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Original Article

EFFECTS OF TWO TYPES OF TRAINING ON ANTHROPOMETRY AND PHYSICAL FITNESS IN COVID-19 CONVALESCENTS

EFEITOS DE DOIS TIPOS DE TREINOS EM VARIÁVEIS ANTROPOMÉTRICAS E DE APTIDÃO FÍSICA EM CONVALESCENTES DA COVID-19

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ABSTRACT

The aim of this study has been to analyze the effects of two types of training, in a research context and another in a university extension project, on anthropometric and physical fitness variables in patients recovering from COVID-19. Height, body weight, waist circumference (WC) and hip circumference (HC), waist-to-hip ratio (WHR) were measured before and after 8 weeks, as well as chair stand (CS), agility and dynamic balance (ADB), and 6-minute walk (6MW) tests. In this study, the research group (ResG) performed moderate-intensity interval aerobic training, and in the extension group, the participants (ExtG) performed a multicomponent model. Data have been analyzed through a generalized linear regression model, with Bonferroni post-hoc. The total sample consisted of 117 participants, predominantly women (62.39%) and a mean age of 50.09 (9.57) years. Decreases in WC, HC, and WHR were observed in the ResG ($p<0.05$) with 4.08%, 1.21%, and 3.30% delta, respectively. In physical fitness, intra-group differences ($p<0.05$) were observed, with ResG showing a relative increase of 27.06% and ExtG 12.62% in CS. Both ResG and ExtG showed a delta of 6.60% and 8.71% for ADB and 9.78% and 6.01% for 6MW, respectively. Although only ResG showed positive effects on anthropometric measurements, both the research training and the extension training were effective in improving physical fitness.

Keywords: Physical fitness. Coronavirus Infections. Exercise.

RESUMO

O objetivo do presente estudo foi analisar os efeitos de dois tipos de treinamento, um no contexto de pesquisa e outro no de projeto de extensão universitária, em variáveis antropométricas e de aptidão física em convalescentes da covid-19. Foram realizadas, pré e pós 8 semanas, as medidas de estatura, peso corporal, circunferência da cintura (CC) e quadril (CQ), relação cintura-quadril (RCQ) e testes de sentar e levantar da cadeira (SL), agilidade e equilíbrio dinâmico (AED) e caminhada de 6 minutos (C6). Na pesquisa, o grupo intervenção (GPq) realizou um treino aeróbio intervalado de moderada intensidade, e na extensão, os participantes (GExt) realizaram um modelo multicomponente. Os dados foram analisados por meio de um modelo de regressão linear generalizada, com post-hoc de Bonferroni. A amostra contou com um total de 117 participantes e média de idade de 50,09 (9,57) anos. Houve diminuição nas medidas da CC, CQ e RCQ do GPq ($p<0,05$) com delta de 4,08%, 1,21% e 3,30%, respectivamente. Na aptidão física, houve diferença ($p<0,05$) intra-grupo com GPq apresentando um aumento relativo de 27,06%, e o GExt de 12,62% no SL. GPq e GExt apresentaram delta de 6,60% e 8,71% para AED e 9,78% e 6,01% para C6, respectivamente. Enquanto apenas o GPq apresentou efeitos positivos nas medidas antropométricas, tanto o treino realizado na pesquisa quanto o realizado na extensão foram eficientes para a aptidão física.

Palavras-chave: Aptidão física. Infecções por coronavírus. Exercício físico.

Introduction

COVID-19 is an infectious disease caused by the SARS-CoV-2 virus, with its outbreak beginning in December 2019 in Wuhan, China. It rapidly spread geographically, leading the World Health Organization (WHO) to classify it as a pandemic on March 11, 2020.

Despite the high recovery rate of COVID-19 and the disease manifesting with mild to moderate intensity in most individuals, a new demand emerged in the post-COVID context, with many convalescents presenting persistent symptoms such as weakness in 18.0% of patients, myalgia (8.0%), fatigue (19.5%), and intolerance to daily activities (14.5%). This can result in difficulties for patients to return to daily activities with full functionality[1].

