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# Concurrent and Aerobic Exercise on Maximal Oxygen Consumption in Adults with Obesity: Study Protocol for a Randomized Controlled Trial

## Ejercicio Concurrente y Aeróbico sobre el Consumo Máximo de Oxígeno en Adultos con Obesidad: Protocolo de estudio para un ensayo controlado aleatorizado

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**Cite like this**
Madrid Zapata F, Orozco Osorio J, Cruz-González JJ, Arboleda-Serna VH. Concurrent and Aerobic Exercise on Maximal Oxygen Consumption in Adults with Obesity: Study Protocol for a Randomized Controlled Trial. Revista de Investigación e Innovación en Ciencias de la Salud. 2025;7(1):1-16. e-v7n1a306. https://doi.org/10.46634/riics.306

**Received**: 03/11/2024
**Revised**: 05/10/2024
**Accepted**: 06/11/2024

**Editor**:
Fraidy-Alonso Alzate-Pamplona, MSc.



## Abstract

**Background**. Concurrent and aerobic physical exercise are strategies for treating overweight and obesity. Most interventions have utilized cardiovascular or guided execution machines, which often involve high-cost materials not easily accessible to the general population.

**Objective**. Identify the effect of 12 weeks of exercise (concurrent vs. aerobic training) based on the polarized training intensity distribution model on maximal oxygen consumption, muscle strength, and body composition.

**Materials and methods**. A randomized controlled trial with two groups, concurrent vs. aerobic training (n = 28), in overweight and obese individuals. Both groups will perform 36 sessions, 3 times a week, on alternate days.

**Results**. Current evidence has not demonstrated the superiority of concurrent over aerobic exercise on $VO_2$max, muscle strength, and body composition. Additionally, the few randomized studies with concurrent exercise and the methodological limitations in their designs justify the importance of comparing both types of exercise to determine the best strategies for overweight and obese individuals regarding the mentioned outcomes.

## Keywords

Cardiorespiratory fitness; circuit-based exercise; obesity; body composition; resistance training; concurrent training; endurance training; strength.

**Declaration of interests**
The authors have declared that there is no conflict of interest.

**Data availability**
All relevant data is in the article. For futher information, contact the corresponding author.

**Financing**
This research is supported by SENA POMAR, INDER of Girardota and University of Antioquia.

**Disclaimer**
The content of this article is the sole responsibility of the authors and does not represent an official opinion of their institution or of the *Revista de Investigación e Innovación en Ciencias de la Salud*.

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## Resumen

**Antecedentes**. El ejercicio físico concurrente y el entrenamiento aeróbico son estrategias para tratar el sobrepeso y la obesidad. La mayoría de las intervenciones han usado máquinas cardiovasculares o de ejecución guiada, que frecuentemente implican materiales de alto costo no fácilmente accesibles para la población general.

**Objetivo**. Identificar el efecto de 12 semanas de ejercicio (entrenamiento concurrente vs. aeróbico), basado en el modelo de distribución de intensidad de entrenamiento polarizado, sobre el consumo máximo de oxígeno, la fuerza muscular y la composición corporal.

**Materiales y métodos**. Ensayo controlado aleatorizado con dos grupos, entrenamiento concurrente vs. aeróbico (n = 28), en personas con sobrepeso y obesidad. Ambos grupos realizarán 36 sesiones, 3 veces por semana, en días alternos.

**Resultados**. La evidencia actual no ha demostrado la superioridad del ejercicio concurrente frente al aeróbico sobre el $VO_2$max, la fuerza muscular y la composición corporal. Además, los pocos estudios encontrados con ejercicio concurrente y las limitaciones metodológicas justifican en sus diseños la importancia de comparar ambos tipos de ejercicio y así identificar las mejores estrategias para las personas con sobrepeso y obesidad en relación con los desenlaces mencionados.

## Palabras clave

Aptitud cardiorrespiratoria; ejercicio en circuito; obesidad; composición corporal; entrenamiento de resistencia; entrenamiento concurrente; entrenamiento aérobico; fuerza.

## Introduction

Overweight is characterized by excessive fat deposits, whereas obesity is defined as a disease marked by a significant increase in adipose tissue, which is detrimental to health [1]. It is a risk factor for developing different diseases such as diabetes, hypertension, and cancer [2]. Excess weight is generated by different causes in which the following stand out: excessive consumption of food and sedentary behaviors [2].

