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Title: Effect of moderate vs. vigorous exercise intensity on body composition in young untrained adults: The ACTIBATE randomized controlled trial

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ABSTRACT

The present study aimed to investigate the effect of a 24-weeks aerobic + resistance training programs at moderate vs. vigorous intensity on body composition, and the persistence of the changes after a 10-month free living period, in young untrained adults. This report is based on a secondary analysis from the ACTIBATE single-center unblinded randomized controlled trial. A total of 144 young adults (65.6% women) aged 18-25 years were randomly allocated to 3 different groups: (i) aerobic + resistance exercise training program based on the international physical activity recommendations at vigorous intensity (Ex-vigorous group), (ii) at moderate intensity (Ex-moderate group), and (iii) control group (no exercise). Body composition outcomes were determined by a DXA scanner. Both Ex-Vigorous and Ex-Moderate decreased body weight, fat mass and visceral adipose tissue mass in a similar manner (all $P<0.04$). After a 10 months free living period, these parameters returned to baseline levels in both exercise groups (all $P<0.03$). No differences between the exercise groups and the control group were noted in lean mass changes (all $P>0.1$). A 24-week aerobic + resistance training intervention based on the international physical activity recommendations were enough to improve body weight, fat mass and visceral adipose tissue mass in untrained young adults, independently of the exercise intensity (moderate vs. vigorous).

INTRODUCTION

The prevalence of overweight and obesity has dramatically increased in most countries over the last decades, reaching pandemic proportions (Elagizi et al., 2018; Skinner et al., 2015). Previous studies have reported a higher prevalence of hypertension, coronary heart disease, or hearth failure in obese individuals when compared with their lean counterparts, making obesity the second cause of all-cause mortality, after tobacco consumption (Elagizi et al., 2018; Ng et al., 2014). Obesity is defined as a excessive amount of adipose tissue accumulated in the whole body that result in serious problems for human' health (Elagizi et al., 2018). Recent investigations have demonstrated that obesity is a heterogeneous condition whose consequences depend on the regional distribution of adipose tissue (Ladeiras-Lopes et al., 2017; Wajchenberg, 2000). Concretely, an excess of visceral adipose tissue (VAT) has been better correlated with increased risk of cardiovascular disease and premature death than the whole-body FM (Ladeiras-Lopes et al., 2017; Wajchenberg, 2000).

Sedentary lifestyles and low physical activity levels increase obesity incidence and decrease lean mass (LM) in healthy individuals and patients (Polyzos & Margioris, 2018). Taking these facts into account, numerous studies have been conducted to determine the best type of exercise training capable of improving body composition, i.e., decreasing FM while preserving or incrementing LM (Petridou et al., 2018; Westerterp, 2018).

Aerobic training reduces whole body and visceral adiposity (McTiernan et al., 2007), and increases fat oxidation rates in skeletal muscle and liver (Jeukendrup et al., 1998), improves muscle mitochondrial activity (Häkkinen et al., 2003), and reduces levels of proinflammatory cytokines (Cronin et al., 2017). On the other hand, other studies revealed that resistance training, in addition to increasing LM, is also able to enhance the carbohydrate oxidation in skeletal muscle and muscle anabolism (Silva et al., 2014), elevating resting metabolic rate

(Silva et al., 2014) and, consequently, increasing energy expenditure (Elagizi et al., 2018; Lavie et al., 2016). Therefore, it has been suggested that aerobic + resistance training could be an excellent option to improve body composition (Davitt et al., 2014; Donges et al., 2013; Michell et al., 2014). Indeed, previous studies have demonstrated that resistance training not only improves muscle mass and strength (Carbone et al., 2020; Kaminsky et al., 2022), but also reduces the risk of cardiovascular disease and all-cause mortality (Liu T et al., 2019)

