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Original Article

The Effects of L-Carnitine Supplementation During Concurrent Training on the Functional Capacities and Body Composition in Obese Men

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Abstract

Background Despite extensive research, the effects of L-carnitine supplementation in treating obesity are still unclear and equivocal. L-carnitine transports fatty acids into mitochondria for oxidation and is marketed as a weight loss supplement. The purpose of the present research is to investigate the efficacy of L-carnitine during concurrent training on the functional capacities and body composition in obese men.

Methods Thirty nonactive, obese males (age = 37.2 ± 1.5 years; body mass index = 33.8 ± 2.5 kg/m^2) participated in this research. The participants were randomly divided into three groups: experimental group 1 (EXP1)—concurrent training with L-carnitine supplementation; experimental group 2 (EXP2)—L-carnitine supplementation without training; and control group—without training or L-carnitine supplementation. Concurrent training was performed for 8 weeks, three sessions per week, with a training intensity ranging from 60 to 75% of the maximum heart rate reserve and one-repetition maximum. Both experimental groups were supplemented with 35 mg L-carnitine supplement per kilogram body weight. Various functional and body composition variables were collected at three time points (pre-test, mid-test, and post-test).

Results A number of variables were significantly improved in EXP1 after 4 and 8 weeks (systolic blood pressure, maximal oxygen consumption, weight, body mass index, and one-repetition maximum) and only after 8-weeks (diastolic blood pressure, resting heart rate, percentage of body fat, and fat-free mass). No significant changes were observed for EXP2 and the control group.

Conclusion L-carnitine supplementation, in conjunction with concurrent training, emerges as a highly effective approach for enhancing body composition and boosting functional capacities in obese adult men. Therefore, it is recommended that overweight male individuals integrate concurrent training into their regimen while taking L-carnitine.

Keywords

- L-carnitine
- Exercise Training
- Body Composition
- one-repetition maximum

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Introduction

Overweight and obesity are considered as major health concerns all around the world; in addition, they play a great role in the progression of several noncommunicable diseases, including diabetes, cardiovascular diseases, and cancer.[1] The etiology of obesity is closely related with a reduction in habitual physical activity, physical fitness levels, and everyday mobility. Among the various factors contributing to the excess of body fat over time, significant attention has been directed toward insufficient engagement in physical activity as a behavior that can predispose individuals to a positive energy balance. Consequently, it is important to recognize physical inactivity as an essential determinant in the context of weight gain and onset of obesity.[2]

L-carnitine is an amino acid–like compound that plays a role in energy metabolism by supporting transport of fatty acids into the mitochondria, where they can be used for energy production through β-oxidation.[3] L-carnitine is essential for the transfer of long-chain fatty acids across the inner mitochondrial membrane for subsequent β-oxidation.[4] Therefore, without carnitine most of the dietary lipids cannot be used as an energy source and our body would accumulate fatty acids promoting obesity.[5] L-carnitine might decrease body weight through a variety of mechanisms—improving insulin resistance and decreasing appetite and food intake through a direct effect on hypothalamus. L-carnitine transports fatty acids into the mitochondria for oxidation and is marketed as a weight loss supplement.[6]

Nevertheless, previous clinical studies reported inconsistent data regarding the effects of L-carnitine supplementation on obesity-related indexes. A previous meta-analysis conducted by Pooyandjoo et al[7] showed that L-carnitine supplementation significantly decreases body weight and body mass index (BMI) compared with controls. In addition, in a double-blind, randomized, and placebo-controlled treatment[8] found that 12 weeks of L-carnitine supplementation combined with concurrent training resulted in significant improvements in body composition (reduced body fat percentage [BF%] and increased lean mass) and functional capacities (increased muscular strength and endurance) compared to concurrent training alone in obese men. Similarly, one study reported that L-carnitine supplementation could lead to significantly increased muscle mass accompanied by a decrease in body weight and reduced physical and mental fatigue.[9] Another study conducted by Talenezhad et al[1] investigated the effect of L-carnitine on weight loss in adults. The authors reported significant reductions in fat mass, body weight, and BMI compared with the control group, especially among overweight/obese adults.