By 2030, one in five women and one in seven men are expected to be obese, which is equivalent to more than 1 billion people worldwide [2]. In Latin America, overweight affects 59.5% of the adult population, and obesity affects almost 25% of adults [3]. The increase in overweight has brought different consequences worldwide, such as the annual cost of treatments related to this disease, which oscillates around USD 2.0 trillion.

A protective factor for obesity is the increase in maximum oxygen consumption ($VO_2$max). Due to having high levels, the probability of morbidity and mortality from any cause decreases [4]. A systematic review that inquired about $VO_2$max in this population reported that low $VO_2$max values are associated with obesity [5].

Exercise-based strategies such as aerobic training (AT), strength training (ST) and combined training (CT) have been used. These three types of training generate effects on $VO_2$max, muscle strength (MS) and body composition (BC) in overweight and obese people [4].

### Training intensity distribution models in interventions with AT and CT

Treadmill [6] cycle ergometer [7] tests have been used to determine the intensities of the AT and CT interventions. The control of the intensity in the interventions has been carried out by heart rate (HR) reserve [8] % $VO_2$max [6], $VO_2$peak [9], and ventilatory thresholds (VT) [10]. Table 1 presents the dosage of the load components for AT, ST, and CT.

**Table 1.** Dosage of the load components for the interventions of AT, ST, and CT.

| Intervention | Load quantification | |
|---|---|---|
| AT [6,11]. | Volume: Per km traveled during the week. Intensity: 75% of $VO_2$max (HR-max) at 70%. Time: 60 minutes. Frecuency: 4 times a week, for 8 weeks in both studies. | |
| ST [7,12]. | Volume: 3 to 4 sets, 10-12 repetitions. Intensity: 70-85% of one maximum repetition (1RM), or 50-85% of 1 RM. Exercise: 5 to 10. Micropause: 90 seconds. | |
| CT [7]. | AT. Duration: 30 minutes. Intensity: 75-85% HRmax. | ST. Duration: 20 minutes. Volume: 2 sets, 12 exercises, 18-20RM at 60% or 8RM at 75%. Exercise: 8 to 12. |

There is a scarcity of studies on training intensity distribution models (TID) to determine the load in AT or CT [6,8,11]. These models are defined by the total time spent in each training zone during a microcycle or mesocycle and quantify the intensity based on physiological markers such as VT and lactate threshold (LT) [13]. Using these parameters, 3 training zones are established. Zone 1: low intensity, below VT 1 (<VT1) or LT1 (<LT1). Zone 2: moderate intensity, between VT1 and VT2 or LT1 and LT2. Zone 3: high intensity, above VT2 (>VT2) or LT2 (>LT2) [13]. Some of the TID include:

- Pyramidal TID: primarily focuses on Zone 1 (<VT1), 80%, with a lower percentage in Zone 2 (between VT1 and VT2) and minimal in Zone 3 (>VT2) [14].
- High intensity TID: focused around 70% in Zone 3 (>VT2) [15].
- Low-intensity and high-volume TID: predominantly in Zone 1 (<VT1), almost 100% [16].
- Polarized TID: 75-80% in Zone 1 (<VT1), 15-20% in Zone 3 (>VT2); rest in Zone 2 (between VT1 and VT2) [16].

The polarized TID increases $VO_2$max in overweight and obese individuals. In a study with obese women, it compared continuous moderate-intensity training, high-intensity interval training, and polarized TID. Polarized training showed superior effects, with a 2.6 ml/min [95% Confidence Interval (CI) 1.5 - 3.8] in $VO_2$peak compared to the other interventions. This also allowed for greater exercise tolerance in this population. However, further investigation is needed regarding the effects of polarized TID on cardiometabolic factors [17].

The following tables describe the effects of AT, CT, and ST on $VO_2$max, MS, visceral adipose tissue (VAT), free fat mass (FFM), fat mass (FM), and waist circumference (WC).

### Effects of physical exercise on $VO_2$max

Observe the effects of AT and CT on $VO_2$max in Table 2.

