved from 8-weeks to of training (p= 0.01) The CON group bench press increased from initial to mid-point (p= 0.02), and showed an increasing trend from the respective timepoints in leg press (p= 0.07 and p= 0.10 respectively). There was no significant interaction between groups or differences between groups at any time point in either strength measure.

There was a main effect of training on 1-RM shoulder press ($F_{(2,30)}$ = 12.15, p< 0.001, η_p^2 = 0.45). Post- hoc comparisons showed that shoulder press did not significantly increase after 8-weeks but was significantly higher than initial after 16 weeks in both groups. There was no significant interaction or group differences.

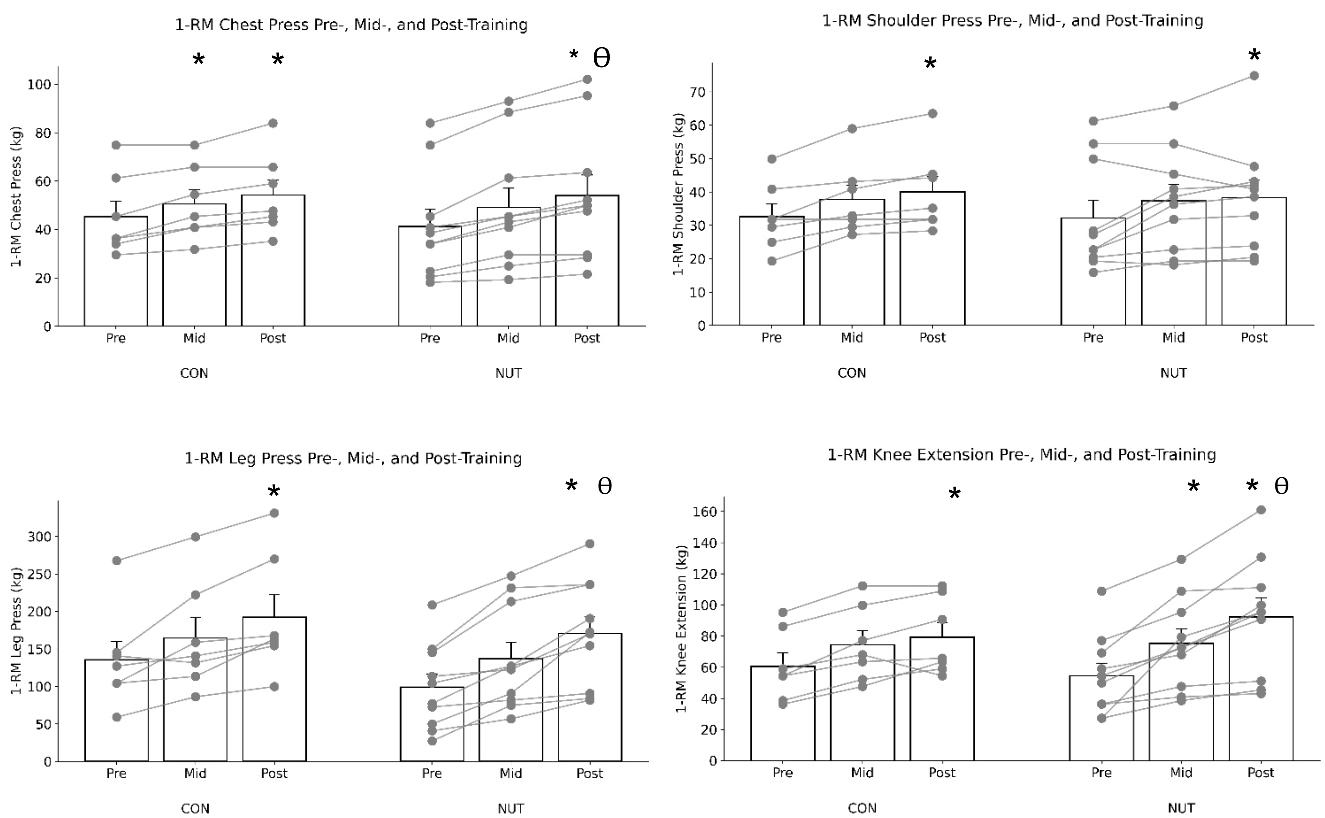

Figure 5. Strength 1-RM measures pre-training, after 8-weeks, and post-training of exercise training between NUT and CON nutrition groups. * Indicates the time point is significantly different from Pre-training. θ indicates significantly different from mid-point. There is a significant group by timepoint interaction in knee extension, otherwise there were no significant differences between groups. (p< 0.05).

There was also a significant main effect of training on 1-RM knee extension strength ($F_{(2,30)}$ = 35.3, p< 0.001, η_p^2 = 0.70) with a significant group by training interaction ($F_{(2,30)}$ = 4.10, p= 0.03, η_p^2 =

0.22). Post-hoc comparisons indicate that the NUT group significantly increased from initial to mid-point (p< 0.001), and from mid-point to final (p< 0.001), while the CON group only had a significant increase from initial to final (p= 0.02). Isometric knee extension measures responded similarly with significantly more torque at the final time point in both CON and NUT ($F_{(2,30)}$ = 7.34, p= 0.002, η_p^2 = 0.33), but no differences between groups (data not shown).