However, certain authors have reported conflicting outcomes. In a recent comprehensive systematic review and dose-response meta-analysis of randomized controlled trials conducted by Askarpour et al,[10] the researchers found that L-carnitine supplementation did not ensure a significant impact on BF% or waist circumference among overweight or obese adults. It is essential to acknowledge that the individual response to L-carnitine supplementation can be influenced by factors such as dietary habits and exercise intensity. The authors proposed that the diversity in study design and lack of evidence to determine the optimal dosage and duration of L-carnitine supplementation may contribute to the inconsistencies in results concerning weight loss and the facilitation of lipid oxidation, primarily involving the transport of long-chain fatty acids into the inner mitochondrial region.[11]

We hypothesized that supplementation with L-carnitine during 8 weeks will result in a significant improvement in functional and body composition variables in obese individuals who are engaged in concurrent training. This study therefore aimed to examine the effect of L-carnitine supplementation on functional capacities and body composition in obese men during concurrent training.

Materials and Methods

Study Design

This semi-experimental research study employed purposive sampling to select participants based on specific criteria. Subsequently, the participants were allocated into three groups using the systematic random grouping method, ensuring an equal distribution of male subjects across each group. The experimental groups received L-carnitine supplementation (BioTechUSA, L-Carnitine 1,000 mg) 30 minutes prior to each exercise session, administered at a dosage of 35 mg/kg of body weight. This supplementation occurred three times per week over an 8-week period, with L-carnitine dissolved in distilled water.[12]

Obtaining written consent from study participants was a crucial step, involving a comprehensive explanation of the research objectives and methods. This process aimed to ensure participants' thorough comprehension of the study, enabling an informed decision regarding their involvement. Participants were familiarized with various aspects, including concurrent training, research characteristics, variable measurement, training protocol, pretest, midtest, and posttest procedures, as well as instructions, possibilities, and limitations related to the research time and location.

The participants engaged in both strength and endurance programs on the same day, with aerobic sessions preceding strength sessions. Training sessions occurred on Mondays, Wednesdays, and Fridays or Saturdays, all meticulously supervised by a minimum of two experienced personal trainers. Variable measurements were conducted for all groups before the study initiation, at the 4-week mark, and at the conclusion of the 8-week period. The study protocol comprised three sessions per week, each lasting 70 to 85 minutes, maintaining an intensity of 60 to 75% of maximal heart rate reserve (HRR) and one-repetition maximum (1RM). The concurrent training protocol, integrating strength and endurance training, commenced in the first week at 60% HRR and 1RM for 70 minutes, progressively increasing to 85 minutes with 75% maximum HRR and 1RM by the conclusion of the study. This progression involved the addition of 5 minutes to the duration and a 5% intensity increase every 2 weeks (refer to ►**Tables 1** and **2**).

Table 1 Training protocol (concurrent training)

Week	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Warmup (min)	5	5	5	5	5	5	5	5
CT	30 min, R + 30 min, RT	30 min, R + 30 min, RT	30 min, R + 35 min, RT	30 min, R + 35 min, RT	35 min, R + 35 min, RT	35 min, R + 35 min, RT	35 min, R + 40 min, RT	35 min, R + 40 min, RT
Duration (min)	60	60	65	65	70	70	75	75
Intensity (%)	60	60	65	65	70	70	75	75
Cooldown (min)	5	5	5	5	5	5	5	5
Total (min)	70	70	75	75	80	80	85	85

Abbreviations: CT; concurrent training; R, running; RT, resistance training.

Sample Size and Sampling Techniques

The study employed the purposive sampling technique to select participants based on predetermined criteria. The inclusion criteria specified sedentary males aged between 35 and 40 years with a BMI within the range of 30 to 35 kg/m^2. Recruitment occurred in the Behshahr city area in Iran through direct outreach and advertising. The exclusion criteria included allergies to L-carnitine, a lack of recent physical activity, chronic illnesses, and medication use. Prospective participants were also required to have refrained from engaging in conditioning exercises exceeding 2 hours per week for the 6 months preceding the study.

Initially, 35 sedentary males were recruited based on the sampling technique and criteria. However, five individuals withdrew from the study for reasons unrelated to the research. Consequently, a cohort of 30 males, with a mean weight of 106.48 $\pm$ 11.78 kg, height of 1.77 $\pm$ 0.08 m, BMI of 33.83 $\pm$ 2.52 kg/m^2, and an average age of 37.22 $\pm$ 1.49 years, were enrolled. These participants were randomly assigned to one of three groups: experimental group 1 (L-carnitine + 8 weeks of training), experimental group 2 (L-carnitine + no training), and control group (no L-carnitine + no training). Participant demographics and characteristics are detailed in ►**Table 3**.