Current physical activity recommendations provided by the World Health Organization (WHO) (Bull et al., 2020) and by the US Department of Health and Human Services (Piercy et al., 2018), includes an aerobic + resistance training methodology. They propose 150-300 minutes of moderate intensity or 75-150 minutes of vigorous intensity aerobic exercise combined with muscle-strengthening activities at moderate or greater intensity on 2 or more days a week. These recommendations are based on evidence showing that this exercise dose is an effective tool for reducing all-cause mortality and cardiometabolic disease incidence, also achieving a healthier body weight and composition (Bull et al., 2020; Piercy et al., 2018). Several studies have reported a significant improvement of body composition after the application of an aerobic + resistance training program in sedentary men (Ghahramanloo et al., 2009; Michell et al., 2014; Shaw et al., 2010) and women (Davitt et al., 2014). However, to avoid the prevalence of lifestyle-related diseases, it is important not only to perform an exercise training program, but also to maintain the adherence to an active lifestyle, since physiological improvements produced by exercise could be lost following a detraining period (Davitt et al., 2014).

Following the WHO physical activity guidelines, the relationship of physical activity and adiposity in adult aged 18 to 64 years is still unclear since (Bull et al., 2020). In general terms, it has been demonstrated that higher levels of physical activity reduce levels of adiposity and prevent weight gain (Bull et al., 2020). However, the WHO guidelines indicates that further research is needed to establish consistent results and effects (Bull et al., 2020). To our knowledge, there are no studies comparing the effects of a moderate vs. vigorous intensity long-term aerobic + resistance training program (matching training time) based on the international physical activity recommendations proposed by the WHO (Bull et al., 2020) on body composition in young untrained adults. Moreover, little is also known about the effects of long-term detraining after an aerobic + resistance training program in untrained young adults of both sexes. Therefore, this work aimed to investigate the effect of a 24-weeks aerobic + resistance training programs at moderate vs. vigorous intensity on body composition in young untrained adults. A secondary aim of the study was to investigate changes in body composition after 10-months of free living after the training program.

METHODS

Experimental design

The present study includes a secondary analysis from the single-center ACTIBATE randomized controlled trial (Sanchez-Delgado, G, Martinez-Tellez, B, Olza, J, Aguilera, CM, Labayen, I,. Ortega, FB, Ruiz, 2015), a 24-week exercise intervention conducted according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al., 2010; Welch et al., 2017) (see Supplementary Table S1). The participants were evaluated at the baseline, after 12-weeks of the intervention, at the end of the 24-weeks of the intervention, and 10 months after the end of the training program (follow-up). The participants were randomly assigned to either an aerobic + resistance training program based on the international physical activity recommendations at moderate intensity (Ex-Moderate group), or at vigorous intensity (Ex-Vigorous group), or a control group (no exercise training). The randomization process was conducted after the baseline assessment.

Participants

A total of 144 young adults (65.6% women) were enrolled in this randomized control trial (the ACTIBATE study; ClinicalTrials.gov ID: NCT02365129) (Sanchez-Delgado, G, Martinez-Tellez, B, Olza, J, Aguilera, CM, Labayen, I,. Ortega, FB, Ruiz, 2015), which was conducted at the Instituto Mixto Universitario Deporte y Salud (iMUDS) at the University of Granada (Spain). It was performed according to the last revision of the Declaration of Helsinki, and was approved by the Human Research Ethics Committee of both University of Granada (n° 924) and Servicio Andaluz de Salud (Centro de Granada, CEI-Granada) [0838-N-2017]. The participants were recruited through social networks, local media and posters allocated at the Faculties of the University of Granada. The participants contacted the research team by e-mail, Facebook or Twitter and several appointments were made in order to carry out a detailed explanation of the study objectives, assessments to be undertaken, inclusion criteria, and the exercise intervention. The inclusion criteria were as follows: (i) being between 18 and 25 years old, (ii) having a body mass index (BMI) between 18.5 and 35 kg/m2, (iii) not engaging in a regular physical activity programme (>20 min on >3 days/week), (iv) having a stable body weight during the last 3 months (changes <3kg), (iv) being considered suitable for exercise intervention after a medical examination, (v) not taking medication for chronic diseases, (vi) not consuming tobacco, and (vii) signing a written informed consent form.