Given the need to restore the functional capacity of convalescents, the practice of exercise has demonstrated efficacy in contributing to this improvement. Through training, an

increase in the distance covered in the 6-minute walk test[2] and cardiorespiratory fitness[3] was observed. However, various training models are available, with some focusing more on a specific physical capacity or stimulating multiple physical capacities such as strength, flexibility, agility, balance, and speed.

In this context, two projects were developed over time. One research project, named AEROBICOVID, was a randomized, double-blind, controlled clinical study that investigated the effects of moderate-intensity interval training on a cycle ergometer, with or without normobaric hypoxia, conducted between September 2020 and February 2021[4-6]. Following the positive results of the research, an extension project titled "Body practices and physical activity for COVID-19 convalescents" was developed[7]. This project began in September 2021, with the availability of vaccines, proposing multicomponent training for COVID-19 convalescents. The AEROBICOVID project was a research project. It had a more controlled methodology than the extension project, which was broader. Additionally, the extension project allowed for exploring more physical capacities due to the multicomponent training. Thus, the objective of this study was to analyze the effects of 8 weeks of training from a research and extension project on physical fitness and anthropometric variables in COVID-19 convalescents.

Methodological Procedures

Both projects received approval from the Research Ethics Committee of the School of Physical Education and Sport of Ribeirão Preto (EEFERP – USP), the institution where the training was conducted, and the research project also received approval from the Committee of the Faculty of Pharmaceutical Sciences of Ribeirão Preto (FCFRP – USP) (Research CAAE: EEFERP 33783620.6.0000.5659/FCFRP 33783620.6.3001.5403) (Extension CAAE: EEFERP 58595122.0.0000.5659).

The inclusion criterion for both projects was being a COVID-19 convalescent (with a positive test). For the research project, participants were included approximately 30 days after recovery from clinical symptoms or medical discharge, aged between 30 and 69 years. In the extension project, there was no fixed recovery time from clinical signs or medical discharge, and the age range was maintained. Exclusion criteria for the research project included: exposure to places with altitudes > 1500 m in the last three months; significant physical limitations affecting the intervention or evaluations; acute or chronic clinical diseases without medical follow-up; anemia; use of immunosuppressive drugs; pregnancy; hormone replacement therapy; smoking; excessive alcohol or drug use. Exclusion criteria for the extension project included: participation in a regular exercise program, significant physical limitations impacting the intervention or evaluations, and acute or chronic clinical diseases without medical follow-up.

Evaluations were conducted before the start (week 0) and after the intervention (week 9). A partial evaluation was performed in week 5 only in the research project to adjust the training load.

Participants signed the Informed Consent Form and were informed during week 0 about the evaluations and intervention protocol. Before the start and after 8 weeks of intervention, participants underwent anthropometric assessment (body mass, height, waist, and hip circumference) and physical fitness tests (chair-stand, agility, and dynamic balance, and 6-minute walk) (Figure 1).