Experimental Measurements and Materials for Data Collection

Resting heart rate (RHR) was assessed in beats per minute using the Polar RS400 Heart Rate Monitor following a 10-minute rest period in the supine position, adhering to standard protocols. Subsequently, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were determined in millimeters of mercury through examination of the brachial artery, utilizing a mercurial sphygmomanometer (blood pressure monitor Model BP380A), in accordance with established clinical procedures.[13] Oxygen saturation was quantified employing pulse oximetry (AccuMed CMS-50DL Fingertip Pulse Oximeter Blood Oxygen SpO2 Sports and Aviation Fingertip Monitor), a measure reflecting the proportion of oxygen-carrying hemoglobin in the blood relative to non-oxygen-carrying hemoglobin.[14]

Maximal oxygen consumption (VO_2 max) was determined through a continuous treadmill test for exhaustion on a motorized treadmill, employing the modified Bruce protocol.[15] The treadmill speed was adjusted during the warmup phase to achieve a heart rate of approximately 70% of the predicted maximal heart rate. Subsequently, the treadmill speed remained constant, and the treadmill grade increased by 2% every 2 minutes until volitional fatigue. To estimate the

Table 2 Resistance training

Training sessions	Training movements			
Chest, biceps, triceps (first session)	Bench press, incline barbell bench press, machine fly, triceps pushdown, biceps barbell curl			
Shoulder, back (second session)	Lateral dumbbell raises, dumbbell shoulder press, lift dumbbell, lateral pulldown, seated pulley row			
Leg, abdominal (third session)	45-degree leg press, machine leg extension, machine leg flexion, ball crunch, side bend			
Week	**Set**	**Repeat**	**1RM**	**Rest between sets**
First and second	3	12–14	60%	30 s–1 min
Third and fourth	3	12–14	65%	30 s–1 min
Fifth and sixth	3	12–14	70%	30 s–1 min
Seventh and eighth	4	13–15	75%	1–2 min

Table 3 Participant characteristics

Participant characteristics	EX G1	EX G2	C G
Sample size	10	10	10
Age (y)	37.34 ± 1.44	37.38 ± 1.59	36.94 ± 1.55
Height (m)	1.78 ± 0.83	1.75 ± 0.92	1.78 ± 0.87
Weight (kg)	104.86 ± 12.66	104.73 ± 12.04	109.85 ± 11.1
BMI (kg/m^2)	32.85 ± 1.93	33.93 ± 1.76	34.73 ± 3.41
1RM	153.4 ± 4.14	155.6 ± 5.29	152.4 ± 5.16

Abbreviations: EX G1, experimental group 1; EX G2, experimental group 2; C G, control group; BMI, body mass index; 1RM; one-repetition maximum.
Note: All values are presented as mean ± standard deviation.

1RM strength, the participants underwent an 8- to 10-minute warmup, and the test was conducted under the supervision of a researcher. The 1RM for chest press and leg press was recorded and estimated using the formula proposed by Brzycki.[16]

Bioelectrical impedance (BIA) analysis was employed to estimate the body composition, involving the passage of a weak electric current through the body, with voltage measurements used to calculate body impedance (resistance). The Tanita TBF-300 Body Composition Analyzer was utilized to measure variables such as weight, BMI, BF%, and fat-free mass (FFM).[16,17] Body height and weight measurements were obtained using a calibrated height–weight digital balance beam scale, with recordings in meters and kilograms, respectively.[18]

Statistical Analysis

All data were set as mean ± standard deviation (SD). The Kolmogorov–Smirnov test was used to examine if variables were normally distributed. For the data analysis, factorial analysis of variance (ANOVA) with the post hoc analysis of variance (least significant difference [LSD] test) was used, with significance level set at $p \leq 0.05$. All the data were processed using SPSS software (IBM SPSS Statistics 22).[13]

Results

Body Composition

Body composition of the participants pre-, mid-, and posttest based on the mean and SD is shown in ►**Table 4**. The ANOVA test in the groups in three stages showed that 8 weeks of L-carnitine supplementation during concurrent training had a significant effect in experimental group 1 in comparison to experimental group 2 and the control group. Research findings showed that L-carnitine supplementation in experimental group 1 improved weight and BMI more than experimental group 2 and control group at both midtest and posttest and improved BF% and FFM only posttest in obese men. These variables were not significant for experimental group 2 and the control group ($p \leq 0.05$).