**Table 2**. Effects of AT and CT on $VO_2$max.

| Study | Comparisons | Outcome (mean differences in ml/kg/min) (SD) | Confidence Interval (CI) | p-value |
|---|---|---|---|---|
| (Batrakoulis et al., 2022) [4] | AT vs. CON | 4.45* | IC (–0.11 - 9.01) | $p > 0.05$ |
| | CT vs. CON | 6.35* | IC (1.46 - 11.24) | $p < 0.05$ |
| (Van Baak et al., 2021) [18] | AT vs. CON | 4.08* | IC (3.22 - 4.95) | $p < 0.00$ |
| | CT vs. CON | 4.57* | IC (2.14 - 7.00) | $p < 0.00$ |
| (Scapini et al., 2019) [19] | AT vs. CON | 3.35* | IC (1.55 – 5.11) | ** |
| | CT vs. CON | 5.01* | IC (3.26 - 6.57) | ** |

**Note**. AT: Aerobic training; CT: Combined training; CON: Control group. *No inform standard deviation (SD) and ** Not reported $p$>value.

As seen in Table 3, to date the superiority of one training over the other cannot be determined, since there are no statistically significant or important differences for practice.

**Table 3**. Differences between AT and CT on $VO_2$max.

| Study | (mean differences in ml/kg/min) | Confidence Interval (CI) | $p$-value (SD) |
|---|---|---|---|
| (Jin et al., 2018) [11] | 1.28 | & | $p > 0.05$ * |
| (Donges CE et al., 2023) [7] | 1.2 | & | $p > 0.05$ * |
| (Schroeder et al., 2019) [8] | 2.8 | & | $p > 0.05$ * |
| (Ratajczak et al., 2019) [20] | 0.09 | & | $p > 0.05$ * |
| (Batrakoulis et al., 2022) [4] | 0.25 | IC (–2.45 - 2.95) | $p > 0.05$ * |
| (Van Baak et al., 2021) [18] | 0.38 | IC (–0.63 - 1.38) | $p > 0.05$ * |
| (Scapini et al., 2019) [19] | 1.66 | IC (–0.83 - 3.93) | $p > 0.05$ * |
| (O'Donoghue et al., 2021) [21] | 3.05 | IC (–4.73 - 0.83) | $p > 0.05$ * |

**Note**. *No inform standard deviation (Sd) and ** not reported $p$>value. & No inform Confidence Interval (CI)

### Effects of physical exercise on BC (fat-free mass, fat mass, waist circumference, visceral adipose tissue), and muscle strength.

The benefits of physical exercise on visceral adipose tissue (VAT), fat-free mass (FFM), waist circumference (WC), fat mass (FM), and muscular strength (MS) are shown in Table 4.

**Table 4**. Effects of CT, AT, and ST on BC and MS.

| Study | Intervention | Variable | Outcome (mean differences in ml/kg/min) | Confidence Interval (CI) | *p*-value (SD) |
|---|---|---|---|---|---|
| (Slentz et al., 2011) [6] | CT | VAT | Pre-Test vs. Pos-Test (-10.9 $cm^2$) | & | $p$ >0.05 (33) |
| (Batrakoulis et al., 2022) [4] | | FFM | CT vs. CON (1.62 kg) | IC (-0.27 -3.51) | $p$ >0.05 * |
| | | WC | CT vs. CON (-3.98 cm) | IC (-5.51 - -2.45) | $p$ >0.05 * |
| (Morze et al., 2021) [22] | AT | FM | AT vs. CON (-1.54%) | IC (-2.23 - -0.85) | $p$ >0.05 * |
| | | WC | AT vs. CON (-2.33 cm) | IC (-3.19 - -1.47) | $p$ >0.05 * |
| (Batrakoulis et al., 2022) [4] | ST | FFM | ST vs. CON (1.63kg) | IC (-0.36 - 3.61) | $p$ >0.05 * |
| (Chen et al., 2017) [23] | ST | MS | ST vs. CON (5.14 kg)$^a$ | & | $p$ <0.05 * |
| | AT | | AT vs CON (0.63 kg)$^b$ | & | $p$ >0.05 * |
| (Slentz et al., 2011) [6] | CT | | Pre-Test vs. Pos-Test (3492 kg)$^c$ | & | $p$ <0.0001 (386) |

**Note**. AT: Aerobic training; ST: strength training; CT: Combined training; BC: body composition; VAT: visceral adipose tissue; FFM: fat free mass; FM: fat mass; WC: waist circumference; MS: muscle strength; a: Knee extensor muscles; back extensor muscles; c: Kilograms mobilized per training session. * No inform standard deviation. & No inform Confidence Interval (CI).