Interventions

The exercise training program designed for this study has been explained in detail elsewhere (Sanchez-Delgado, G, Martinez-Tellez, B, Olza, J, Aguilera, CM, Labayen, I, Ortega, FB, Ruiz, 2015). Briefly, both Ex-Moderate and Ex-Vigorous group performed an aerobic + resistance training based on the minimum international physical activity recommendations (Bull et al., 2020). Importantly, both interventions were time-matched with manipulation of the intensity and, therefore also the caloric dose (i.e., the Ex-Vigorous group trained at higher intensity and had a higher exercise energy expenditure). For both groups, aerobic training time was 150 min/week, and the resistance training time was ~80 min/week. For the aerobic training, the Ex-Vigorous group completed 75 min/week at 60% of heart rate reserve (moderate intensity) and 75 min/week at 80% of heart rate reserve (vigorous intensity), while the Ex-Moderate group performed the total of 150 min/week of aerobic training at 60% of heart rate reserve. The resistance training was performed at 50% of one repetition maximum for the Ex-Moderate group, and at 70% of one repetition maximum for the Ex-Vigorous group. Different ergometers were used to do the aerobic training (i.e., treadmill, cycle ergometer, and elliptical ergometer), and weight bearing and guided pneumatic machines were used to perform strength exercises that involved upper and lower body muscle groups for the resistance training (i.e., bench press, lateral pull down, squat, dead lift and hip thrust among others). Compensatory exercises were also prescribed (i.e., flexibility and core stability exercises among others) in order to reduce the injury risk and to increase the participant´s adherence. The training frequency was 3-4 sessions/week at the participant´s choice. We adjusted the length of the training sessions to ensure that all participants had the same weekly dose. Resistance training was performed 2 out of these 3 or 4 sessions/week, thus 1 or 2 sessions/week consisted solely on aerobic training. A standardized warm-up was performed at the beginning of each training session, and an active global stretching protocol was conducted as a cooling-down phase. The heart rate was continuously monitored. All sessions were performed in reduced groups and were supervised by certified trainers. We systematically registered the daily attendance at the sessions, and the participants were contacted upon any missing session. The participants were asked to replace these sessions on alternative days, or were invited to train on their own when attending was not possible.

The participants randomly assigned to the control group received verbal information about healthy habits including the international physical activity recommendations (Bull et al., 2020), and also nutritional advices based on the Mediterranean diet patterns (Estruch & Bach-Faig, 2018).

Measurements

Body weight and height were assessed using an electronic scale and analogue stadiometer (SECA, model 799, Electronic Column Scale, Hamburg, Germany), with a precision of 0.1 kg and 0.1 cm, respectively. The participants were evaluated barefoot with light clothes and standing at the base of the stadiometer, positioning their head in the Frankfort plane. After that, the BMI was calculated as body weight(kg)/body height(m)^2. Body composition outcomes (i.e., FM and FM percentage, VAT, LM [total, legs and arms LM], bone mineral content [BMC] and bone mineral density [BMD]) were determined by a whole-body dual-energy X-ray absorptiometry scanner (Hologic Wi, Hologic Inc., Bedford, MA, USA). VAT was estimated for a region of interest extended from the midpoint of the intervertebral space between the T12 and L1 vertebrae to the midpoint of the intervertebral space between the L4 and L5 vertebrae. All DXA assessments followed the manufacturer´s recommendations.

Statistical Analysis

Since the current study is based on a secondary analysis from the ACTIBATE randomized controlled trial (which aimed to investigate the effects of a 24-week supervised exercise intervention on brown adipose tissue volume and activity), no power calculation was performed regarding the present outcomes.

