Effects of a concurrent training program on metabolic response, functionality, and quality of life in overweight or obese adults in primary healthcare

Efectos de un programa de entrenamiento concurrente sobre la respuesta metabólica, la funcionalidad y la calidad de vida en adultos con sobrepeso u obesidad en atención primaria de salud

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Abstract

Introduction: Overweight/obesity is a global and national public health problem associated with cardiometabolic risk, functional limitation, and reduced health-related quality of life. Pragmatic evidence from primary healthcare (PHC) programs remains limited.
Objective: To evaluate whether a 12-week concurrent training program delivered in PHC was associated with pre-post changes in cardiometabolic profile, functional performance, SF-36 total score, and serum IL-6 in adults with overweight/obesity.
Methodology: Quasi-experimental single-group pre-post study in two CESFAMs (La Cisterna, Chile). Adults 18-60 years with BMI >25 kg/m^2 attended three sessions/week (planned aerobic and strength components) plus educational support and non-standardized nutritional counseling. Outcomes were assessed at baseline and week 12. Wilcoxon matched-pairs signed-rank tests were used, and effect sizes were estimated using r and rank-biserial correlation.
Results: Forty participants completed assessments (estimated VO_2max n=18). Weight and BMI remained stable. Favorable pre-post changes were observed in HOMA-IR, HbA1c, triglycerides, VLDL, functional performance, 6MWT distance, estimated VO_2max, SF-36 total score, and IL-6. Total cholesterol increased modestly and should therefore be interpreted cautiously. Functional outcomes showed the largest effect sizes.
Discussion: In a real-world PHC context, favorable cardiometabolic, functional, and person-centered changes may occur without marked weight loss; however, given the single-group pre-post design, these findings should be interpreted as preliminary and non-causal.
Conclusions: A 12-week concurrent training program implemented in CESFAM was associated with favorable pre-post changes in insulin resistance, selected lipid fractions, function, quality of life, and IL-6. Controlled pragmatic studies are needed to confirm causality and implementation potential.

Keywords

Obesity, primary health care, exercise therapy, quality of life, Interleukin-6.

Resumen

Introducción: El sobrepeso/obesidad constituye un problema de salud pública global y nacional, asociado con riesgo cardiometabólico, limitación funcional y deterioro de la calidad de vida. En atención primaria de salud (APS) existe evidencia pragmática limitada sobre programas implementados en CESFAM.
Objetivo: Evaluar si un programa de entrenamiento concurrente de 12 semanas en APS se asoció con cambios pre-post en perfil cardiometabólico, desempeño funcional, puntaje total del SF-36 e IL-6 sérica en adultos con sobrepeso/obesidad.
Metodología: Estudio cuasi-experimental pre-post de grupo único en dos CESFAM (La Cisterna, Chile). Adultos de 18 a 60 años con IMC >25 kg/m^2 realizaron tres sesiones semanales con componentes aeróbicos y de fuerza, además de apoyo educativo y consejería nutricional no estandarizada. Los desenlaces se evaluaron en basal y semana 12. Se utilizaron pruebas de Wilcoxon pareadas y tamaños de efecto mediante r y correlación rank-biserial.
Resultados: Cuarenta participantes completaron evaluaciones (VO_2max estimado n=18). El peso y el IMC se mantuvieron estables. Se observaron cambios favorables en HOMA-IR, HbA1c, triglicéridos, VLDL, desempeño funcional, TM6M, VO_2max estimado, puntaje SF-36 e IL-6. El colesterol total aumentó levemente y debe interpretarse con cautela. Los desenlaces funcionales mostraron los mayores tamaños de efecto.
Discusión: En APS pueden observarse cambios cardiometabólicos y funcionales sin pérdidas de peso marcadas; sin embargo, el diseño de grupo único implica que los hallazgos son preliminares y no causales.
Conclusiones: El programa se asoció con mejoras en resistencia a la insulina, perfil lipídico, función, calidad de vida e IL-6. Se requieren estudios controlados para confirmar causalidad.

Palabras clave

Obesidad, atención primaria de salud, terapia por ejercicio, calidad de vida, Interleuquina-6.

Introduction

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (Piché et al., 2020). Globally, excess body weight remains one of the most relevant public health challenges. According to the World Health Organization, in 2022 approximately 2.5 billion adults were living with overweight, including more than 890 million adults with obesity; this represented 43% of adults worldwide and reached higher proportions in the Region of the Americas (World Health Organization, 2025). In Chile, national data also show a high burden of excess weight, with 40.2% of the population classified as overweight, 31.4% as obese, and 3.4% as morbidly obese (MINSAL, 2018). Excess body weight is associated with high blood pressure, dyslipidemia, type 2 diabetes mellitus, hepatic steatosis, obstructive sleep apnea, some types of cancer, sarcopenia, and mortality (Apovian, 2016; Flegal et al., 2013; Piché et al., 2020). Therefore, feasible interventions implemented within the Chilean public health system are needed to address this cardiometabolic and functional burden.

Among the strategies with evidence for the management of overweight and obesity, structured physical exercise has shown benefits on cardiometabolic risk, functional capacity, and health-related quality of life in adults (Celik & Yildiz, 2021; Oppert et al., 2021). In addition, recent evidence published in Retos supports the relevance of exercise-based interventions, including concurrent training, for improving indicators of physical condition and quality of life (Gómez-Rossel & Merellano-Navarro, 2024; Pleticosic-Ramírez et al., 2024). These approaches are particularly relevant in community and PHC contexts, where low-cost and feasible programs may help translate exercise recommendations into practice.

Different training modalities have been used in adults with overweight or obesity, including endurance training, resistance training, high-intensity interval training, and combined or concurrent training (Ho et al., 2012; Su et al., 2019). Concurrent training is clinically attractive because it integrates aerobic and strength stimuli within the same session, potentially improving time efficiency, exercise tolerance, cardiorespiratory fitness, and neuromuscular performance (Wadsworth et al., 2022). However, for pragmatic programs to be interpreted and replicated, the exercise dose, perceived exertion targets, and week-by-week progression must be described transparently.

Health-related quality of life is frequently impaired in adults with overweight or obesity, and its assessment is relevant when evaluating interventions that aim to affect not only body weight but also perceived function and well-being (Stephenson et al., 2021; Taylor et al., 2013). The SF-36 was selected because it is a generic, widely used instrument for assessing physical and mental dimensions of health-related quality of life across clinical and community populations. Although instruments such as EQ-5D or WHOQOL-BREF are also useful, SF-36 was considered appropriate for this PHC study because it allows broad characterization of perceived health and comparison with exercise-based interventions. Its use is also supported by evidence of validity and reliability in Chilean populations (Lera et al., 2013).

Nutritional education and counseling are commonly incorporated into comprehensive lifestyle programs for overweight and obesity (Hsu et al., 2019; Shalitin & Moreno, 2021). In the present study, however, nutritional support was provided only as general counseling within the real-world PHC context. Dietary intake was not standardized, prescribed, monitored, or quantified; therefore, nutritional counseling should be interpreted as a non-controlled cointervention rather than as an independent nutritional intervention.

We understand cardiometabolic variables to be a set of measurements and parameters related to a person's cardiovascular and metabolic health (Sattar et al., 2020). These variables include factors that affect the heart and metabolism and studying them is essential for assessing the risk of cardiovascular and metabolic diseases (Domanski et al., 2020). Some of the commonly considered cardiometabolic variables include Blood pressure, glucose levels, lipid profile (including total cholesterol, LDL cholesterol (low-density lipoprotein), HDL cholesterol (high-density lipoprotein), and triglycerides. Body mass index (BMI), waist circumference, insulin levels, insulin resistance index (Sidhu et al., 2023). These variables provide a comprehensive view of a person's cardiovascular and metabolic health, allowing healthcare professionals to assess risks, diagnose diseases, and design strategies for the prevention and treatment of obesity or overweight (Trouwborst et al., 2018).

Physical functional variables in the human context refer to measures and characteristics that assess physical functioning and the human body's ability to perform various activities (Haskell et al., 2007).