However, when comparing these interventions (AT, CT, and ST) to determine which is the best for BC, no statistically significant differences or practically important results were found [20,21]. Conversely, when evaluating MS, CT seemed to be superior to AT in muscle strength gains in both the lower limbs [4] and upper limbs [23]. See Table 5.

### Limitations and gaps in the evidence

The formulation of randomized controlled trials (RCTs) for CT and its effects on this variable becomes relevant. In addition, a greater number of RCTs for AT compared to CT is evident in the following systematic reviews and meta-analyses on $VO_2$max in overweight and obese individuals. For example, Batrakoulis et al. [4] included 45 studies for AT and 15 for CT, Van Baak et al. [18] reported 24 studies for AT and 7 for CT, Scapini et al. [19] selected 21 for AT and 12 for CT, and O'Donoghue et al. [21] considered 35 studies for AT and 11 for CT.

For the aerobic component, most of the interventions used activities, such as walking or running, a cycle ergometer or treadmill [4,18,19,21] and exercises in water [26]. For ST, Van Baak et al. and Ratajczak et al. used body-building machines [18,20] and Slentz et al. and Jin et al. used guided machines [6,11]. There have been few studies on outdoor exercise [4,24,27], and limited interventions have been conducted using block circuits. In these circuits, each block focuses on a specific component, such as strength or aerobic training, and includes self-loading and short-duration cardiovascular exercises [18,20]. Additionally, there is limited evidence regarding the aerobic component of CT, particularly involving coordinated aerobic steps [28,29].

**Table 5**. Differences between CT, ST, and AT in BC and MS.

| Study | Intervention | Variable | Outcome (mean differences in ml/kg/min) | Confidence Interval (CI) | *p*-value (SD) |
|---|---|---|---|---|---|
| (O'Donoghue et al., 2021) [21] | CT | BF | EC vs. EA -1.12% | IC (-4.12 - 1.88) | $p > 0.05$ * |
| (Hsu et al., 2019) [24] | | | EC vs. CON -2.05% | IC (-3.5 - -0.61) | $p > 0.05$ * |
| (Jin et al., 2018) [11] | AT | | EA vs. EC -0,3% | & | $p > 0.05$* |
| (Batrakoulis et al., 2022) [4] | CT | WC | EC vs. EA 0.25 cm. | IC (-2.04 - 1.54) | $p > 0.05$ * |
| (Wang et al., 2022) [25] | CT | | EC vs. EA 0.64 cm | IC (-0.40 - 1.70) | $p > 0.05$ * |
| (Batrakoulis et al., 2022) [4] | CT | FFM | EC vs. EA 0.13 kg | IC (-2.05 - 2.30) | $p > 0.05$ * |
| (Slentz et al., 2011) [6] | AT | VAT | EA vs. EC -5 $cm^2$ | & | $p > 0.05$* |
| (Van Baak et al., 2021) [18] | CT | MS | EC vs. EF 0.5 kg[a] | IC (−0.21 - 1.21) | $p > 0.05$ * |
| (Chen et al., 2017) [23] | | | EC vs. EF 2.62 kg[b] | & | $p > 0.05$* |
| | | | EC vs. EA 1.68 kg[c] | & | $p > 0.05$* |
| (Batrakoulis et al., 2022) [4] | | | EC vs. EA 33.3 kg[d] | IC (3.8 - 62.8) | $p > 0.05$ * |

**Note**. AT: Aerobic training; ST: strength training; CT: Combined training; BC: body composition; BF: Body Fat; VAT: visceral adipose tissue; FFM: fat free mass; FF: fat mass; WC: waist circumference; MS: muscle strength; a: Musculature of lower and upper limbs; b: Musculature of lower limbs; c: Knee extensor musculature: d: Lower limb musculature.

*No inform standard deviation & No inform Confidence Interval (CI)

The methodological designs have limitations, including small sample sizes [11,30], absence of reported sample size calculation [4,18,21], and lack of intergroup comparisons despite having three intervention arms (AT, ST, CT) [8,23]. The authors of the systematic review also declared limitations, including few studies of high methodological quality [11,20,23].