Descriptive parameters are expressed as mean ± standard deviation unless otherwise stated. We checked the normality of our data by the Shapiro-Wilk test, visual check of histograms, and Q-Q plots. We analysed the Sex × Time interaction effects on body composition outcomes by a mixed model including Sex and Time as fixed effects. Given that there was no Sex interaction in any case (all $P > 0.1$), all statistical analyses were conducted for men and women together.

The analyses were conducted following a per protocol approach and, therefore, no imputation methods were applied. We calculated different differences for each outcome as: (i) week 12 - value minus baseline value, (ii) week 24 value minus baseline value, and (iii) 10 months after the program value minus baseline value. To examine the influence of the intervention on body weight and composition outcomes (dependent variable in all time-points [i.e., changes after 12-weeks of the intervention, changes after 24-weeks of the intervention, and changes after a 10 months free living period]), analyses of covariance (ANCOVA) were conducted adjusting for the baseline values (model 1). Bonferroni post hoc test for correcting for multiple comparisons were also performed. Additional models were built controlling for baseline values and sex (model 2), and for baseline values and age (model 3). We additionally performed as sensitive analysis: (i) mixed-effects regression models with random intercepts to the primary outcomes (i.e., body weight, FM, FM percentage, VAT mass, LM (total, legs and arms LM), BMC and BMD) and (ii) analyses excluding those participants that did not reach a minimum of 70% of attendance and a minimum of 40% of adherence to the pre-determined intensity fixed for each exercise group. Pearson's correlation analysis was used to correlate attendance to the exercise training program and adherence to the pre-determined intensity pre-determined for each exercise group with changes in anthropometric and body composition parameters.

We established a level of significance of $P<0.05$. The Statistical Package for Social Sciences (SPSS, v. 22.0, IBM SPSS Statistics, IBM Corporation, Chicago, IL, USA) was selected to perform the statistical analysis. The GraphPad Prism 5 (GraphPad Software, San Diego, CA, USA) was used for generate the graphical plots.

RESULTS

The flow-chart is presented in Figure 1. A total of 144 participants were randomly assigned to either the control group (N=54), the Ex-Moderate group (N=48), or the Ex-Vigorous group

(N=44). A total of 36 participants (~78%) finished the intervention program in the Ex-Moderate group, while 36 participants (~82%) finished the intervention program in the Ex-Vigorous group, and 33 participants (~75%) finished the 24-week participation in the control group. The attendance average at the exercise sessions was ~95% for the Ex-Moderate group, and ~96% for the Ex-Vigorous group. We registered a loss to the 10-month follow-up of 30% in the control group, 22% in the Ex-Moderate group, and 19% in the Ex-Vigorous group.

Figure 1

Table 1 shows the baseline descriptive characteristics of the study participants together and separated by groups.

Table 1

Effect of aerobic + resistance training on body weight and composition after 12-weeks of intervention

Participants of the Ex-Moderate and Ex-Vigorous significantly decreased their body weight, FM, and FM percentage as compared with the control group (all $P<0.042$; Figure 2A, 2C, and 2E), while no significant between-group differences were noted on changes in VAT mass and LM (all $P>0.09$; Figure 2G and 2I; Table 2). We did not observe differences in changes in body weight and composition between the Ex-Moderate and Ex-Vigorous groups (all $P>0.3$; Figure 2A, 2C, 2E, 2G and 2I; Table 2).

Table 2

Effect of aerobic + resistance training on body weight and composition after 24-weeks of intervention

Participants of the Ex-Moderate and Ex-Vigorous significantly decreased their body weight, FM, FM percentage, and VAT mass as compared with the control group (all $P<0.025$; Figure

2A, 2C, 2E, and 2G; Table 2), while no significant between-group differences were noted on changes in LM (P=0.104; Figure 2I; Table 2). We did not observe differences on changes in body weight and composition between the Ex-Moderate and Ex-Vigorous groups (all P>0.6; Figure 2A, 2C, 2E, 2G and 2I; Table 2).