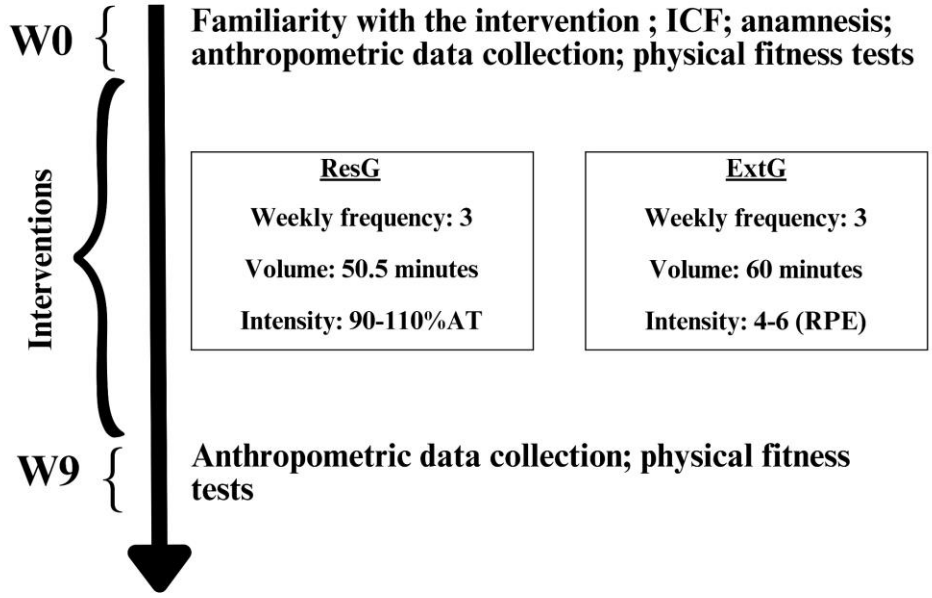

Figure 1. Experimental Design. ICF = Informed Consent Form; ResG = Research Group; ExtG = Extension Group; AT = Anaerobic Threshold; RPE = Rate of Perceived Exertion (Borg scale adapted by Foster)[11]; W0 = pre-intervention; W9 = post-intervention.
Source: Authors.

Evaluations

PAR-Q and Anamnesis

In compliance with São Paulo State Law No. 16724 of May 22, 2018, participants aged 15 to 69 years answered the Physical Activity Readiness Questionnaire (PAR-Q). Those who answered positively to at least one question signed the Responsibility Term for Physical Activity Practice.

An anamnesis was conducted to obtain data on general and specific health conditions related to COVID-19, including responses about symptoms for assessing their intensity, lifestyle, comorbidities, and medication treatments.

Anthropometry

Measurements of body mass and waist and hip circumferences were taken. The circumference measurements were conducted with the participant standing upright using a flexible and non-stretchable tape measure, accurate to one decimal place. The anatomical point considered for the waist was the umbilical scar, and for the hip, it was the most prominent part of the gluteal region, with the tape positioned to follow these directions.

COVID-19 Severity Classification

The severity of the disease was classified according to the following criteria[8]: presence of symptoms but no dyspnea for grade 1; presence of symptoms with dyspnea for grade 2; hospitalization without intensive care for grade 3; and hospitalization in the intensive care unit for grade 4.

Physical Fitness Tests

Chair-Stand Test

Participants were instructed to perform as many repetitions as possible in 30 seconds. The number of times the participant could sit and stand from a chair was counted[9].

Agility and Dynamic Balance Test

For this test, cones were positioned diagonally from a chair. The chair was placed in the middle, with cones 1.80m to the side and 1.50m behind it (thus located on each of the back diagonals). The participant was instructed to walk as quickly as possible without running. Starting seated in a chair, after the command, the participant had to circle the cone on their left and return to the chair, sitting and immediately lifting both feet off the ground before circling the cone on the opposite side. The participant completed this cycle twice (making two laps around each cone) in each attempt, with two attempts being performed. The final result considered was the shortest time of the two attempts[9].

6-Minute Walk Test

O participante percorreu um trajeto retangular pré-determinado cujas dimensões eram de 18,28m x 4,57m. Foram dispostos 6 cones ao longo do caminho, sendo um em cada vértice do retângulo e um em cada lado cujo comprimento é maior, sendo equidistantes dos cones imediatamente anterior e posterior. Cada participante foi orientado a caminhar do lado externo dos cones, o mais próximo possível deles, porém sem encostar. A caminhada deveria ser realizada o mais rápido possível, sem correr, por 6 minutos contínuos, sendo que o participante era informado quando faltavam 3 minutos e 1 minuto para o término do teste. A distância total foi contabilizada em número de voltas completas somadas às distâncias percorridas em uma volta incompleta e, posteriormente, convertida para metros[9].