## Objective and hypothesis

This study aims to assess the effect of a CT program compared to an AT program, both following a polarized TID, on various health parameters including $VO_2$max, lower limb MS, FM, VAT, FFM, and WC in overweight and obese adults aged 18 to 59 years. The goal is to detect a minimum difference of 3.5 ml/kg/min in $VO_2$max between the CT and AT groups [21,27]. Previous research has shown values close to 3.5 ml/kg/min, but this difference between groups has not been achieved. This study proposes a novel intervention that may produce this significant difference, which holds practical significance [31].

## Materials and methods

We used an RCT involving two parallel groups, designed under the CERT [32] and CONSORT [33] guidelines. This protocol is registered on ClinicalTrials.gov with the identifier NCT05867498.

### Participants

Participants will be individuals aged 18-59 from the Municipality of Girardota, Antioquia, Colombia, who are overweight or obese. The sample was calculated using the Epidat 4.2 program, with a mean difference of 3.5 ml/kg/min in $VO_2$max, standard deviations (SDs) of 1.3 and 3.1 [11], 95% confidence level, 90% power, 5% alpha error, with a 1:1 ratio between groups. A sample size of 12 people per group was obtained, plus a 15% oversampling due to potential dropouts.

### Selection criteria

Twenty-eight (28) individuals, both men and women, between 18 and 59 years old, who have a Body Mass Index (BMI) >25.0, WC ≥85 cm in women and ≥94 cm in men will be included. All participants must voluntarily consent to participate in the study by signing an informed consent form, which will detail the objectives of the research, the benefits, the possible risks and the strategies to mitigate those risks. The University of Antioquia Research Ethics Committee of the University Institute of Physical Education in Medellín, Colombia, has approved the protocol of this RCT, along with the informed consent form (ACEI 33-2023). Smokers, individuals with a history of cardiovascular and pulmonary diseases, those with uncontrolled psychiatric problems, those being treated with anticoagulants, beta-blockers, calcium antagonists, or bronchodilators, individuals with musculoskeletal injuries that may affect participation in exercise sessions, pregnant women, and individuals following a nutritional plan for weight loss will be excluded.

### Recruitment and assessment and intervention sites

The Sports and Recreation Institute (INDER Girardota) database will be searched to identify potential participants who meet the inclusion criteria. Additionally, information will be sent through the INDER Girardota social networks.

The initial and final assessments of $VO_2$max, MS, and BC will be conducted at the laboratory of the National Learning Service (SENA) located at the POMAR headquarters Medellín, Colombia. The interventions will take place at sports centers within the Municipality of Girardota.

### Randomization process

The randomization sequence will be generated using Sealed Enveloped software [34], employing blocks of four and six. To ensure concealment, the sequence will be enclosed in opaque, sealed envelopes numbered from 1 to 28. The assignment will be made according to the order of initial evaluation. These procedures will be conducted by personnel external to the research team.

### Adherence strategies

A presentation will be held to discuss the benefits of participation, the project's cost (which is free for participants), and the study schedule will be outlined to identify individuals with available time to participate. The training plans will be implemented by professionals according to training principles, ensuring participant safety and minimizing the risk of injury and dropout during exercise sessions. Messages will be sent via WhatsApp to users, reminding them of upcoming sessions and inquiring about their absence if it occurs. Everyone will receive the results of both initial and final evaluations along with their respective interpretation.

### Bias control

The previously presented inclusion and exclusion criteria will allow us to control selection biases. Confounding biases will be controlled through the randomization process and statistical analyses will include analyses of covariance to control for sources of bias arising from potential confounding variables. To control information biases during evaluations, specialized personnel including a sports medicine specialist physician and laboratory technicians will be involved. Valid and reliable equipment will be utilized, and tests will be conducted at consistent times of the day, following established protocols. The personnel in charge of this process will be blinded to the interventions. Participants will receive detailed instructions on the necessary preparation for evaluations, and their compliance with these requirements will be confirmed before the evaluations begin.

### Collection of information and measuring instruments

Participants will be scheduled to arrive at 6:00 AM for all tests, and their readiness for evaluation will be confirmed, including instructions to have a light breakfast, abstain from caffeine, tea, or alcoholic beverages for 12 hours prior to the tests, maintain adequate hydration, avoid vigorous physical exercise the day before evaluations, wear sportswear and comfortable shoes, and reschedule evaluations if experiencing fever or body discomfort on the day of the test.