Effect of aerobic + resistance training on body weight and composition 10 months after completing the training program

ANCOVA unveiled no significant differences between groups in body weight, FM, FM percentage, VAT, and LM after 10 months follow-up compared with the baseline levels (all P≥0.5, Figure 2; Table 2).

Figure 2

Effect of aerobic + resistance training on body weight and composition after 12-weeks, 24-weeks, and a 10 months free living period: sensitivity analyses

All the above-mentioned findings persisted after conducting the mixed-effects regression models analyses in all body weight and composition outcomes (Figure 2B, 2D, 2F, 2H, and 2J; Table 2). Moreover, no significant changes in response to the exercise interventions were noted neither in BMC or BMD compared to the control group (Supplementary Figure S1). All the results remained in all cases when sex and age were included in the model as a covariate (Supplementary Table S2).

Interestingly, 11 participants of the control group (~32%) reported having performed regular exercise during the intervention study. Therefore, to compare both exercise training groups (i.e., Ex-Moderate group and Ex-Vigorous group) with participants of the control group that did not perform regular physical exercise during our intervention, we conducted an additional analysis excluding those participants. Similar results were revealed in term of changes in body weight, FM, FM percentage, and VAT mas after 12 weeks, after 24 weeks and 10 months follow-up of the intervention study (data not shown). However, while no significant between-group differences were noted on changes in LM after 12 weeks of the intervention (all $P>0.09$; Figure 3A), the participants of the Ex-Moderate and Ex-Vigorous significantly increased their LM as compared with the control group ($P<0.001$; Figure 3A). Nevertheless, these exercise-related changes in LM were not maintained in both intervention groups 10 months after completing the training program (all $P>0.4$; Figure 3A). Importantly, these results did not change neither after performing the mixed-effects regression models analyses (Figure 3B) or after controlling the analyses by sex and age (data not shown).

Figure 3

We found a lack of association between attendance to the exercise training program and the pre-determined intensity fixed for each exercise group with changes in body weight, FM, FM percentage, VAT, and LM after the intervention study (all $P\geq0.05$).

DISCUSSION

The main findings of the present study were that 24 weeks of aerobic + resistance training based on current WHO' physical activity guidelines improved body weight and composition (i.e., FM, FM percentage and VAT mass) in young untrained adults - independently of the predetermined exercise intensity (moderate vs. vigorous intensity; training time-matched) -, while no significant between-group differences were noted on changes in LM. Importantly, these improvements were already observed by the twelfth week of the training program. Thus, no body weight and composition changes were produced during the last 3-months of the exercise program (except for VAT mass that was only decreased after 24 weeks of aerobic + resistance training, independently of the exercise intensity). However, the above-mentioned positive changes did not persist 10 months after the completion of the training program.

Within the current study, we observed significant differences in FM and FM percentage between the Ex-Moderate group (a FM decrease of ~7%) and the Ex-Vigorous group (a FM decrease of ~9%) compared with the control group, with no differences between both exercise groups. These findings concurred with those obtained by previous studies which applied slightly different aerobic + resistance training programs in young sedentary men (a FM decrease of ~20%) (Ghahramanloo et al., 2009; Shaw et al., 2010), in sedentary middle-aged men (a FM decrease of ~5%) (Michell et al., 2014), and in active young women (a FM decrease of ~5%) (Davis et al., 2008). However, Davitt et al. reported that an 8-weeks aerobic + resistance training program did not produce significant improvements of FM in college underclassmen women (Davitt et al., 2014). Although it is expected that an aerobic + resistance training program induces significant decrements of FM (specially in untrained individuals) (Ghahramanloo et al., 2009; Michell et al., 2014; Shaw et al., 2010), the results reported by Davitt et al. (Davitt et al., 2014) may be explained because they conducted a short-duration intervention program compared with other studies (Davis et al., 2008; Ghahramanloo et al., 2009; Michell et al., 2014; Shaw et al., 2010). In addition, they also recognized that the participants of their study were instructed to maintain their regular nutritional habits during the intervention program, and it has been previously described that a FM gain is typically seen in college underclassmen (Cluskey & Grobe, 2009; Gillen & Lefkowitz, 2011).