These variables are fundamental to understanding a person's health and physical performance. Some physical functional variables are muscle strength, flexibility, cardiovascular endurance (Ferrari et al., 2022). These physical functional variables provide a comprehensive view of a person's physical condition and are essential both for assessing overall health and for designing personalized exercise programs (Gálvez et al., 2022). The evaluation of these variables can be measured with functional tests in subjects who are obese or overweight (Cifuentes Silva et al., 2023).

At the physiological level, skeletal muscle plays an endocrine role by secreting soluble factors in response to stimuli such as exercise, known as myokines (Severinsen & Pedersen, 2020). IL-6 has a dual biological role in the context of obesity and exercise. Chronically elevated resting IL-6 is commonly interpreted as part of the low-grade inflammatory state associated with excess adiposity, whereas transient exercise-induced IL-6 release from skeletal muscle may act as a myokine involved in metabolic regulation and anti-inflammatory signaling (Muñoz-Cánoves et al., 2013; Pedersen & Febbraio, 2008). Therefore, changes in resting serum IL-6 after an exercise program must be interpreted cautiously, considering both inflammatory and myokine-related pathways.

In the community of La Cisterna, Chile, a 12-week concurrent training program was implemented in CESFAM facilities with three weekly sessions. The program was designed to be operational with community resources and to progress according to participant tolerance. From a PHC perspective, evaluating this type of program provides local evidence on feasible, real-world interventions for a highly prevalent condition at a level of care where continuity and adherence are central challenges.

Therefore, the objective of this study was to evaluate whether 12 weeks of concurrent training implemented in PHC were associated with pre-post changes in cardiometabolic profile, functional capacity, health-related quality of life measured using SF-36, and serum IL-6 concentration in adults with overweight or obesity. We hypothesized that the program would be associated with favorable pre-post changes in these outcomes, particularly functional performance, even in the absence of marked changes in body weight.

Method

A single-group quasi-experimental study with a before-after (pre-post) design was conducted in the context of primary health care (PHC). Measurements were taken at week 0 (baseline assessment) and week 12 (post-intervention). The study did not include randomization, blinding, or a parallel control group; therefore, it was designed to evaluate within-participant changes after a real-world PHC intervention, but not to establish causal effects attributable exclusively to concurrent training. The intervention was implemented at the Eduardo Frei Montalva and Santa Anselma CESFAMs, located in La Cisterna (Metropolitan Region, Chile).

Adults between 18 and 60 years of age with a BMI >25 kg/m^2, residing in La Cisterna and users of the participating CESFAMs, who were medically cleared to perform physical activity were included. Recruitment was carried out through informational activities, social media, and printed material, followed by an informational talk. People with moderate-to-severe cognitive impairment, traumatic conditions preventing exercise, severe heart disease contraindicating exercise, or absence of medical clearance were excluded. Participant flow is summarized in Supplementary Figure S1. Of 112 individuals assessed for eligibility, 56 entered baseline assessment and started the program; 16 were lost during the 12-week intervention and 40 completed post-intervention assessment. No a priori sample size calculation was performed because the study was embedded in a PHC-based community program; therefore, the sample should be interpreted as pragmatic and exploratory.

The intervention program consisted of 12 weeks of concurrent training at a frequency of three sessions per week. Each session included a warm-up phase, an aerobic component, and a strength component. The aerobic component was structured using functional and adaptable movements, including jogging, skipping, jumping jacks, side-to-side movements, and adapted burpees. Intensity was guided by perceived exertion using the Borg scale, progressing from moderate perceived exertion to higher-intensity interval blocks according to participant tolerance. The strength component included isotonic and isometric exercises targeting lower limbs, upper limbs, and trunk, with progression based on sets, repetitions, time under tension, and technical execution. The detailed week-by-week progression of the

aerobic and strength components is provided in Supplementary Tables S2 and S3. Heart rate monitors, direct load quantification, and VO_2-based intensity prescription were not systematically available; therefore, Borg and OMNI-RES were used operationally to guide intensity, but were not analyzed as study outcomes. In parallel with exercise sessions, educational talks and general nutritional counseling were provided; however, dietary intake was not standardized, monitored, or quantified.

The variables were collected at the beginning and end of the program (week 0 and 12) following standardized procedures. For biochemical evaluation, venous blood samples were obtained to determine lipid profile (total cholesterol, LDL, HDL, and triglycerides), glycemic markers (fasting glucose and HbA1c), fasting insulin, and HOMA-IR calculation as an estimator of insulin resistance. For the inflammatory component, the analysis was restricted to serum cytokines, quantifying IL-6 using high-sensitivity ELISA according to the manufacturer's protocol (Invitrogen™ Human IL-6 ELISA Kit, Thermo Fisher; KHC0061). Anthropometry included measurement of weight and height, as well as waist and mid-thigh circumference using a non-stretchable tape measure; BMI and waist circumference were calculated from these measurements.

Physical and functional performance was assessed using a set of tests designed to measure strength and functional capacity. Handgrip strength was measured with a dynamometer according to protocol, performing three attempts per hand with 60 seconds of rest, recording the best value (Cifuentes-Silva et al., 2023). Functional capacity was assessed with the 6-minute walk test (6MWT) in a 30-meter marked corridor, with standardized instructions. Cardiorespiratory capacity was estimated using the 20 m Shuttle Run Test, starting at 8.5 km/h and increasing by 0.5 km/h per minute, recording meters covered and estimating VO_2max according to estimation equations (Léger & Lambert, 1982). Additionally, the elbow flexion-extension test (maximum repetitions with standardized technique) and the prone plank were applied, recording the total time and using as the completion criterion the loss of technique not corrected within 3 seconds according to protocol (Foster et al., 2025). Health-related quality of life was assessed exclusively using the SF-36 questionnaire, self-administered at the beginning and end of the intervention. During the program, perceived exertion was monitored using the Borg scale (0–10) for the aerobic component and OMNI-RES (0–10) for the strength component, in order to guide intensity control in a practical way in the community setting.

In terms of safety, in the event of major adverse events (e.g., syncope, status epilepticus, or cardiopulmonary arrest), a blue alert was activated in accordance with CESFAM protocol. All participants provided written informed consent before entering the study. The study was approved by the Institutional Ethics Committee of the University of Santiago, Chile (Ethics Report N° 028/2025), and was conducted according to the principles of the Declaration of Helsinki. Statistical analysis was performed using GraphPad Prism 9.0. Given the nonparametric approach, results were reported as median and interquartile range (IQR = Q1-Q3 = p25-p75). Pre-post comparisons were performed using the Wilcoxon matched-pairs signed-rank test, considering statistical significance at $p < 0.05$. Effect size was estimated using $r = Z/\sqrt{N}$ and rank-biserial correlation for Wilcoxon comparisons. Complete effect-size estimates are presented in Supplementary Table S1.

Results

Participant flow is shown in Supplementary Figure S1. Forty participants completed baseline and post-intervention assessments and were included in the main analysis, except for estimated VO_2max, which was analyzed in the subgroup that completed the shuttle-run test at both time points (n=18). Baseline characteristics, including sociodemographic, anthropometric, cardiometabolic, functional, comorbidity, and medication-use variables, are presented in Table 1. Attendance and adherence data are summarized in Table 2. Variables are presented as median [IQR: Q1-Q3], and pre-post comparisons were performed using the Wilcoxon matched-pairs signed-rank test. Effect sizes for all outcomes displayed in the main figures are reported in Supplementary Table S1.

Overall, the largest effect sizes were observed for functional outcomes, particularly prone plank, push-ups, 1-min sit-to-stand, 6MWT, estimated VO_2max, and handgrip strength. SF-36 total score and VLDL cholesterol also showed favorable changes with moderate effect sizes, whereas body weight and BMI showed trivial-to-small changes.