### Order of evaluations

*Body composition*

To analyze the BC, height (cm) will first be measured with a stadiometer (SECA, Germany) with a measurement range of 3.5-230 cm. Then, the WC (cm) will be measured with a metric tape (GMD, Colombia) with a length of 150 cm. Finally, the information will be entered in the InBody 270 electrical bioimpedance device (InBody, USA) that works at a frequency of (20kHz, -100kHz) for the evaluation of body weight (kg), FFM (kg), GF (%), and VAT estimation (high>10, low<10); this equipment has a Kendall's concordance correlation of 0.71 in the FM [35], and 0.14 for the FFM [35].

Measurements will begin with height. The participant will stand barefoot, facing forward, with their heels, buttocks, shoulder blades, and occiputs against the wall to record the height. Next, the WC will be measured. With the participant's authorization, cut-off points will be marked with a pencil on the upper edge of the iliac crest and the costal margin. The tape measure will be passed through the midpoint to take the WC measurement. Finally, the participant will stand barefoot without any metallic object on the Inbody 270, which will be placed on a flat, firm surface. The participant's feet will make contact with the four lower electrodes, and they will hold the upper electrodes with their hands, abducting the shoulders maintaining an upright position while the device performs the measurement.

*Strength measurement*

The T-Forcé tf-100 (ERGOTECH, Spain) will be used. It is a linear encoder that measures average propulsive speed (m/s), maximum strength (N) and maximum peak power (W). The mean relative error in velocity measurements <0.25% and the absolute error in displacement is less than ±0.5 mm [36]. The mean propulsive velocity has an intraclass correlation coefficient of 1.00 (95% CI: 1.00-1.00) and a coefficient of variation of 0.57% [36].

To evaluate lower limb strength, the half-squat exercise will be performed on a Smith machine. The participant will stand under the barbell, resting it on their trapezius after scapular retraction. With feet placed shoulder-width apart, the participant will descend in a controlled manner, performing pelvic anteversion and maintaining the natural curvatures of the spine. Upon reaching 90° of knee flexion, the participant will then ascend at the highest possible speed.

The warm-up will last 2 minutes, consisting primarily of mobility exercises (hip, knees, ankles). Participants will be instructed in the squat technique without weight, supported on a bench; when mastery of the technique is noted, they will perform the exercise on the Smith machine without weight. After every 3 repetitions, the load will be increased by 5 kg until the initial load is reached, which will be 40% of the body weight. With this load, they will be asked to perform 3 repetitions at maximum speed to evaluate the average propulsive speed (m/s), maximum strength (N), peak maximum power (W), and mobilized weight (kg). Increases of 10 kg will be made until the average propulsive speed is <0.4 m/sec, this being a criterion to finish the test, or until the person is unable to continue; the breaks will last 2 minutes between each set.

*$VO_2$max measurement*

To assess cardiorespiratory capacity, a bicycle ergospirometry (ERGO-FIT, Germany) will be performed with a gas analyzer (METAMAX 3B cortex, Germany). This equipment has a reliability of ICC ≥ 0.969; p = 0.000 and a precision of % SEM ≤ 4.6 [37]. The following variables will be measured: $VO_2$max, HRmax, VT1, and VT2.

The cycle ergometer will be calibrated with the gas analyzer; the characteristics of the test will be explained, and the participant's weight, height and age will be recorded. Next, their blood pressure (BP) and the HR will be measured. The height of the bicycle seat will be adjusted.

The test will begin with a resistance of 30 Watts, maintaining a pedaling cadence of 50 revolutions per minute (rpm) for 3 minutes; this will be the first ergometric charge. Subsequently, 30 Watts will be increased while maintaining the cadence at >50 rpm for another 3 minutes. This process will continue until the participant reaches exhaustion or decides to stop voluntarily. The following criteria will be considered to identify $VO_2$max: Respiratory Quotient (≥1.10) and Heart Rate (≥95%) of the theoretical maximum. HR and BP will be recorded at the end of each load. The recovery phase will last 5 minutes, with a load of 30 Watts at 30 rpm, the HR and BP will be measured at minutes 1, 3, and 5.