Table 4 Body composition and strength characteristics of study participants

Variable	Group	Pre-test	Mid-test	Post-test
Weight (kg)	EXP1	104.86 ± 12.66	100.59 ± 12.12[a,b]	94.46 ± 12.01[a,b]
	EXP2	104.73 ± 12.04	104.04 ± 11.87	102.70 ± 12.08
	Control	109.85 ± 11.10	110.10 ± 11.79	110.03 ± 10.45
BMI (kg/m^2)	EXP1	32.85 ± 1.92	31.51 ± 1.75[a,b]	29.58 ± 1.88[a,b]
	EXP2	33.93 ± 1.76	33.71 ± 1.76	33.26 ± 1.68
	Control	34.73 ± 3.41	34.83 ± 3.40	34.80 ± 3.36
BF (%)	EXP1	31.81 ± 2.51	30.02 ± 2.34	27.89 ± 2.48[a,b]
	EXP2	33.11 ± 2.10	32.85 ± 2.11	32.31 ± 2.02
	Control	33.97 ± 3.98	34.09 ± 3.95	34.06 ± 3.90
FFM (kg)	EXP1	71.31 ± 7.10	70.04 ± 7.08	67.93 ± 7.09[a,b]
	EXP2	69.95 ± 7.73	69.77 ± 7.28	69.41 ± 7.36
	Control	72.32 ± 6.28	72.38 ± 6.03	72.37 ± 6.04

Abbreviations: EXP1, experimental group 1; EXP2, experimental group 2; BMI, body mass index; BF, body fat; FFM, fat-free mass.
Note: All values are presented as mean ± standard deviation.
[a]Significant differences compared to pretest.
[b]Significant difference compared to the control group.

Table 5 Functional capacities characteristics of study participants

Variable	Group	Pretest	Midtest	Posttest
RHR (bpm)	EXP1	76.60 ± 24.15	75.20 ± 4.46	71.70 ± 4.37[a,b]
	EXP2	75.95 ± 4.74	75.60 ± 4.47	75.30 ± 3.91
	Control	77.10 ± 4.29	77.00 ± 4.29	76.90 ± 4.12
SBP (mm Hg)	EXP1	121.30 ± 3.19	117.20 ± 2.61[a,b]	114.70 ± 2.21[a,b]
	EXP2	120 ± 7.46	119 ± 7.02	118.60 ± 6.68
	Control	122 ± 4.24	121.80 ± 4.31	121.80 ± 4.31
DBP (mm Hg)	EXP1	76.5 ± 3.47	72.30 ± 3.49	69 ± 3.62[a,b]
	EXP2	76.5 ± 5.24	75.80 ± 5.49	75.5 ± 5.19
	Control	78 ± 5.77	77.70 ± 5.69	74.06 ± 6.05
SpO_2 (%)	EXP1	95.10 ± 1.10	96.6 ± 0.84	97.80 ± 0.78
	EXP2	95.10 ± 0.87	95.30 ± 1.05	95.50 ± 1.17
	Control	95.10 ± 1.28	95.10 ± 1.28	95.20 ± 1.22
VO_2 max ($mL \times kg^{-1} \times min^{-1}$)	EXP1	32.24 ± 3.54	33.88 ± 2.45[a,b]	34.21 ± 3.65[a,b]
	EXP2	32.84 ± 2.86	32.33 ± 4.12	32.46 ± 2.79
	Control	32.01 ± 3.66	32.78 ± 2.40	32.37 ± 4.95
1RM (kg)	EXP1	153.4 ± 4.14	159.7 ± 3.94[a,b]	166.3 ± 4.94[a,b]
	EXP2	155.6 ± 5.29	158.9 ± 4.77	161.8 ± 5.03
	Control	152.4 ± 5.16	152.6 ± 5.21	152.9 ± 5.3

Abbreviations: EXP1, experimental group 1; EXP2, experimental group 2; RHR, resting heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; SpO_2, oxygen saturation; VO_2 max, maximal oxygen consumption; 1RM, one-repetition maximum.
Note: All values are presented as mean ± standard deviation.
[a]Significant differences compared to pretest.
[b]Significant difference compared to the control group.