It is well-known the clinical relevance of VAT, since numerous studies have demonstrated a strong association between VAT mass and greater risk of metabolic syndrome, heart failure, hypertension and/or diabetes mellitus, even in the absence of obesity (determined by a BMI>30 kg/m2) (Okura et al., 2005; Shaw et al., 2010). Despite literature has reported that both endurance and resistance training are able to reduce VAT mass (Keating et al., 2015; Strasser et al., 2012), data are scarce regarding the effects of an aerobic + resistance supervised training program on VAT. Shaw et al. observed a significant decrement of abdominal adipose tissue estimated by waist circumference (a decrease of ~3%) after 8-weeks of aerobic + resistance training in sedentary young men (Shaw et al., 2010). However, it remains unknown whether a longer aerobic + resistance training program applying different exercise intensities reduces VAT mass in both untrained young men and women. In the current study, we showed, for the first time, that a 24-weeks aerobic + resistance training program based on the international physical activity recommendations (Bull et al., 2020) significantly reduced VAT mass, estimated by DXA, in young untrained adults, independently of the exercise intensity applied (a decrease of ~15% in both Ex-Moderate and Ex-Vigorous groups). Moreover, we also observed that 12 weeks of aerobic + resistance training seems not to be time enough to induce VAT mass reductions in untrained healthy adults of both sexes.

The results of this study suggested that there were no significant differences in LM between both the Ex-Moderate and the Ex-Vigorous groups compared with the control group. These unexpected findings did not concur with those reported by previous investigations which observed that an concurrent training program improved LM in sedentary young men (a LM increase of ~2%) (Ghahramanloo et al., 2009), in sedentary middle-aged men (a LM increase of ~1%) (Michell et al., 2014), in sedentary young women (a LM increase of ~2%) (Davitt et al., 2014), and in active young women (a LM increase of ~3%) (Davis et al., 2008). An important point to note is that the participants of our study allocated in the control group received verbal information about healthy habits including the international physical activity recommendations provided by the WHO (Bull et al., 2020), and also nutritional advices based on the traditional Mediterranean diet patterns (Estruch & Bach-Faig, 2018). In this context, 11 participants of the control group reported having performed regular physical exercise and/or modified their nutritional habits during the intervention study. Considering that young individuals are characterized by an increased muscle anabolic signalling and myofibrillar protein synthesis (Harber et al., 2012; Kumar et al., 2009), it is plausible that the lack of differences in LM changes between the experimental groups and the control group could be explained by the inclusion of participants that performed regular physical activity and/or modified their dietary habits in the control group. To test this hypothesis, we conducted the same analysis excluding these participants, and we found significant differences in LM between both Ex-Moderate and Ex-Vigorous groups compared with the control group after a 24-weeks aerobic + resistance training program (an increase of ~5% in both cases), while only the Ex-Vigorous group showed a significant improvement in LM compared with the control group after 12-weeks of the intervention program (an increase of ~4%). These results suggest that the training program induced a 2-fold higher increase in LM as compared with those reported by previous investigations (Davis et al., 2008; Davitt et al., 2014; Ghahramanloo et al., 2009; Shaw et al., 2010), which could be explained by a longer duration (24-weeks vs. <16-weeks), a higher total training volume (150 minutes/weeks vs. <120 minutes/week of aerobic training), and the supervised and structured nature of the intervention program. Moreover, the high importance of the aerobic training part in our intervention could also explain the obtained results.