**Intervention protocols**

Two groups, CT and AT, will undergo a 12-weeks program, 3 sessions per week on alternate days, each lasting 60 minutes. Participants will have a HR monitor (MI BAND 4) to control the intensity. Training zones for the polarized TID will be determined based on ergo spirometry results

Both groups will start each session with an 8-minute warm-up. AT will perform aerobic steps at an intensity <VT1 for 12 weeks. CT will do the same for 6 weeks and then switch to joint mobility exercises for the remaining 6 weeks. The session will conclude with 4-minute stretch of the main muscle groups.

*The CT group*

The main part of the session, lasting 48 minutes, will consist of 2 components: strength and aerobics; each lasting 24 minutes. The strength component will involve a circuit of 7 exercises. (As seen in Tables 6, 7 and 8).

**Table 6**. Strength component for the CT group.

| Weeks | Circuit | E/T | S/R | I | Mi/Ma |
|---|---|---|---|---|---|
| 1-4 | General training | 7/60 | 2/15-18 | 4-5 | 10/180 |
| 5-8 | Block training | 7/45 | 3/12-15 | 5-6 | 10/70 |
| 9-12 | Concentrated training | 7/35 | 3/8-12 | 6-8 | 15/110 |

**Note**. Abbreviations: E, number of exercises. T, time per exercise in seconds. S, sets. R, repetitions. I, intensity in OMNI-RES scale. Mi, micro pause (rest between exercises in seconds). Ma, macro pause (rest between sets in seconds).

**Table 7**. Exercises of the strength component for the CT group.

| Weeks 1-4 | Weeks 5-8 | Weeks 9-12 |
|---|---|---|
| Bodyweight Squat | Resistance bands red squats | Medicine Ball Squat Throw |
| Dumbbell deadlift | Barbell deadlift | Barbell deadlift + shoulder abduction resistance band |
| Gluteal bridge and hip abduction with resistance bands | kettlebell swing | kettlebell swing + dumbbell snatch |
| Dumbbell Calf Raise | Farmer Walk whit dumbbell | Farmer Walk whit dumbbell + Dumbbell Calf Raise |
| knee push-ups | Push up | Push up + dumbbell rows in plank |
| Dumbbell rows | Dumbbell rows in plank | Plank |
| Dumbbell shoulder press | Push up + dumbbell shoulder press | Dumbbell shoulder press + dumbbell lunges |

**Table 8**. Aerobic component of the TC group.

| Weeks | 1 y 2 | 3 y 4 | 5, 6 y 7 | 8 | 9, 10 y 11 | 12 |
|---|---|---|---|---|---|---|
| **Method** | CV | CV | CV | CV | CV | CV |
| **TA** | RA | RA | RA | RA | RA | RA |
| **D** | 18’ | 16’ | 18’ | 16’ | 18’ | 16’ |
| **I** | <VT1 | <VT1 | <VT1 | <VT1 | <VT1 | <VT1 |
| **Method** | Intervalic | Intervalic | Intervalic | Intervalic | Intervalic | Intervalic |
| **TA** | GC | GC | GC | GC | GC | GC |
| **D** | 5’ | 6’ | 5’ | 6’ | 5’ | 6’ |
| **I** | >VT2 | >VT2 | >VT2 | >VT2 | >VT2 | >VT2 |
| **Volume** | CG 30” x 5 | GC 45” x 4 | GC 50” x 5 | GC 60” x 4 | GC 70” x 3 | GC 80” x 4 |
| **Mi** | 30’’ | 45’’ | 25’’ | 30’’ | 35’’ | 40’’ |

**Note**. Abbreviations: CV, Continuous variable; TA, Type of activity; RA, Rumba-aerobic (Steps of ballroom and folkloric dances); D, Duration in minutes per session; VT1, Low intensity; CG, Combat gestures (Fists, knees, and plantar flexion with hand-foot dissociation); I, Intensity; C, Charges in seconds; VT2, High intensity; Mi, Micro pause in seconds; Ma, Macro pause in seconds.

The aerobic component will include 18 minutes of variable continuous method with rumba-aerobic (ballroom and folk-dance steps), followed by 6 minutes of interval method with combat gestures (fists, knees, and plantar flexions).

*The AT group*

This group will perform the same rumba steps, combat gestures, intensities, and time as the CT group during the aerobic component. However, in the AT group, the variable continuous method will last 36 minutes and the interval method will last 12 minutes (see Table 9).