Table 1. Baseline characteristics of the sample

Variable	Median [Q1–Q3] or n (%)	Unit
Sociodemographic characteristics		
Age	42.0 [35.0–51.0]	years
Female sex	28 (70%)	n (%)
Male sex	12 (30%)	n (%)
Anthropometry and metabolic index		
Height	163.0 [158.0–169.0]	cm
Body weight	86.0 [77.0–98.0]	kg
Body mass index (BMI)	32.30 [29.18–34.45]	kg/m^2
BMI classification: overweight (25–29.9)	14 (35%)	n (%)
BMI classification: obesity (≥30)	26 (65%)	n (%)
Waist circumference	98.5 [91.0–107.0]	cm
Systolic blood pressure	128.0 [118.0–140.0]	mmHg
Diastolic blood pressure	82.0 [76.0–89.0]	mmHg
Metabolic and biochemical profile		
Fasting glucose	97.0 [88.5–108.0]	mg/dL
Glycated hemoglobin (HbA1c)	5.60 [5.50–5.85]	%
Fasting insulin	14.8 [9.6–20.3]	µIU/mL
HOMA-IR	3.94 [2.30–5.01]	AU
Total cholesterol	160.0 [135.0–193.0]	mg/dL
LDL cholesterol	98.0 [78.0–122.5]	mg/dL
HDL cholesterol	46.5 [39.0–55.0]	mg/dL
Triglycerides	133.5 [92.5–179.0]	mg/dL
VLDL	28.0 [19.5–36.0]	mg/dL
Baseline functional variables		
Handgrip strength (right hand)	32.0 [27.5–40.0]	kg
Handgrip strength (left hand)	31.0 [25.5–38.0]	kg
Prone plank	48.0 [31.0–63.5]	s
Push-ups	12.0 [4.5–19.0]	reps
1-min sit-to-stand	27.0 [25.0–33.5]	reps
6-minute walk test (6MWT)	570.0 [517.5–600.0]	m
Estimated VO_2max (n=18)	32.80 [29.08–37.05]	$mL \cdot kg^{-1} \cdot min^{-1}$
Quality of life and inflammation		
SF-36 total score	57.38 [41.75–78.44]	points
Serum IL-6	3,900 [2,555–5,048]	pg/mL
Comorbidities and medications		
Hypertension	18 (45%)	n (%)
Type 2 diabetes mellitus	7 (17.5%)	n (%)
Diagnosed dyslipidemia	22 (55%)	n (%)
Metabolic syndrome	15 (37.5%)	n (%)
Use of antihypertensives	16 (40%)	n (%)
Use of oral hypoglycemics	6 (15%)	n (%)
Use of statins or other lipid-lowering drugs	12 (30%)	n (%)
Polypharmacy (≥2 drugs)	19 (47.5%)	n (%)

Data are presented as median [Q1–Q3] for continuous variables and as n (%) for categorical variables. Baseline values correspond to assessments performed at week 0, before the beginning of the 12-week concurrent training program. Estimated VO_2max is reported for the subgroup that completed the shuttle-run test at baseline and post-intervention (n = 18). Comorbidities and medication use are presented to characterize the clinical profile of the sample and to support interpretation of cardiometabolic outcomes. Abbreviations: Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1); BMI, body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; LDL, low-density lipoprotein; HDL, high-density lipoprotein; VLDL, very low-density lipoprotein; 6MWT, 6-minute walk test; VO_2max, maximum oxygen consumption; SF-36, Short Form-36; IL-6, interleukin-6; AU, arbitrary units.

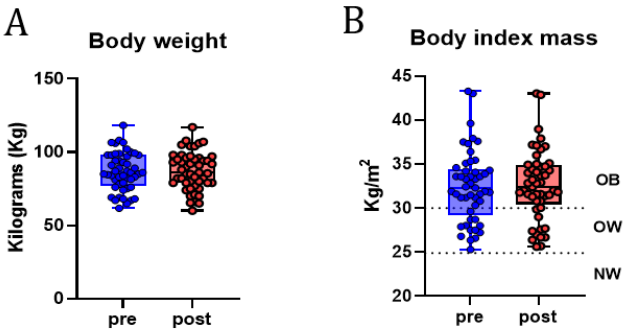
Table 2. Adherence and attendance to the concurrent training program

Variable	Median [Q1–Q3] or n (%)	Unit / Observation
Attendance (completers only, n=40)		
Total sessions attended	30.0 [26.0–33.0]	sessions
Percentage of sessions completed	83.3 [72.2–91.7]	%
Distribution of attendance percentage (completers, n=40)		
≥ 90% (32–36 sessions)	12 (30%)	n (%)
75–89% (27–31 sessions)	18 (45%)	n (%)
60–74% (22–26 sessions)	8 (20%)	n (%)
< 60% (≤ 21 sessions)	2 (5%)	n (%)
Explicit minimum adherence criterion		
Operational definition	Not missing 3 consecutive sessions without justification	a priori criterion
Accepted justification	Illness, medical appointment, family emergency (with prior notice or medical certificate)	does not count as unjustified absence
Adherence according to criterion (among those who started, n=56)		
Adherent (met criterion throughout the intervention)	44 (78.6%)	n (%)
– Completed 12 weeks without violating the criterion	40 (71.4%)	n (%)
– Completed 12 weeks with 1 violation episode + counseling (recovered)	4 (7.1%)	n (%)
Non-adherent (violated criterion → dropped out of the program)	12 (21.4%)	n (%)

Total losses during the intervention (consistent with flow diagram)	16 (28.6%)	n (% of 56 starters)
Composition of the 16 losses		
Non-adherent due to criterion violation (3 consecutive unjustified absences)	12 (75%)	% of losses
Other reasons for dropout (with or without criterion violation)	4 (25%)	% of losses
Detailed reasons for the 16 losses		
3 consecutive unjustified absences (without prior withdrawal)	8 (50.0%)	% of losses
Voluntary withdrawal (lack of time/motivation) that also violated criterion	4 (25.0%)	% of losses
Non-serious injury unrelated to the program	2 (12.5%)	% of losses
Minor adverse event (musculoskeletal pain)	1 (6.25%)	% of losses
Moved outside catchment area	1 (6.25%)	% of losses
Adverse events		
Serious adverse events (cardiopulmonary arrest, syncope, etc.)	0 (0%)	n (%)
Minor adverse events (transient muscle pain, fatigue)	1 (2.5% of completers)	n (%)

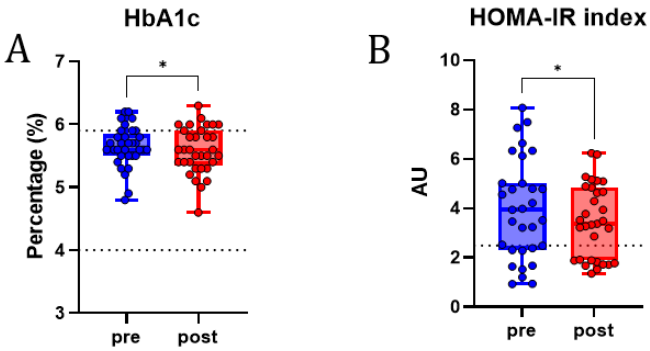
Attendance was calculated based on the expected dose of 36 sessions (3 sessions/week for 12 weeks). Attendance variables are reported for participants who completed the post-intervention assessment (n = 40), whereas adherence, losses, and dropout reasons are reported among participants who started the intervention (n = 56). Operational adherence was defined a priori as not missing three consecutive sessions without justification. Justified absences included illness, medical appointments, or family emergencies communicated to the research team or supported by a medical certificate when applicable. Percentages are expressed according to the denominator indicated in each section of the table. Minor adverse events corresponded to transient musculoskeletal symptoms, whereas serious adverse events were defined as events requiring activation of the CESFAM emergency protocol; no serious adverse events were recorded. Data are presented as median [Q1–Q3] for continuous variables and as n (%) for categorical variables. Abbreviations: Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Figure 1. Body weight and BMI remained stable after the concurrent training program.