Interventions

Research: AEROBICOVID

The study included 84 participants divided into four groups: the control group (CG) (25 people) – consisting of individuals who could not participate but wanted health monitoring – and the training group, subdivided into: stimulus and recovery in hypoxia; stimulus in normoxia and recovery in hypoxia; stimulus and recovery in normoxia. For the present study, the research intervention groups were combined into a single group (ResG) with 59 people. Broad dissemination was conducted through the University's channels (radio, website, among others) and media such as regional websites and a local TV channel.

The intervention involved a bike training program with sessions 3 times a week, lasting up to 50.5 minutes each. The sessions included an initial part (warm-up – 5 minutes) corresponding to the "easy" level on the rate of perceived exertion scale (RPE), a main part, and a final part (cool down – 3 minutes) with "easy" intensity according to the RPE. The bikes were spaced 3m apart around a hypoxia tent that controlled oxygen concentration (simulating air at an altitude of 3000m for hypoxia and sea level for normoxia). The tent supplied air to participants via an individual mask system (provided to each participant) for exclusive use during the intervention, ensuring their safety. A safety valve was also used. The masks had a system allowing only inhaled air to enter through the nose, preventing ambient air inspiration (providing greater study precision) and only exhaled air to exit through the mouth, avoiding air contamination in the tent. Two tents were used, with 8 participants in each, allowing a total of 16 at a time.

The main part's intensity was controlled by lactate concentration, heart rate, and RPE. The stimuli lasted 5 minutes at 90 – 110% of the anaerobic threshold, with passive pauses of 2.5 minutes between efforts. Loads were increased during the first four weeks: week 1 with 3 sets, week 2 with 4 sets, week 3 with 5 sets, and week 4 onwards with 6 sets.

Extension Project: Physical Practices and Activities for COVID-19 Convalescents

The study included 33 participants who formed the extension group (ExtG). Participants from the AEROBICOVID project and the entire community of Ribeirao Preto were invited through extensive dissemination via social media and open TV programs, as done in the research project.

The training program occurred 3 times a week with sessions lasting approximately 60 minutes each, characterized by multicomponent physical activity stimulating different physical capacities. Sessions started at 30 minutes and increased by 10 minutes every 2 weeks until reaching the planned 60 minutes. Sessions included a warm-up (5 to 10 minutes – dynamic stretching, coordination, and/or balance exercises), the main part (30 to 50 minutes – circuit with strength endurance + aerobic endurance + agility exercises), and a cool down (5 to 10 minutes – relaxation activities such as massage or stretching exercises)[10]. The training intensity was controlled by RPE, aiming for an intensity of 4 to 611. This structure occurred in 2 sessions per week, with the remaining session dedicated to games and sports initiation. Sessions were conducted by a Physical Education professional, with the participation of undergraduate scholarship students.

An extension project typically does not have a control group, as these projects aim to reach the community, offering physical activity opportunities without excluding participants from practice.

For the present study, a division has been made into the research group (ResG) (referring to the three research intervention modalities), the research control group (CG), and the extension intervention group (ExtG).

Statistical Analyses

Continuous quantitative variables are expressed as mean (standard deviation) and categorical variables as absolute frequency. The effect of time and groups, as well as their interaction, were analyzed using a generalized linear mixed-effects regression model with gamma distribution, random effects on individuals, unstructured covariance matrix, and covariates, with Bonferroni post-hoc and identity link function. Covariates were determined by residual analysis, correlating the dependent variables only from the pre-moment with other collected variables using Pearson's correlation and one-way ANOVA, including in the model variables with $p<0.05$. The model was chosen based on the lowest AIC (Akaike Information Criterion) value and the best residual distribution (by Q-Q plot). The effect of the difference between measurements and groups was analyzed using GC and S0 as the reference for comparison, presented as mean difference [95% CI]. The GAMLj package in JAMOVI software (v 2.3) was used for all analyses, assuming a significance level of 5%.