Functional Capacities

L-carnitine had a significant effect on the development of functional capacities in obese men during concurrent training (►**Table 5**). The results of repeated measures ANOVA showed a significant effect in experimental group 1 in comparison to experimental group 2 and the control group on SBP, VO_2 max, and 1RM at midtest and posttest for DBP and RHR only posttest, and there was no significant effect on SpO_2 in all the groups. These variables were not significant for experimental group 2 and the control group ($p \leq 0.05$).

Discussion

This research explored the impact of L-carnitine supplementation in combination with concurrent training on functional capacities and body composition among obese males. The primary outcome of this investigation revealed that an 8-week regimen of L-carnitine supplementation paired with concurrent training led to substantial improvements in both functional capacities and body composition. In contrast, in the experimental group that consumed L-carnitine supplements without engaging in physical exercise, no significant alterations were observed across the measured variables. These results highlight the critical role of physical exercise in eliciting beneficial changes in functional capacities and body composition, reinforcing the synergy between dietary supplementation and physical training.

The results showed that L-carnitine combined with exercise training led to a significant reduction in RHR in experimental group 1. It is well known that RHR after exercise could be modified by weight loss and RHR after exercise has been shown to be an independent risk factor for cardiovascular disease and mortality in healthy adults.[19] Richard et al reported an improvement in RHR after a weight loss program that only involved dieting without any change in physical activity.[20] They found a good correlation of the change in RHR with the reduction of metabolic parameters (weight, BMI, waist circumference, triglycerides [TG], glucose, and the TG/high-density lipoprotein [HDL] to cholesterol ratio).[21] Previous studies by Belayneh et al on healthy individuals among students at Haramaya University were compatible with our studies and indicated that L-carnitine ingestion probably improved the heart's ability to pump blood efficiently and that human muscle contains large amounts of carnitine, but this depends on the uptake of this compound from the bloodstream.[18] Regular physical activity had a positive effect on autonomic control of the heart in adults by decreasing the RHR and reducing the risk of cardiovascular disease associated with obesity through enhancing autonomic function.[22] It was hypothesized that L-carnitine supplementation would result in a significant reduction in SBP after 4 and 8 weeks and DBP only after 8 weeks of concurrent training in experimental group 1 compared to experimental group 2 and the control group. With the widespread increase in mortality in obese people, more importance has been placed on preventing the disease and finding better ways to manage it. One of the most commonly given adjunct treatments is a lifestyle change, including modifications to diet and exercise. Numerous studies have demonstrated that systemic blood pressure can be decreased and controlled through increased physical activity. Similarly, Tamayo Acosta et al's research found that continuous training reduces blood pressure, which is consistent with the results of this study.[23]

However, our results failed to report any significant change in oxygen saturation between the groups. This issue was probably due to the low tolerance of lactate in the blood and some changes to intracellular biochemicals in the participants.[24] Kashef and Shabani observed that L-carnitine had a positive relationship with oxygen saturation, because the participants were active men and athletes,[24] and other studies reported high level of physical fitness of the participants.[25,26]

Our analysis showed that L-carnitine supplementation along with concurrent training significantly increased VO_2 max in experimental group 1 after 4 and 8 weeks. Since oxidation of fat requires more oxygen compared to carbohydrates, the cardiovascular system should receive more oxygen for muscles. In this regard, L-carnitine increases oxygen consumption and lipid oxidation by stimulating the pyruvate dehydrogenase complex and the entry of pyruvate into the β-oxidation pathway.[24] L-carnitine protects the cell from acyl-CoA accretion through the generation of acylcarnitine. Mitochondrial fatty acid oxidation represents an important energy source for muscle metabolism, particularly during physical exercise. Considering the important role of fatty acids in muscle bioenergetics, and the limiting effect of free carnitine on fatty acid oxidation during endurance exercise, L-carnitine supplementation has been hypothesized to improve exercise performance. Differences in exercise intensity, training or conditioning of the subjects, amount of L-carnitine administered, route, and timing of administration relative to the exercise led to different experimental results.[27] Vecchiet et al showed that 2 g of L-carnitine given to athletes 1 hour prior to exercise increases the maximal oxygen intake and the energy they spend.[28] Mustafa et al showed that an L-carnitine dose of 4 g/d given for 2 weeks improved VO_2 max.[26] Probably, the difference in duration and period of L-carnitine supplement consumption, gender, type of sport, characteristics and physical qualifications of obesity/overweight people, and type of exercises or training in studies could cause the differences.