Taking into account the findings obtained in our study, we suggest that a 12 to 24-weeks aerobic + resistance training program is an effective strategy to improve body composition in young untrained adults. However, to avoid the prevalence of chronic diseases related to body weight gain and/or body composition changes, it is important to create adherence to an active lifestyle, since exercise-induced adaptations could be lost following a detraining period (Davitt et al., 2014). Rossi et al. observed significant improvements in FM and LM after the application of a 16-weeks aerobic + resistance training program in sedentary postmenopausal women, that returned to pre-training values after 6 months (Rossi et al., 2017). These findings concur with those obtained in our study, since the enhancements observed in FM, LM, and VAT mass after the intervention program in both Ex-Moderate and Ex-Vigorous groups, disappeared 10 months after completing the intervention. Therefore, future studies are needed to investigate the application of different strategies that promote regular physical activity habits after a aerobic + resistance training intervention. Curiously, we observed a slightly lower dropouts' rates in the Ex-Vigorous group compared with the Ex-Moderate (82% vs. 78%, respectively). Thus, the organization of informative talks after an exercise intervention giving information about the importance of performing regular physical activity at vigorous intensity (Bull et al., 2020) ("WHO | Global Recommendations on Physical Activity for Health," 2015) and also nutritional advices based on the traditional Mediterranean diet patterns (Estruch & Bach-Faig, 2018), caloric restriction(He et al., 2021), or time-restricted eating (Zhang et al., 2022) might be a correct approach to maintain and/or improve the body composition changes obtained during an aerobic + resistance training intervention (Donnelly et al., 2009).

The limitations of this study need to be considered when interpreting the findings. The high number of participants allocated in the control group that performed regular physical activity exercise and or modified their nutrition habits during our intervention program make the comparison between groups difficult to interpret. The follow-up time may have been insufficient to well-understand the evolution of body composition changes in response to a free-living period, thus future studies should include different follow-up measurements (i.e., 3-months follow-up, 6-months follow-up, 9-months follow-up, and 12-months follow-up). DXA only provides an estimation of VAT and, therefore, the use of a gold standard method (i.e., magnetic resonance imaging) for this purpose would be desirable in future studies. Finally, we only recruited untrained young adults aged between 18 to 25 years, thus we cannot extend these results to younger, older, or trained individuals.

In summary, the findings of the current study pointed out that 24 weeks of aerobic + resistance training at moderate intensity based on the international physical activity recommendations provided by the WHO improve body weight and composition in a similar way as vigorous intensity in untrained young adults, while no significant between-group differences were noted on changes in LM. However, the effects were reverted 10-month after completing the training program.

Considering that the present update of the WHO international physical activity guidelines based on the scientific evidence (Bull et al., 2020) - which suggest an increment of the aerobic exercise volume until 300 min/week at moderate intensity or 150 min/week at vigorous intensity (Piercy et al., 2018) - future studies are needed to elucidate whether a aerobic + resistance training program with higher volume is able to induce extra benefits on body composition in other people with similar and different biological characteristics than our study' cohort.

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Table 1. Baseline descriptive characteristics of the study participants.

	N	All	N	Control	N	Ex-Moderate	N	Ex-Vigorous
Age (years)	98	22.1±2.2	34	22.2±2.1	32	22.0±2.1	32	22.1±2.3
Sex [n, (%)]	98		34		32		32	
Men		30 (30.6)		13 (38.2)		9 (28.1)		8 (25.0)
Women		68 (69.4)		21 (61.8)		23 (71.9)		24 (75.0)
Body weight (kg)	98	69.6±14.6	34	68.6±16.2	32	69.4±12.8	32	70.8±15.0
Body height (cm)	98	167.3±8.0	34	167.1±8.1	32	166.7±8.6	32	168.0±7.6
Body mass index (kg/m^2)	98	24.8±4.3	34	24.4±4.5	32	24.9±3.9	32	25.0±4.4
Fat mass (kg)	98	24.6±8.1	34	23.1±7.7	32	25.2±8.3	32	25.5±8.2
Fat mass (%)	98	35.8±7.5	34	34.4±7.3	32	36.7±8.3	32	36.5±6.9
Visceral adipose tissue (g)	98	341±172	34	322±173	32	358±164	32	346±183
Lean mass (kg)	98	41.1±9.1	34	41.7±10.7	32	40.4±8.0	32	41.2±8.5
Lean mass (%)	98	58.9±9.2	34	60.8±7.1	32	58.6±7.9	32	58.8±5.9
Legs lean mass (kg)	98	13.2±3.7	34	13.6±4.1	32	13.1±2.9	32	13.4±3.7
Arms lean mass (kg)	98	4.3±1.5	34	4.5±1.7	32	4.3±1.4	32	4.3±1.5