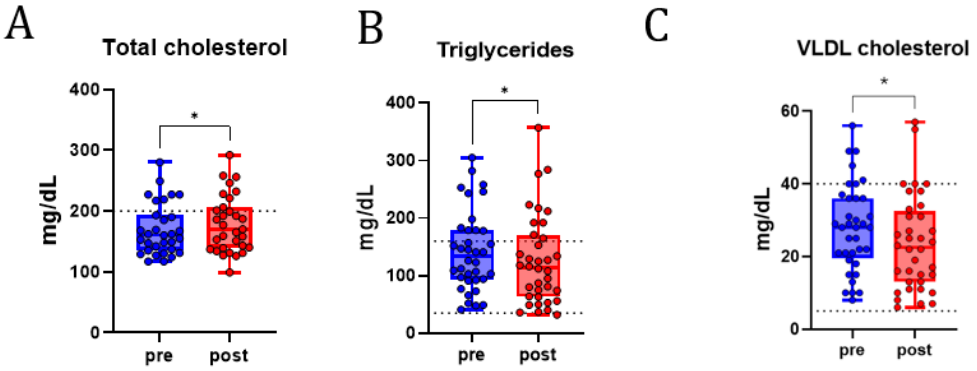
Comparison of body weight (kg) (A) and body mass index (BMI; kg/m^2) (B) between baseline (week 0) and post-intervention (week 12). Weight: 86.0 [77.0–98.0] vs. 86.0 [79.0–96.0]; BMI: 32.30 [29.18–34.45] vs. 32.40 [30.43–34.84]. Data are presented as median [Q1–Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test. Effect sizes are reported in Supplementary Table S1. Abbreviations: BMI, body mass index; Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Figure 2. Pre-post changes in insulin resistance and glycemic parameters after the concurrent training program.



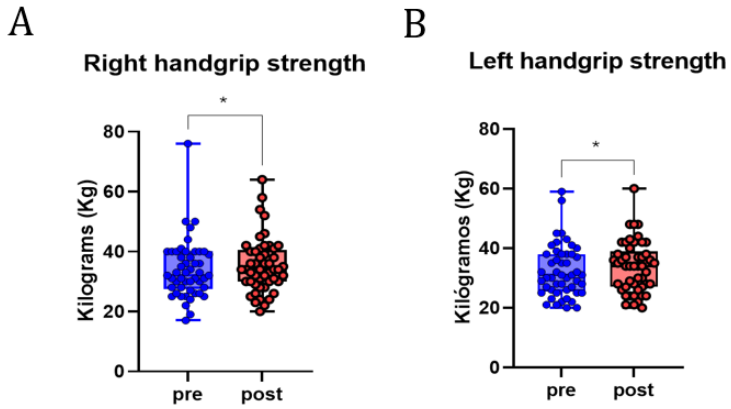
Comparison of glycosylated hemoglobin (HbA1c; %) (A) and HOMA-IR index (AU) (B) between week 0 and week 12. HbA1c: 5.600 [5.500-5.850] vs. 5.600 [5.350-5.900]; HOMA-IR: 3.940 [2.300-5.010] vs. 3.370 [1.880-4.840]. Data are presented as median [Q1-Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Effect sizes are reported in Supplementary Table S1. Abbreviations: HbA1c, glycated hemoglobin; HOMA-IR, homeostasis model assessment of insulin resistance; AU, arbitrary units; Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3-Q1).

Figure 3. Changes in selected lipid profile markers after the concurrent training program.



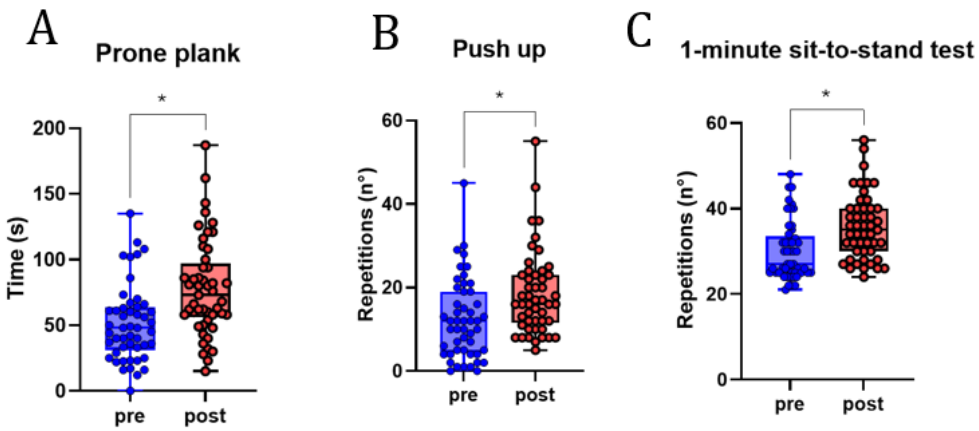
Comparison of total cholesterol (A), triglycerides (B), and VLDL cholesterol (C) (mg/dL) between week 0 and week 12. Total cholesterol: 160.0 [135.0-193.0] vs. 170.0 [139.0-206.0]; triglycerides: 133.5 [92.5-179.0] vs. 114.0 [63.25-169.5]; VLDL cholesterol: 28.0 [19.5-36.0] vs. 22.5 [13.0-32.5]. Data are presented as median [Q1-Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Because total cholesterol increased, the lipid profile should not be interpreted as uniformly improved. Effect sizes are reported in Supplementary Table S1. Abbreviations: VLDL, very low-density lipoprotein; Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3-Q1).

Figure 4. Pre-post changes in bilateral handgrip strength after the concurrent training program.



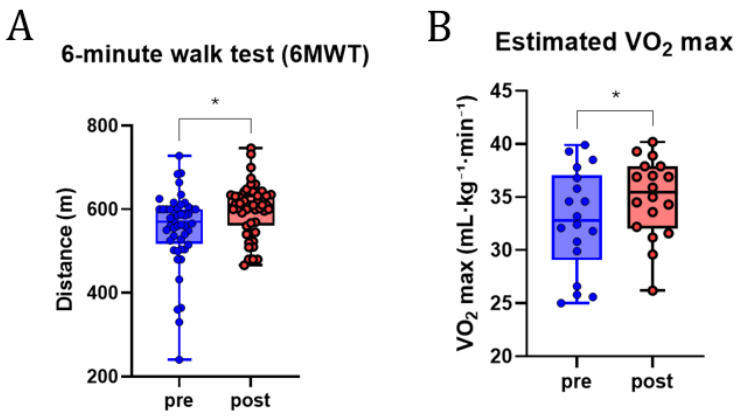
Comparison of handgrip strength (kg) in the right (A) and left (B) hands between week 0 and week 12. Right hand: 32.0 [27.5–40.0] vs. 34.0 [30.0–40.5]; left hand: 31.0 [25.5–38.0] vs. 34.0 [27.0–39.0]. Data are presented as median [Q1–Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Effect sizes are reported in Supplementary Table S1. Abbreviations: Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Figure 5. Pre-post changes in trunk and limb performance after the concurrent training program.



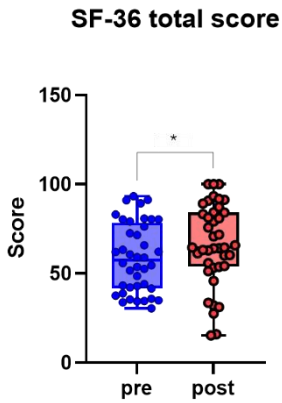
Comparison of physical performance between week 0 and week 12 using prone plank (s) (A), push-ups (repetitions) (B), and 1-minute sit-to-stand test (C) (repetitions). Prone plank: 48.0 [31.0–63.52] vs. 73.0 [56.0–97.0]; push-ups: 12.0 [4.5–19.0] vs. 16.0 [11.5–23.0]; sit-to-stand in 1 min: 27.0 [25.0–33.5] vs. 35.0 [30.0–40.0]. Data are presented as median [Q1–Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Effect sizes are reported in Supplementary Table S1. Abbreviations: Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Figure 6. Pre-post changes in functional capacity and estimated VO_2max after the concurrent training program.



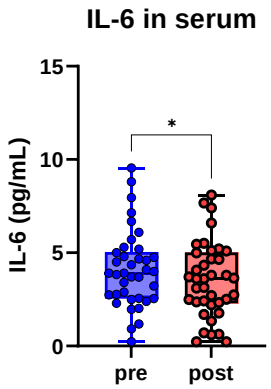
Comparison of functional capacity measured by the 6-minute walk test (A) (6MWT; m) and estimated VO_2max (B) ($mL \cdot kg^{-1} \cdot min^{-1}$) between week 0 and week 12. 6MWT: 570.0 [517.5–600.0] vs 610.0 [561.8–634.8], n=40; Estimated VO_2max: 32.80 [29.08–37.05] vs 35.45 [32.05–37.90], n=18. Data are presented as median [Q1–Q3]. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Effect sizes are reported in Supplementary Table S1. Abbreviations: 6MWT, 6-minute walk test; VO_2max, maximum oxygen consumption; Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Figure 7. Pre-post change in health-related quality of life after the concurrent training program.