Discussion

The purpose of this study was to determine whether consumption of peanut butter as a post-exercise nutrition source augments adaptations to a 16-week concurrent aerobic and resistance training program in healthy, middle-aged adults. Contrary to our hypothesis, post-exercise peanut consumption did not enhance training-induced improvements in lean mass, muscular strength, cardiorespiratory fitness, or exercise tolerance when compared to an isocaloric, carbohydrate-based snack. All participants who completed the program demonstrated significant improvements across the measured outcomes, indicating that the exercise prescription itself was sufficient to elicit substantial health-related adaptations.

Across both groups, cardiorespiratory fitness improved by ~10%, exercise tolerance improved by ~122%, upper body strength improved by over 20%, and lower body strength improved by over 50%, along with a 4% gain in lean mass. The magnitude of these changes is consistent with prior investigations examining concurrent training programs in previously sedentary, middle-aged adults.[25] The lean mass gains are comparable to those reported in studies utilizing isolated protein supplementation in conjunction with resistance or concurrent training.[27] This finding is notable given that the smoothies provided substantially less protein than typical whey-based supplements, and the peanut butter smoothies had a much higher proportion of dietary fat. These results align with evidence that whole-food protein sources can support training adaptations similarly to isolated protein supplements when total dietary protein intake is sufficient.[11] The absence of between-group differences here and in other studies suggests that, under conditions where total energy intake and habitual protein intake are adequate, the macronutrient composition of a post-exercise snack may be of secondary importance for broad health-related training outcomes.[28,29]

Few studies have examined the role of peanuts in exercise training adaptations. Peanut protein did not significantly enhance resistance training adaptations in younger adults, although positive trends were observed in some measures.[19] A resistance training study in older adults reported modest but significant improvements in muscle size and strength with peanut protein.[18] In contrast, the present study did not observe greater beneficial adaptations with peanut consumption. The shorter duration of training in the previous studies (6-10 weeks) was noted as a limitation; however, even with the longer duration of the present study (16 weeks), no differences between groups emerged. Other possible cause for the discrepancy could be due to differences in participant age or in the training program (e.g., the concurrent nature of this exercise program). Additionally, the previous training studies utilized defatted peanut protein instead of whole peanuts, as found in peanut butter. Importantly in this study, peanut consumption did not adversely affect body composition, despite a higher fat content in the NUT smoothie. Fat mass and body fat percentage remained unchanged across both groups, consistent with previous evidence showing that nut consumption does not promote fat gain, even when energy intake increases.[17]

Several limitations should be acknowledged. First, the study was not blinded. Although participants were not informed that the study specifically examined peanuts, those in the NUT group were aware of peanut butter consumption due to the provided ingredients. However, perceived group assignment bias was likely minimal, as a majority of control participants (71%) believed they were consuming peanuts, possibly due to the "nutty" flavor of oat milk powder.

Second, dietary intake was assessed using a single 3-day diet record during the intervention. While this method is commonly used, it may not reflect habitual intake across the full 16-week training period and is subject to underreporting and recall bias.[30] At least two participants reported average intake of ~ 4000 kJ/day, of which the post-exercise nutrition would have been one-third of their daily intake. Despite this, stable body mass throughout the intervention suggests participants were near energy balance, supporting the validity of the dietary comparisons, despite the limitations of self-reporting.

Third, the attrition rate (~43%) was higher than anticipated despite the relatively low time commitment of the program (< 3 hours per week). This potentially left the study underpowered. However, differences between groups were minimal, so even achieving the desired group numbers would not be likely to affect the overall conclusions. While this attrition rate is relatively high compared to research study interventions,[31] similar dropout rates have been reported in community-based exercise interventions among middle-aged adults.[32] Work and family obligations are often reported as too demanding on time, and while data were not collected on these factors for this study, anecdotally, these were provided as reasons for discontinuing. This further highlights barriers to long-term exercise adherence and underscores the importance of identifying simple, accessible activity and nutrition strategies that do not add additional burden.

From a practical standpoint, these findings suggest that peanut butter is a viable post-exercise nutrition option for middle-aged adults engaging in exercise consistent with public health guidelines. Notably, the longer duration of the study (16 weeks) compared to most exercise-training studies allowed sufficient time for meaningful strength and cardiorespiratory adaptations to occur. While peanut butter did not enhance training adaptations beyond those achieved with a carbohydrate-based snack, it also did not attenuate gains in lean mass, strength, or cardiorespiratory fitness. Given the low cost, availability, long shelf-life, and established cardiometabolic benefits, peanuts, whole or as peanut butter, may represent a pragmatic alternative to more expensive or highly processed supplements.

Future research should examine whether peanut consumption influences muscle protein synthesis or degradation, recovery, inflammation, or metabolic health markers during training, particularly in populations with elevated cardiometabolic risk. Additionally, larger trials powered to detect smaller between-group differences, or studies incorporating different training volumes or intensities, might further clarify which whole-food post-exercise nutrition is most beneficial.

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In the spirit of accountability & healing, we collectively acknowledge that Southwestern University is located within the traditional, ancestral, and contemporary lands of Native peoples. The University resides on land that was cared for and called home by the sovereign nations of the Tonkawa, Comanche and Jumano people. This land still holds great historical, spiritual, and personal significance for its original stewards.

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