Results

The two projects included 117 participants, predominantly female, with a mean age of 50.09 (9.57) years, 165.00 (0.09) cm in height, 83.65 (16.61) kg in weight, and absolute frequencies of 24 for severity grade 1, 65 for severity grade 2, 10 for severity grade 3, and 18 for severity grade 4 (Table 1).

No group showed a significant difference at the pre-intervention moment for the analyzed variables. No significant difference in body mass was found between the groups. However, there was a reduction ($p<0.05$) in waist circumference (-4.08%), hip circumference (-1.21%), and waist-hip ratio (-3.30%) only in the ResG compared to the pre-intervention moment (Table 2); and an effect of the difference between the pre and post-intervention measures compared to the CG in the waist measurements (W9 - W0 ✻ ResG - CG = -2.83 [-4.11; -1.56]), and hip (W9 - W0 ✻ ResG - CG = -1.45 [-2.55; -0.34]).

Table 1. Sample characterization.

	ExtG	ResG	CG
Age (years)	54.18 (7.73)	48.12 (9.60)	49.32 (10.36)
Height (meters)	1.61 (0.08)	1.67 (0.09)	1.67 (0.09)
Gender			
Female	20	37	16
Male	13	22	9
COVID-19 severity			
1	8	11	5
2	14	38	13
3	1	4	5
4	10	6	2
Sample size			
W0	33	59	25
W9	15	46	19

Note: ExtG = extension group; ResG = research group; CG = research control group. Mean and standard deviation for age and height; absolute frequency for gender, COVID-19 severity, and sample size.
Source: Authors.

Both training interventions showed positive effects on physical performance tests (Figure 2). There was an improvement at the post-intervention moment compared to the pre-intervention moment in both the ResG and the ExtG in the chair sit-to-stand test ($p<0.05$) with a relative increase of 27.06% and 12.62%, respectively; both groups showing an effect of the difference between pre and post-intervention measures compared to the CG (W9 - W0 ✻ ResG - CG = 3.79 [2.69; 4.89]; W9 - W0 ✻ ExtG - CG = 1.96 [0.51; 3.42]). The ResG also showed a difference ($p<0.05$) compared to the CG in week 9.

Tabela 2. Valores antropométricos pré e pós intervenção.

	ExtG		ResG		CG	
	W0	W9	W0	W9	W0	W9
Body mass (kg)	90.52 (21.89)	91.12 (14.79)	87.82 (24.50)	87.57 (21.64)	92.90 (23.70)	93.22 (20.66)
Waist circumference (cm)	105.18 (16.20)	105.52 (11.12)	100.94 (18.20)	96.82 [a] (16.14)	100.13 (17.85)	98.85 (15.60)
Hip circumference (cm)	113.79 (16.72)	114.31 (11.39)	109.51 (18.97)	108.18 [a] (16.82)	111.96 (18.4)	112.07 (16.08)
WHR	0.94 (0.11)	0.94 (0.08)	0.91 (0.08)	0.88 [a] (0.07)	0.90 (0.10)	0.89 (0.09)

Note: Mean and standard deviation. Generalized linear regression with mixed effects; gender and COVID-19 severity as covariates of body mass; gender, COVID-19 severity, and age as covariates of waist circumference; gender as covariate of hip circumference; gender and COVID-19 severity as covariates of waist-to-hip ratio. ExtG = extension group; ResG = research group; CG = research control group; WHR = waist-to-hip ratio; a = $p<0.05$ compared to the same group at the pre-intervention moment.
Source: Authors.

Similar to the chair sit-to-stand test, there were differences at the post-intervention moment compared to the pre-intervention moment in both the ResG and the ExtG, with a reduction in time in the agility and balance test ($p<0.05$), with a relative delta of 6.60% and 8.71%, respectively; and an effect of the difference between pre and post-intervention measures compared to the CG (W9 - W0 ✻ ResG - CG = -1.45 [-2.56; -0.33]; W9 - W0 ✻ ExtG - CG = -2.16 [-3.59; -0.74]).