Comparison of the total SF-36 score (points) between week 0 and week 12. Total SF-36: 57.38 [41.75–78.44] vs. 64.57 [53.80–84.23]. Data are presented as median [Q1–Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Effect sizes are reported in Supplementary Table S1. Abbreviations: SF-36, Short Form-36; Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Figure 8. Pre-post change in serum IL-6 concentration after the concurrent training program.



Comparison of serum interleukin-6 (IL-6; pg/mL) concentration between week 0 and week 12. IL-6: 3,900 [2,555–5,048] vs. 3,600 [2,295–5,024]. Data are presented as median [Q1–Q3], n=40. The pre-post comparison was performed using the Wilcoxon matched-pairs signed-rank test; * indicates $p < 0.05$. Effect sizes are reported in Supplementary Table S1. Abbreviations: IL-6, interleukin-6; Q1, quartile 1 (p25); Q3, quartile 3 (p75); IQR, interquartile range (Q3–Q1).

Discussion

In this single-group pre-post study conducted in PHC, a 12-week concurrent training program was associated with favorable changes in insulin resistance-related markers, selected lipid fractions, physical performance, SF-36 total score, and serum IL-6, with stable weight and BMI. These findings should not be interpreted as causal effects because the design lacked a control group, randomization, and blinding. Instead, they provide preliminary real-world evidence suggesting that a feasible concurrent exercise program may be associated with clinically relevant functional and metabolic signals in adults with overweight or obesity.

A key finding was the coexistence of favorable metabolic and functional changes with stable weight and BMI. This pattern suggests that health-related adaptations may occur even in the absence of substantial weight loss, particularly when exercise improves cardiorespiratory capacity and neuromuscular performance (Duncan et al., 2003; Ross et al., 2000). This interpretation is consistent with adult evidence showing that combined or concurrent exercise can improve metabolic and fitness outcomes in overweight or obese populations (AbouAssi et al., 2015; Jamka et al., 2022; Schwingshackl et al., 2013), and with recent Retos publications emphasizing the role of exercise programs in physical condition and quality-of-life outcomes (Gómez-Rossel & Merellano-Navarro, 2024; Pleticosic-Ramírez et al., 2024).

In terms of glycemic profile and insulin resistance, HOMA-IR and HbA1c showed favorable pre-post changes with moderate effect sizes. These findings are biologically plausible because exercise can increase contraction-mediated glucose uptake, GLUT4 translocation, mitochondrial adaptations, and the metabolic sink represented by active skeletal muscle (Fealy et al., 2014; Richter & Hargreaves, 2013). However, the absence of a control group and the presence of non-standardized counseling prevent attributing these changes exclusively to the exercise program.

With regard to the lipid profile, triglycerides and VLDL decreased, which is consistent with mechanisms expected from regular exercise, including increased lipoprotein lipase activity, fatty acid oxidation, and improved metabolism of triglyceride-rich lipoproteins (Gill & Hardman, 2003; Haskell, 1984; Muscella et al., 2020). However, total cholesterol increased modestly and significantly in the analysis, which prevents interpreting the lipid profile as uniformly improved. In the absence of a control group, dietary monitoring, and a detailed causal assessment of medication or dietary changes, this increase may reflect individual variability, unmeasured nutritional changes, seasonal variation, changes in lipid subfractions, or regression to the mean (Ockene et al., 2004; Smith et al., 1993). Future studies should include LDL, HDL, non-HDL cholesterol, TG/HDL ratio, medication stability, and dietary intake monitoring to better interpret lipid-risk directionality.

In the functional domain, bilateral handgrip strength, plank time, push-ups, sit-to-stand performance, 6MWT, and estimated VO_2max showed the largest effect sizes. These results suggest relevant changes in neuromuscular performance, exercise tolerance, and functional capacity, all of which are clinically meaningful in community settings where excess weight is associated with early functional limitation (Adair et al., 2018; Bohannon, 2019). The detailed aerobic and strength progressions reported in Supplementary Tables S2 and S3 strengthen the replicability of the exercise component and respond to the need for transparent reporting of intervention dose.

Consistently, functional capacity measured by TM6M increased in the entire group, and estimated VO_2max increased in the subgroup with available measurements. In PHC, these changes acquire clinical value because they are linked to mobility, exercise tolerance, and the ability to sustain daily physical activity (van Baak et al., 2021). The literature shows that exercise, including combined programs, can improve cardiorespiratory fitness and strength, and that these improvements are not only associated with lower cardiometabolic risk but also with better perceived functionality (Lee et al., 2024; Ross et al., 2016). Furthermore, in interventions where the objective is comprehensive (cardiometabolic risk + function), the combination of stimuli is often more efficient than single-modality approaches, especially when planning seeks to adapt to time and resource constraints (Healy et al., 2024; Lee et al., 2024).

A relevant person-centered finding was the increase in the SF-36 total score, with a moderate effect size. This is consistent with evidence showing that exercise may improve perceived health, physical function, and psychological outcomes in adults with excess weight or cardiometabolic risk (Carraça et al., 2021; Collins et al., 2020). Nevertheless, because only the total SF-36 score was analyzed, it was not possible to determine whether the change was mainly driven by physical functioning, bodily pain, vitality, social functioning, or mental health domains. Future analyses should examine individual SF-36 domains to improve clinical interpretation.

In the inflammatory analysis, resting serum IL-6 decreased after the intervention, with a small effect size. This finding should be interpreted cautiously because IL-6 has complex and context-dependent biology. Lower resting IL-6 may reflect attenuation of chronic low-grade inflammation associated with adiposity, whereas acute exercise-induced IL-6 release from skeletal muscle may participate in metabolic regulation and anti-inflammatory signaling (Pedersen & Febbraio, 2008; Muñoz-Cánoves et al., 2013). Therefore, the present result should be considered a preliminary inflammatory signal rather than definitive evidence of an anti-inflammatory effect. Future studies should include broader inflammatory panels, body composition, and follow-up assessments.

From a PHC perspective, the study provides real-world evidence on a program that was feasible to implement in CESFAM, with three weekly sessions, aerobic and strength components, and an adaptable progression. However, the term scalability should be used cautiously because this study did not formally assess cost, staff training requirements, fidelity, resource use, or implementation outcomes. Thus, the findings may inform future PHC-based interventions but do not by themselves demonstrate scalability.

This study has several limitations. First, the single-group pre-post design without randomization, blinding, or a control group prevents causal attribution of the observed changes to concurrent training alone. Second, the sample was pragmatic and relatively small, with no a priori power calculation, limiting precision and generalizability. Third, estimated VO_2max was available only in a subsample (n=18), which may introduce selection bias. Fourth, educational and nutritional counseling were not standardized or quantified, and dietary intake was not monitored; therefore, their independent contribution to cardiometabolic outcomes cannot be separated from the exercise component. Fifth, Borg and OMNI-RES were used to guide intensity during sessions, but perceived exertion data were not systematically analyzed as outcomes, limiting intensity verification. Sixth, although adherence and attendance were summarized, dose-response analyses were not performed. Finally, IL-6 was the only inflammatory marker measured, and no follow-up assessment was available to determine maintenance of changes over time.

These limitations coexist with important strengths: implementation in a real PHC setting, reporting of participant flow and adherence, inclusion of baseline clinical characterization, incorporation of effect-size estimates, and detailed reporting of the planned aerobic and strength progression. Future pragmatic controlled trials should include usual-care or active control groups, systematic monitoring of exercise load and adherence, standardized or quantified nutritional components, body composition

assessment, broader inflammatory panels, and follow-up to evaluate the sustainability of changes and their relationship with clinical outcomes.

Conclusions

A 12-week concurrent training program implemented in PHC was associated with favorable pre-post changes in insulin resistance, selected lipid fractions, physical performance, functional capacity, SF-36 total score, and serum IL-6, without significant changes in weight or BMI. Given the single-group pre-post design, these findings should be interpreted as preliminary real-world evidence rather than causal proof of intervention efficacy. Controlled pragmatic studies are needed to confirm these results and determine their sustainability, cost, fidelity, and implementation potential in PHC settings.

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Conflicts of interest

The authors declare no conflicts of interest.