**Table 9**. Group AT.

| Weeks | 1 and 2 | 3 and 4 | 5, 6, 7 and 8 | 9, 10 and 11 | 12 |
|---|---|---|---|---|---|
| **Method** | CV | CV | CV | CV | CV |
| **TA** | RA | RA | RA | RA | RA |
| **D** | 36' | 36' | 36' | 36' | 36' |
| **I** | <VT1 | <VT1 | <VT1 | <VT1 | <VT1 |
| **Method** | Intervalic | Intervalic | Intervalic | Intervalic | Intervalic |
| **TA** | GC | GC | GC | GC | GC |
| **D** | 12' | 12' | 12' | 12' | 16' |
| **I** | >VT2 | >VT2 | >VT2 | >VT2 | >VT2 |
| **Volume** | 2 S x 5 GC 35" | 2 S x 4 GC 45" | 2 S x 4 GC 60" | 2 S x 3 GC 75" | 2 S x 4 GC 80" |
| **Mi** | 35" | 45" | 30" | 40" | 40" |
| **Ma** | 80" | 60" | 60" | 75" | 80" |

**Note**. Abbreviations: CV, Continuous variable; TA, Type of activity; RA, Rumba-aerobic (Steps of ballroom and folkloric dances); D, Duration in minutes per session; VT1, Low intensity; CG, Combat gestures (Fists, knees, and plantar flexion with hand-foot dissociation); I, Intensity; S, Sets; VT2, High intensity; Mi, Micro pause in seconds.

## Statistical analysis

The data analyses will follow the intention-to-treat principle and per protocol analyses (compliance ≥70% of the sessions, only for the primary outcome). The Shapiro-Wilk and Levene tests assess normality and homogeneity of variances. Analysis of covariance (ANCOVA) [38] will be used to identify mean differences between CT and AT groups, adjusting for initial outcome variable values and controlling for possible confounding variables. Summary measures will include means and standard deviations. In case of non-normality or heterogeneous variances, the Mann-Whitney U test will be used, and data will be presented in medians and interquartile ranges. Statistical significance will be set at $p<0.05$ with a 95% confidence interval. Analysis will be conducted using SPSS v27.

*Handling of lost data*

Multiple data imputation will be made, for $VO_2$max and FM.

*Software use and license*

The SPSS license was acquired by the University of Antioquia in a Campus Agreement modality. Epidat 4.2 is freely distributed.

**Ethical aspects**

Based on the Declaration of Helsinki of 2013, participant privacy will be ensured. Sources of financing, conflicts of interest, benefits, and potential risks associated with the research will be disclosed. Additionally, compliance with Resolution 8430 of 1993 from the Colombian Ministry of Health and Social Protection will be considered. Participants will receive training on the informed consent process, providing them with comprehensive knowledge of the study's objectives, justification, benefits, and potential risks, which will enable them to make an informed decision to participate freely.

**Privacy and confidentiality**

The data share in this research will uphold participants' privacy and consent. They will be informed about the data's public use, ensuring confidentiality. Privacy measures include restricted access to electronic files solely by researchers, participant identification through codes, and no disclosure of information compromising privacy. Participants' consent will be consistently obtained.

## Discussion

Obesity, a detrimental health condition [1], increases the risk of various cardiovascular and metabolic diseases such as diabetes, hypertension, and cancer [2]. Increasing $VO_2$max can mitigate risks, lowering morbidity and mortality rates [4]. Therefore, it is important to compare the effectiveness of AT and CT in improving $VO_2$max, MS, and BC in overweight and obese individuals. Furthermore, using polarized TID with outdoor music dynamics and easily accessible materials is an innovative approach that has been relatively under-researched until now.

## Limitations

Using electrical bioimpedance for BC evaluation is preferred due to its cost-effectiveness, although it lacks precision in assessing VAT. Financial and logistical limitations hinder the use of advanced equipment like computed tomography, magnetic resonance imaging, or dual-energy X-ray absorptiometry, which offer greater accuracy.

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*Revista de investigación e innovación en ciencias de la salud*
vol. 7, no. 1, a306, 2025
Fundación Universitaria María Cano,
**ISSN-E:** 2665-2056

**DOI:** https://doi.org/10.46634/riics.306