The same was observed in the 6-minute walk test, with differences at the post-

intervention moment compared to the pre-intervention moment in both the ResG and the ExtG, with an increase in distance covered ($p<0.05$) by 9.78% and 6.01%, respectively; and an effect of the difference between pre and post-intervention measures compared to the CG (W9 - W0 ✻ ResG - CG = 58.04 [38.87; 77.22]; W9 - W0 ✻ ExtG - CG = 36.37 [12.43; 60.31]).

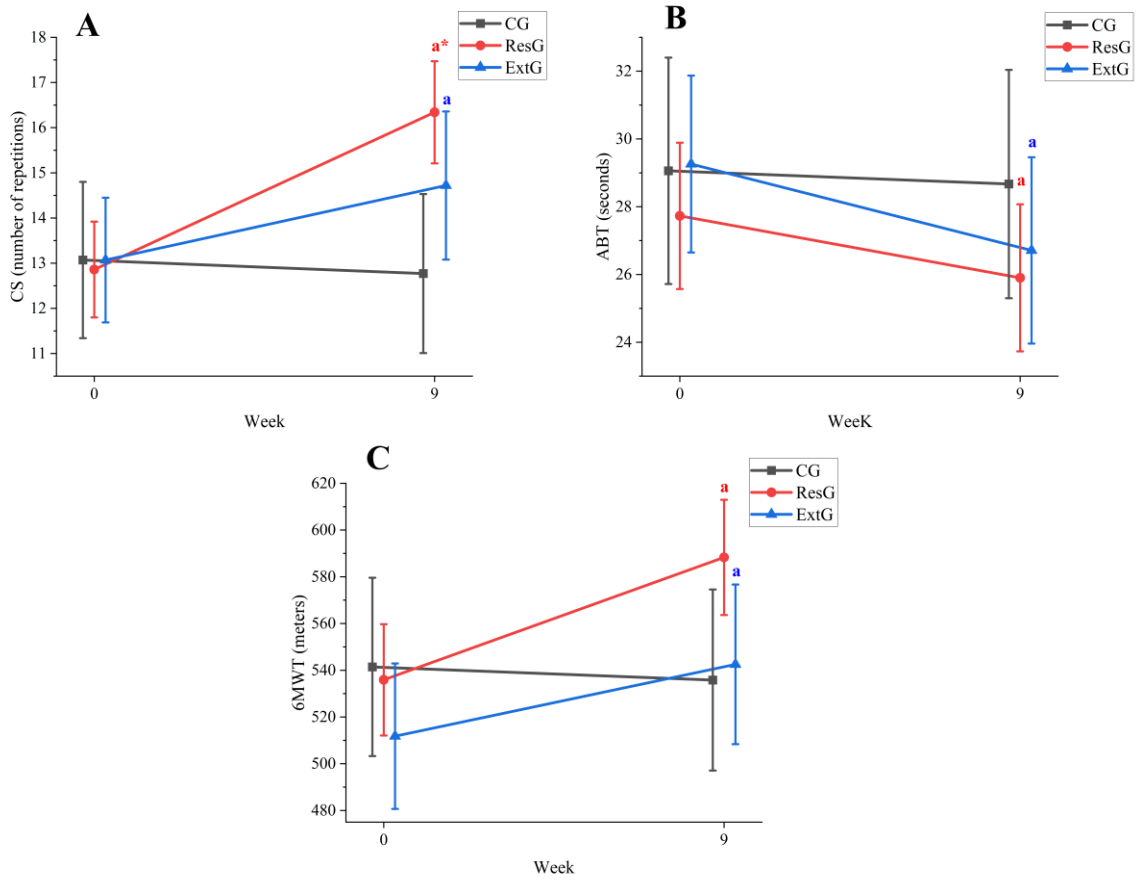

Figure 2. Effects of the interventions on physical fitness tests. Mean and 95% confidence interval. Generalized linear regression with mixed effects. Number of repetitions in the chair sit-to-stand test (CS) in weeks 0 and 9 (A); covariates: age, gender, and severity. Time, in seconds, in the agility and balance test (ABT) in weeks 0 and 9 (B); covariates: age, gender, and severity. Distance covered, in meters, in the 6-minute walk test (6MWT) in weeks 0 and 9 (C); covariates: age, gender, and severity; a = $p < 0.05$ compared to the same group at the pre-intervention moment; * = $p < 0.05$ compared to the CG at the post-intervention moment.
Source: Authors.