Supplementary material

The supplementary material associated with this manuscript is included at the end of this document and can be accessed through the following internal link: Supplementary material.

References

AbouAssi, H., Slentz, C. A., Mikus, C. R., Tanner, C. J., Bateman, L. A., Willis, L. H.,…Kraus, W. E. (2015). The effects of aerobic, resistance, and combination training on insulin sensitivity and secretion in overweight adults from STRRIDE AT/RT: a randomized trial. *J Appl Physiol (1985)*, *118*(12), 1474-1482. https://doi.org/10.1152/japplphysiol.00509.2014

Adair, L. S., Duazo, P., & Borja, J. B. (2018). How Overweight and Obesity Relate to the Development of Functional Limitations among Filipino Women. *Geriatrics (Basel)*, *3*(4). https://doi.org/10.3390/geriatrics3040063

Al-Mhanna, S. B., Alghannam, A. F., Alkhamees, N. H., Sheeha, B. B., Omar, N., Albalawi, H.,…Batrakoulis, A. (2025). Impact of concurrent aerobic and resistance training on body composition, lipid metabolism and physical function in patients with type 2 diabetes and overweight/obesity: a systematic review and meta-analysis. *PeerJ*, *13*, e19537. https://doi.org/10.7717/peerj.19537

Apovian, C. M. (2016). Obesity: definition, comorbidities, causes, and burden. *Am J Manag Care*, *22*(7 Suppl), s176-185.

Bilski, J., Pierzchalski, P., Szczepanik, M., Bonior, J., & Zoladz, J. A. (2022). Multifactorial Mechanism of Sarcopenia and Sarcopenic Obesity. Role of Physical Exercise, Microbiota and Myokines. *Cells*, *11*(1). https://doi.org/10.3390/cells11010160

Bohannon, R. W. (2019). Grip Strength: An Indispensable Biomarker For Older Adults. *Clin Interv Aging*, *14*, 1681-1691. https://doi.org/10.2147/cia.S194543

Bulmer, C., & Avenell, A. (2025). The effect of dietary weight-loss interventions on the inflammatory markers interleukin-6 and TNF-alpha in adults with obesity: A systematic review and meta-analysis of randomized controlled clinical trials. *Obes Rev*, *26*(7), e13910. https://doi.org/10.1111/obr.13910

Caballero, B. (2019). Humans against Obesity: Who Will Win? *Adv Nutr*, *10*(suppl_1), S4-s9. https://doi.org/10.1093/advances/nmy055

Carraça, E. V., Encantado, J., Battista, F., Beaulieu, K., Blundell, J. E., Busetto, L.,…Oppert, J. M. (2021). Effect of exercise training on psychological outcomes in adults with overweight or obesity: A systematic review and meta-analysis. *Obes Rev*, *22 Suppl 4*(Suppl 4), e13261. https://doi.org/10.1111/obr.13261

Celik, O., & Yildiz, B. O. (2021). Obesity and physical exercise. *Minerva Endocrinol (Torino)*, *46*(2), 131-144. https://doi.org/10.23736/s2724-6507.20.03361-1

Chen, C., Zhang, D., Ye, M., You, Y., Song, Y., & Chen, X. (2025). Effects of various exercise types on inflammatory response in individuals with overweight and obesity: a systematic review and network meta-analysis of randomized controlled trials. *Int J Obes (Lond)*, *49*(2), 214-225. https://doi.org/10.1038/s41366-024-01649-6

Church, T. S., Blair, S. N., Cocreham, S., Johannsen, N., Johnson, W., Kramer, K.,…Earnest, C. P. (2010). Effects of aerobic and resistance training on hemoglobin A1c levels in patients with type 2 diabetes: a randomized controlled trial. *Jama*, *304*(20), 2253-2262. https://doi.org/10.1001/jama.2010.1710

Cifuentes-Silva, E., Bueno-Buker, D., Pastene-Maureira, C., & Pacheco-Valles, A. (2023). Characterization of strength, endurance and lung function in subjects with neuromuscular diseases with the R577X polymorphism of the ACTN3 gene. *Andes Pediatr*, *94*(4), 520-528. https://doi.org/10.32641/andespediatr.v94i4.4039

Cifuentes-Silva, E., & Cabello-Verrugio, C. (2024). Bile Acids as Signaling Molecules: Role of Ursodeoxycholic Acid in Cholestatic Liver Disease. *Curr Protein Pept Sci*, *25*(3), 206-214. https://doi.org/10.2174/1389203724666230818092800

Cifuentes Silva, E., Gálvez, E., Foster, P., & Inostroza, M. (2023). Programa de ejercicio concurrente hospitalario en escolares y adolescentes con sobrepeso y obesidad durante la pandemia COVID-19 %J Andes pediatrica. *94*, 209-218.

Collado-Mateo, D., Lavín-Pérez, A. M., Peñacoba, C., Del Coso, J., Leyton-Román, M., Luque-Casado, A.,…Amado-Alonso, D. (2021). Key Factors Associated with Adherence to Physical Exercise in Patients with Chronic Diseases and Older Adults: An Umbrella Review. *Int J Environ Res Public Health*, *18*(4). https://doi.org/10.3390/ijerph18042023

Collins, K. A., Fos, L. B., Ross, L. M., Slentz, C. A., Davis, P. G., Willis, L. H.,…Kraus, W. E. (2020). Aerobic, Resistance, and Combination Training on Health-Related Quality of Life: The STRRIDE-AT/RT Randomized Trial. *Front Sports Act Living*, *2*, 620300. https://doi.org/10.3389/fspor.2020.620300

Contento, I. R. (2008). Nutrition education: linking research, theory, and practice. *Asia Pac J Clin Nutr*, *17 Suppl 1*, 176-179.

Defronzo, R. A. (2009). Banting Lecture. From the triumvirate to the ominous octet: a new paradigm for the treatment of type 2 diabetes mellitus. *Diabetes*, *58*(4), 773-795. https://doi.org/10.2337/db09-9028

Domanski, M. J., Tian, X., Wu, C. O., Reis, J. P., Dey, A. K., Gu, Y.,…Fuster, V. (2020). Time Course of LDL Cholesterol Exposure and Cardiovascular Disease Event Risk. *J Am Coll Cardiol*, *76*(13), 1507-1516. https://doi.org/10.1016/j.jacc.2020.07.059

Duncan, G. E., Perri, M. G., Theriaque, D. W., Hutson, A. D., Eckel, R. H., & Stacpoole, P. W. (2003). Exercise training, without weight loss, increases insulin sensitivity and postheparin plasma lipase activity in previously sedentary adults. *Diabetes Care*, *26*(3), 557-562. https://doi.org/10.2337/diacare.26.3.557

Eder, K., Baffy, N., Falus, A., & Fulop, A. K. (2009). The major inflammatory mediator interleukin-6 and obesity. *Inflamm Res*, *58*(11), 727-736. https://doi.org/10.1007/s00011-009-0060-4

Fealy, C. E., Mulya, A., Lai, N., & Kirwan, J. P. (2014). Exercise training decreases activation of the mitochondrial fission protein dynamin-related protein-1 in insulin-resistant human skeletal

muscle. *J Appl Physiol (1985)*, *117*(3), 239-245. https://doi.org/10.1152/japplphysiol.01064.2013

Ferrari, G., Cofre Bolados, C., Suárez-Reyes, M., Farias Valenzuela, C., Drenowatz, C., Marques, A., & Pizarro, T. (2022). Association of physical activity, muscular strength, and obesity indicators with self-concept in Chilean children. *Nutr Hosp*, *39*(5), 1004-1011. https://doi.org/10.20960/nh.04061

Flegal, K. M., Kit, B. K., Orpana, H., & Graubard, B. I. (2013). Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *Jama*, *309*(1), 71-82. https://doi.org/10.1001/jama.2012.113905

Foster, P., Gálvez, E., Pinto, P., Cifuentes-Silva, E., Mahecha-Matsudo, S., & Inostroza-Mondaca, M. (2025). Results of a concurrent training protocol in muscle function and quality of life in the pediatric population with type 1 diabetes: a pilot study in public health. *Bol Med Hosp Infant Mex*, *82*(2), 129-137. https://doi.org/10.24875/bmhim.24000117

Gálvez, E., Cifuentes-Silva, E., González, F., Bueno, D., Foster, P., & Inostroza, M. (2022). Efectos de una planificación de ejercicio concurrente de 12 semanas en niños, niñas y adolescentes con sobrepeso y obesidad %J Andes pediatrica. *93*, 658-667.