In our results, L-carnitine supplementation significantly reduced body weight and BMI in experimental group 1 after 4 and 8 weeks, but this effect was not observed in other groups. This kind of training could help reduce body weight and fat mass by increasing lean mass and basal metabolic rate. In agreement with this, Talenezhad et al[1] and Pooyandjoo et al[7] showed that the individuals who received L-carnitine showed significant decrease in weight and BMI compared with the control group. It is possible that individuals with acquired L-carnitine deficiency manifested by increased fat deposition in the body may benefit from such supplementation and improve their body composition by consuming adequate amount of this substance accompanied by proper exercise.[29] Physical activity seems to be an important component of lifestyle interventions for weight loss and maintenance. Although the effects of physical activity on weight loss may seem to be modest, there seems to be a dose–response relationship between physical activity and weight loss. Physical activity also seems to be a critically important behavior to promote long-term weight loss and prevent weight regain. The benefits of physical activity on weight loss are also observed in subjects with severe obesity ($BMI \geq 30\,kg/m^2$).[30] Previous publications showed exercise to be a strong factor in the treatment of obesity, and when performed with adequate intensity and frequency, it could provide protection against comorbidities of obesity. These findings were also shown in a study by Da Silva Medeiros et al who demonstrated a reduction in weight, BF%, and waist circumference in overweight adults who performed concurrent training thrice a week with an intensity of 65 to 80% VO_2 peak. However, in this same study, two other groups that performed strength training or aerobic training only had a decrease in waist circumference, showing the relevance of the type of training.[31]

Our analysis showed that L-carnitine along with training significantly increased for 1RM in only experimental group 1 after midtest and posttest, it probably was in related to myofibrillar protein synthesis and recruitment of fast twitch motor units that was in agreement with other authors.[8] In comparison with previous studies, Sawicka et al showed that 8 weeks of L-carnitine combined with training, L-leucine, and vitamin D significantly increased muscle mass and strength due to elevated activation of the mammalian target of rapamycin (mTOR) pathway. However, once L-carnitine was tested alone using the same dosage, but for a longer period (i.e., 24 weeks), no significant effect was found.[32] This may be attributed to the nature of the training program at moderate intensity, where the oxidation of long-chain fatty acids acts as the predominant source of energy and L-carnitine could increase the fat oxidation rate, thereby preserving muscle glycogen stores.[33] In the present study, there was significant decrease in body composition (BF% and FFM) after only 8 weeks of concurrent training with L-carnitine. Our result is similar to the findings of Gimenes et al who investigated the effects of L-carnitine on exercise performance.[34] Our findings were also consistent with those of Bellicha et al who observed favorable effects of exercise training programs on weight loss and changes in body composition in overweight or obese adults.[35] Ghahramanloo et al reported a significant decrease in the fat mass of nontrained men after 8 weeks of resistance training. But several studies have reported contradictory results.[36] For example, Mohammadi et al did not report a significant difference after aerobic training. The possible reason for differences in the outcome may be the differences in the participants' characteristics such as sex and training history. In fact, regular use of carnitine would increase plasma and intracellular concentration of carnitine and increase in fat oxidation and gradually decrease body fat storage.[37]

To our knowledge, this was the first reported case that simultaneously analyses for factors of L-carnitine, functional capacities, body composition of obese males in both resistance and endurance training. The changes mentioned earlier occurred without any change in the body composition or functional parameters. The results of the present study cannot be generalized due to the small sample size. The main limitation of this study is the low number of participants. It is important to be cautious when generalizing the results to other populations since the present study focused on obese men with BMIs above 30 kg/m^2. Another limitation of our study is that stress factors associated with the hypothalamus–pituitary–adrenal axis, like corticosterone, were not taken into consideration, which could have provided insight into the potential neurophysiological impact of L-carnitine supplementation.

Conclusions

L-carnitine supplementation, in conjunction with concurrent training, emerges as a highly effective approach for enhancing body composition and boosting functional capacities in obese adult men. This synergistic approach is thus recommended for overweight males, advocating for the integration of concurrent training into their fitness routines alongside L-carnitine supplementation. This kind of research could be beneficial for prevention of cardiovascular disease in obese men and reduce costs and effects of nonpharmacological interventions related to exercise. Future studies should investigate the potential incremental benefits of this combined protocol (L-carnitine supplementation with concurrent training) over the sole application of concurrent training. Such investigations will be crucial in further delineating the specific advantages and optimizing intervention strategies for this demographic.

Authors' Contributions

All the authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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Conflict of Interest

None declared.

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