Discussion and Conclusion

The study aimed to analyze the effects of two different types of training, one in a research context and the other in an extension context. Both training programs had effects on physical fitness variables (chair-stand, agility and dynamic balance, and 6-minute walk). However, in the anthropometric variables, only the training conducted in the research setting had effects on waist and hip circumference and the waist-hip ratio.

It was observed that supervised exercise practice had effects on the physical fitness of individuals recovering from COVID-19, regardless of the training model. This demonstrates that positive effects on physical fitness were achievable with the extension

project, even though the training load was not as controlled as in the research project. However, the more controlled protocol resulted in significant reductions in some anthropometric values, such as waist and hip circumferences and the waist-hip ratio.

No significant decrease in body mass was found in either type of training. A study[12] conducted in an extension project with multicomponent training for elderly women observed similar results: no reduction in body mass and an increase in repetitions in the chair sit-to-stand test after 16 weeks of training. Another study[13] with women over 60 years of age, following 12 weeks of multicomponent training, observed an increase in distance covered in the 6-minute walk test and in the number of repetitions in the chair sit-to-stand test, as well as a decrease in both body mass and waist circumference, but no significant changes in hip circumference. Another study[14] with a multicomponent intervention lasting approximately 20 weeks in adults did not find a difference in body mass but did find an increase in repetitions in the lower limb endurance test. This indicates the importance of the intervention period. While positive impacts on physical fitness can be observed within a few weeks, longer periods may be necessary to affect anthropometric variables.

A systematic review with network meta-analysis[15] that compared the effects of aerobic, resistance, and combined exercises on metabolic syndrome variables found that combined exercise was the most favorable for reducing body mass and waist circumference. Another systematic review with meta-analysis[16], which compared the effects of aerobic and resistance training in adults with metabolic syndrome, observed that aerobic exercise reduced waist circumference, consistent with the findings of the current study. It was noted[17] that the reduction in waist circumference occurred along with a reduction in visceral adipose tissue, not related to a significant decrease in body mass. This finding might align with what was found in the current study with the research group, although to make such a statement, an assessment of visceral adipose tissue would be necessary, which was not conducted.

Despite the limitations of comparing two projects conducted at different times, the context and population involved should be highlighted – COVID-19 convalescents with varying degrees of disease severity, in a period without (research) and with (extension) available vaccines. The extension project was only feasible and validated based on the positive effects found in the AEROBICOVID research project. The extension project aimed not only to compare the effects of eight weeks of training but also to offer continuous physical activity.

Thus, comparing research with a university extension project is positive, as it provides findings on their efficacy, allowing for an analysis that physical exercise is important and beneficial, even in a context with less rigorously controlled training loads. Furthermore, the importance of knowledge acquisition enabled by these projects, as well as the university's engagement with the external community, is recognized. However, it was observed that despite the positive creation of projects for the external community, many face challenges in maintaining continuous participation. Therefore, the need to establish extramural actions by the university and greater ease of access, such as actions linked to health and education services, is recognized, allowing for comprehensive care for a larger number of people.

In conclusion, both the moderate-intensity interval aerobic training conducted in the research context and the multicomponent training conducted in the extension context were effective in improving the physical fitness of the participants, enhancing performance in the chair-stand, agility and dynamic balance tests, and the 6-minute walk. However, only aerobic training, which had a more controlled training load protocol, was effective in reducing waist and hip circumferences and the waist-hip ratio. The importance of research projects to study new contexts related to special health conditions, such as COVID-19, and university extension projects to offer continuous free physical activities to the community, based on the knowledge and experiences accumulated by these projects, is highlighted.

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