Gill, J. M., & Hardman, A. E. (2003). Exercise and postprandial lipid metabolism: an update on potential mechanisms and interactions with high-carbohydrate diets (review). *J Nutr Biochem*, *14*(3), 122-132. https://doi.org/10.1016/s0955-2863(02)00275-9

Ginsberg, H. N., Packard, C. J., Chapman, M. J., Borén, J., Aguilar-Salinas, C. A., Averna, M.,…Catapano, A. L. (2021). Triglyceride-rich lipoproteins and their remnants: metabolic insights, role in atherosclerotic cardiovascular disease, and emerging therapeutic strategies—a consensus statement from the European Atherosclerosis Society. *Eur Heart J*, *42*(47), 4791-4806. https://doi.org/10.1093/eurheartj/ehab551 %J European Heart Journal

Gómez-Rossel, O., & Merellano-Navarro, E. (2024). Efectos del entrenamiento concurrente en indicadores de condición física y calidad de vida de adultos sanos. Retos, 54, 24-35. https://doi.org/10.47197/retos.v54.102244

Guo, Y., Qian, H., Xin, X., & Liu, Q. (2024). Effects of different exercise modalities on inflammatory markers in the obese and overweight populations: unraveling the mystery of exercise and inflammation. *Front Physiol*, *15*, 1405094. https://doi.org/10.3389/fphys.2024.1405094

Han, M. S., White, A., Perry, R. J., Camporez, J. P., Hidalgo, J., Shulman, G. I., & Davis, R. J. (2020). Regulation of adipose tissue inflammation by interleukin 6. *Proc Natl Acad Sci U S A*, *117*(6), 2751-2760. https://doi.org/10.1073/pnas.1920004117

Haskell, W. L. (1984). The influence of exercise on the concentrations of triglyceride and cholesterol in human plasma. *Exerc Sport Sci Rev*, *12*, 205-244.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A.,…Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*, *39*(8), 1423-1434. https://doi.org/10.1249/mss.0b013e3180616b27

Healy, S., Patterson, F., Biddle, S., Dumuid, D., Glorieux, I., Olds, T.,…Pedisic, Z. (2024). It's about time to exercise: development of the Exercise Participation Explained in Relation to Time (EXPERT) model. *Br J Sports Med*, *58*(19), 1131-1144. https://doi.org/10.1136/bjsports-2024-108500

Ho, S. S., Dhaliwal, S. S., Hills, A. P., & Pal, S. (2012). The effect of 12 weeks of aerobic, resistance or combination exercise training on cardiovascular risk factors in the overweight and obese in a randomized trial. *BMC Public Health*, *12*, 704. https://doi.org/10.1186/1471-2458-12-704

Hsu, K. J., Liao, C. D., Tsai, M. W., & Chen, C. N. (2019). Effects of Exercise and Nutritional Intervention on Body Composition, Metabolic Health, and Physical Performance in Adults with Sarcopenic Obesity: A Meta-Analysis. *Nutrients*, *11*(9). https://doi.org/10.3390/nu11092163

Jamka, M., Makarewicz-Bukowska, A., Bokayeva, K., Śmidowicz, A., Geltz, J., Kokot, M.,…Walkowiak, J. (2022). Comparison of the Effect of Endurance, Strength and Endurance-Strength Training on Glucose and Insulin Homeostasis and the Lipid Profile of Overweight and Obese Subjects: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*, *19*(22). https://doi.org/10.3390/ijerph192214928

Jensen, M. D., Ryan, D. H., Apovian, C. M., Ard, J. D., Comuzzie, A. G., Donato, K. A.,…Yanovski, S. Z. (2014). 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice

Guidelines and The Obesity Society. *J Am Coll Cardiol*, *63*(25 Pt B), 2985-3023. https://doi.org/10.1016/j.jacc.2013.11.004

Jiang, S., Bae, J. H., Wang, Y., & Song, W. (2022). The Potential Roles of Myokines in Adipose Tissue Metabolism with Exercise and Cold Exposure. *Int J Mol Sci*, *23*(19). https://doi.org/10.3390/ijms231911523

Jin, L., Han, S., Lv, X., Li, X., Zhang, Z., Kuang, H.,...Meng, Z. X. (2023). The muscle-enriched myokine Musclin impairs beige fat thermogenesis and systemic energy homeostasis via Tfr1/PKA signaling in male mice. *Nat Commun*, *14*(1), 4257. https://doi.org/10.1038/s41467-023-39710-z

Khalafi, M., Sakhaei, M. H., Kazeminasab, F., Rosenkranz, S. K., & Symonds, M. E. (2023). Exercise training, dietary intervention, or combined interventions and their effects on lipid profiles in adults with overweight and obesity: A systematic review and meta-analysis of randomized clinical trials. *Nutr Metab Cardiovasc Dis*, *33*(9), 1662-1683. https://doi.org/10.1016/j.numecd.2023.05.024

Kosmas, C. E., Rodriguez Polanco, S., Bousvarou, M. D., Papakonstantinou, E. J., Peña Genao, E., Guzman, E., & Kostara, C. E. (2023). The Triglyceride/High-Density Lipoprotein Cholesterol (TG/HDL-C) Ratio as a Risk Marker for Metabolic Syndrome and Cardiovascular Disease. *Diagnostics (Basel)*, *13*(5). https://doi.org/10.3390/diagnostics13050929

Lavie, C. J., Milani, R. V., & Ventura, H. O. (2009). Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. *J Am Coll Cardiol*, *53*(21), 1925-1932. https://doi.org/10.1016/j.jacc.2008.12.068

Lera, L., Fuentes-García, A., Sánchez, H., & Albala, C. (2013). Validity and reliability of the SF-36 in Chilean older adults: The ALEXANDROS study. European Journal of Ageing, 10(2), 127-134. https://doi.org/10.1007/s10433-012-0256-2

Lee, D. C., Brellenthin, A. G., Lanningham-Foster, L. M., Kohut, M. L., & Li, Y. (2024). Aerobic, resistance, or combined exercise training and cardiovascular risk profile in overweight or obese adults: the CardioRACE trial. *Eur Heart J*, *45*(13), 1127-1142. https://doi.org/10.1093/eurheartj/ehad827

Léger, L. A., & Lambert, J. (1982). A maximal multistage 20-m shuttle run test to predict VO2 max. *Eur J Appl Physiol Occup Physiol*, *49*(1), 1-12. https://doi.org/10.1007/bf00428958

Mach, F., Baigent, C., Catapano, A. L., Koskinas, K. C., Casula, M., Badimon, L.,...Wiklund, O. (2020). 2019 ESC/EAS Guidelines for the management of dyslipidaemias: lipid modification to reduce cardiovascular risk. *Eur Heart J*, *41*(1), 111-188. https://doi.org/10.1093/eurheartj/ehz455

MINSAL. (2018). Encuesta Nacional de Salud 2016-2017: Estado Nutricional.

Muñoz-Cánoves, P., Scheele, C., Pedersen, B. K., & Serrano, A. L. (2013). Interleukin-6 myokine signaling in skeletal muscle: a double-edged sword? *Febs j*, *280*(17), 4131-4148. https://doi.org/10.1111/febs.12338

Muscella, A., Stefàno, E., & Marsigliante, S. (2020). The effects of exercise training on lipid metabolism and coronary heart disease. *Am J Physiol Heart Circ Physiol*, *319*(1), H76-h88. https://doi.org/10.1152/ajpheart.00708.2019

Ockene, I. S., Chiriboga, D. E., Stanek, E. J., 3rd, Harmatz, M. G., Nicolosi, R., Saperia, G.,...Hebert, J. R. (2004). Seasonal variation in serum cholesterol levels: treatment implications and possible mechanisms. *Arch Intern Med*, *164*(8), 863-870. https://doi.org/10.1001/archinte.164.8.863

Oppert, J. M., Bellicha, A., van Baak, M. A., Battista, F., Beaulieu, K., Blundell, J. E.,...Busetto, L. (2021). Exercise training in the management of overweight and obesity in adults: Synthesis of the evidence and recommendations from the European Association for the Study of Obesity Physical Activity Working Group. *Obes Rev*, *22 Suppl 4*(Suppl 4), e13273. https://doi.org/10.1111/obr.13273

Pedersen, B. K., & Febbraio, M. A. (2008). Muscle as an endocrine organ: focus on muscle-derived interleukin-6. *Physiol Rev*, *88*(4), 1379-1406. https://doi.org/10.1152/physrev.90100.2007

Piché, M. E., Tchernof, A., & Després, J. P. (2020). Obesity Phenotypes, Diabetes, and Cardiovascular Diseases. *Circ Res*, *126*(11), 1477-1500. https://doi.org/10.1161/circresaha.120.316101

Pleticosic-Ramírez, Y., Mecías Calvo, M., & Navarro-Patón, R. (2024). Efectos de programas de ejercicio físico en la composición corporal, condición física y calidad de vida de personas mayores con sobrepeso u obesidad: Una revisión sistemática. Retos, 56, 47-62. https://doi.org/10.47197/retos.v56.104052

Richter, E. A., & Hargreaves, M. (2013). Exercise, GLUT4, and skeletal muscle glucose uptake. *Physiol Rev*, *93*(3), 993-1017. https://doi.org/10.1152/physrev.00038.2012

Ross, R., Blair, S. N., Arena, R., Church, T. S., Després, J.-P., Franklin, B. A.,…Wisløff, U. (2016). Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign: A Scientific Statement From the American Heart Association. *134*(24), e653-e699. https://doi.org/doi:10.1161/CIR.0000000000000461

Ross, R., Dagnone, D., Jones, P. J., Smith, H., Paddags, A., Hudson, R., & Janssen, I. (2000). Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. A randomized, controlled trial. *Ann Intern Med*, *133*(2), 92-103. https://doi.org/10.7326/0003-4819-133-2-200007180-00008

Sattar, N., Gill, J. M. R., & Alazawi, W. (2020). Improving prevention strategies for cardiometabolic disease. *Nat Med*, *26*(3), 320-325. https://doi.org/10.1038/s41591-020-0786-7

Schwingshackl, L., Dias, S., Strasser, B., & Hoffmann, G. (2013). Impact of different training modalities on anthropometric and metabolic characteristics in overweight/obese subjects: a systematic review and network meta-analysis. *PLoS One*, *8*(12), e82853. https://doi.org/10.1371/journal.pone.0082853

Severinsen, M. C. K., & Pedersen, B. K. (2020). Muscle-Organ Crosstalk: The Emerging Roles of Myokines. *Endocr Rev*, *41*(4), 594-609. https://doi.org/10.1210/endrev/bnaa016

Shalitin, S., & Moreno, L. A. (2021). Obesity, Metabolic Syndrome, and Nutrition. *World Rev Nutr Diet*, *123*, 38-58. https://doi.org/10.1159/000516452

Sidhu, S. K., Aleman, J. O., & Heffron, S. P. (2023). Obesity Duration and Cardiometabolic Disease. *Arterioscler Thromb Vasc Biol*, *43*(10), 1764-1774. https://doi.org/10.1161/atvbaha.123.319023

Smart, N. A., Downes, D., van der Touw, T., Hada, S., Dieberg, G., Pearson, M. J.,…Goodman, S. P. J. (2025). The Effect of Exercise Training on Blood Lipids: A Systematic Review and Meta-analysis. *Sports Med*, *55*(1), 67-78. https://doi.org/10.1007/s40279-024-02115-z

Smith, S. J., Cooper, G. R., Myers, G. L., & Sampson, E. J. (1993). Biological variability in concentrations of serum lipids: sources of variation among results from published studies and composite predicted values. *Clin Chem*, *39*(6), 1012-1022.

Stephenson, J., Smith, C. M., Kearns, B., Haywood, A., & Bissell, P. (2021). The association between obesity and quality of life: a retrospective analysis of a large-scale population-based cohort study. *BMC Public Health*, *21*(1), 1990. https://doi.org/10.1186/s12889-021-12009-8

Su, L., Fu, J., Sun, S., Zhao, G., Cheng, W., Dou, C., & Quan, M. (2019). Effects of HIIT and MICT on cardiovascular risk factors in adults with overweight and/or obesity: A meta-analysis. *PLoS One*, *14*(1), e0210644. https://doi.org/10.1371/journal.pone.0210644

Tabák, A. G., Herder, C., Rathmann, W., Brunner, E. J., & Kivimäki, M. (2012). Prediabetes: a high-risk state for diabetes development. *Lancet*, *379*(9833), 2279-2290. https://doi.org/10.1016/s0140-6736(12)60283-9

Taylor, V. H., Forhan, M., Vigod, S. N., McIntyre, R. S., & Morrison, K. M. (2013). The impact of obesity on quality of life. *Best Pract Res Clin Endocrinol Metab*, *27*(2), 139-146. https://doi.org/10.1016/j.beem.2013.04.004

Teixeira, D. S., Rodrigues, F., Cid, L., & Monteiro, D. (2022). Enjoyment as a Predictor of Exercise Habit, Intention to Continue Exercising, and Exercise Frequency: The Intensity Traits Discrepancy Moderation Role. *Front Psychol*, *13*, 780059. https://doi.org/10.3389/fpsyg.2022.780059

Trouwborst, I., Verreijen, A., Memelink, R., Massanet, P., Boirie, Y., Weijs, P., & Tieland, M. (2018). Exercise and Nutrition Strategies to Counteract Sarcopenic Obesity. *Nutrients*, *10*(5). https://doi.org/10.3390/nu10050605

Turner, L., Wanasinghe, A. I., Brunori, P., & Santosa, S. (2025). Is Adipose Tissue Inflammation the Culprit of Obesity-Associated Comorbidities? *Obes Rev*, *26*(11), e13956. https://doi.org/10.1111/obr.13956

Umpierre, D., Ribeiro, P. A., Kramer, C. K., Leitão, C. B., Zucatti, A. T., Azevedo, M. J.,…Schaan, B. D. (2011). Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. *Jama*, *305*(17), 1790-1799. https://doi.org/10.1001/jama.2011.576

Vallis, M. (2016). Quality of life and psychological well-being in obesity management: improving the odds of success by managing distress. *Int J Clin Pract*, *70*(3), 196-205. https://doi.org/10.1111/ijcp.12765

van Baak, M. A., Pramono, A., Battista, F., Beaulieu, K., Blundell, J. E., Busetto, L.,…Oppert, J. M. (2021). Effect of different types of regular exercise on physical fitness in adults with overweight or obesity: Systematic review and meta-analyses. *Obes Rev*, *22 Suppl 4*(Suppl 4), e13239. https://doi.org/10.1111/obr.13239

Wadsworth, D. D., Suire, K. B., Peart, A., Foote, S., Jones, C., Rodriguez-Hernandez, M.,…Pascoe, D. D. (2022). Concurrent Exercise Training: Long-Term Changes in Body Composition and Motives for Continued Participation in Women with Obesity. *J Funct Morphol Kinesiol*, *7*(4). https://doi.org/10.3390/jfmk7040110

Wang, S., Zhou, H., Zhao, C., & He, H. (2022). Effect of Exercise Training on Body Composition and Inflammatory Cytokine Levels in Overweight and Obese Individuals: A Systematic Review and Network Meta-Analysis. *Front Immunol*, *13*, 921085. https://doi.org/10.3389/fimmu.2022.921085

Wedell-Neergaard, A. S., Lang Lehrskov, L., Christensen, R. H., Legaard, G. E., Dorph, E., Larsen, M. K.,…Krogh-Madsen, R. (2019). Exercise-Induced Changes in Visceral Adipose Tissue Mass Are Regulated by IL-6 Signaling: A Randomized Controlled Trial. *Cell Metab*, *29*(4), 844-855.e843. https://doi.org/10.1016/j.cmet.2018.12.007

Whitlock, G., Lewington, S., Sherliker, P., Clarke, R., Emberson, J., Halsey, J.,…Peto, R. (2009). Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. *Lancet*, *373*(9669), 1083-1096. https://doi.org/10.1016/s0140-6736(09)60318-4

World Health Organization. (2025). Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

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