Data are shown as means ± standard deviation. Abbreviations: Ex-Moderate, moderate intensity group; Ex-Vigorous, vigorous intensity group.

Table 2. Changes in body weight and composition outcomes after the intervention among the three groups including all participants that were assessed after 24 weeks of supervised exercise training.

	Intervention			**Mean Difference (95% CI)**			**P value**		
	Control (N=34) Median (SD)	Ex-Moderate (N=32) Median (SD)	Ex-Vigorous (N=32) Median (SD)	Ex-Moderate vs. Control	Ex-Vigorous vs. Control	Ex-Vigorous vs. Ex-Moderate	Ex-Moderate vs. Control	Ex-Vigorous vs. Control	Ex-Vigorous vs. Ex-Moderate
Weight (kg)	1.24 (2.73)	-0.40 (2.67)	-2.16 (4.61)	-1.56 (-3.94, 0.83)	-3.12 (-5.52, -0.71)	-1.57 (-4.03, 0.91)	0.342	**0.007**	0.375
Fat mass (kg)	0.57 (0.59)	-1.83 (0.62)	-3.27 (0.63)	-2.41 (-4.53, -0.28)	-3.85 (-5.98, -1.71)	-1.44 (-3.60, 0.71)	**0.021**	**<0.001**	0.315
Fat mass (%)	0.30 (0.50)	-2.71 (0.63)	-3.84 (0.63)	-3.00 (-5.18, 0.83)	-4.14 (-6.29, -1.98)	-1.13 (-3.32, 1.05)	**0.004**	**<0.001**	0.622
VAT (g)	10.73 (14.62)	-47.79 (15.44)	-77.26 (15.43)	-58.52 (-111.16, -5.89)	-87.99 (-140.61, -35.38)	-29.47 (-82.91, 23.96)	**0.024**	**<0.001**	0.540
Lean mass (kg)	0.75 (0.37)	1.79 (0.39)	1.70 (0.39)	1.05 (-0.28, 2.37)	0.95 (-0.37, 2.27)	-0.09 (-1.47, 1.27)	0.172	0.248	1.000
Lean mass (%)	0.83 (0.41)	1.93 (0.44)	1.82 (0.44)	1.10 (-0.37, 2.79)	0.99 (-0.49, 2.81)	-0.11 (-1.55, 1.38)	0.183	0.265	0.931
Legs lean mass (kg)	0.27 (0.13)	0.62 (0.15)	0.59 (0.16)	0.35 (-0.13, 0.93)	0.32 (-0.16, 0.96)	-0.04 (-0.52, 0.43)	0.179	0.201	0.975
Arms lean mass	0.08 (0.04)	0.19 (0.05)	0.18 (0.06)	0.11 (-0.05, 0.34)	0.10 (-0.06, 0.32)	-0.01 (-0.18, 0.14)	0.196	0.253	0.925

Abbreviations: SD, standard deviation; Ex-Moderate, moderate intensity group; Ex-Vigorous, vigorous intensity group; VAT, Visceral Adipose Tissue. P value of analysis of covariance analysis between groups with post hoc Bonferroni-corrected. The analyses were adjusted for baseline values.

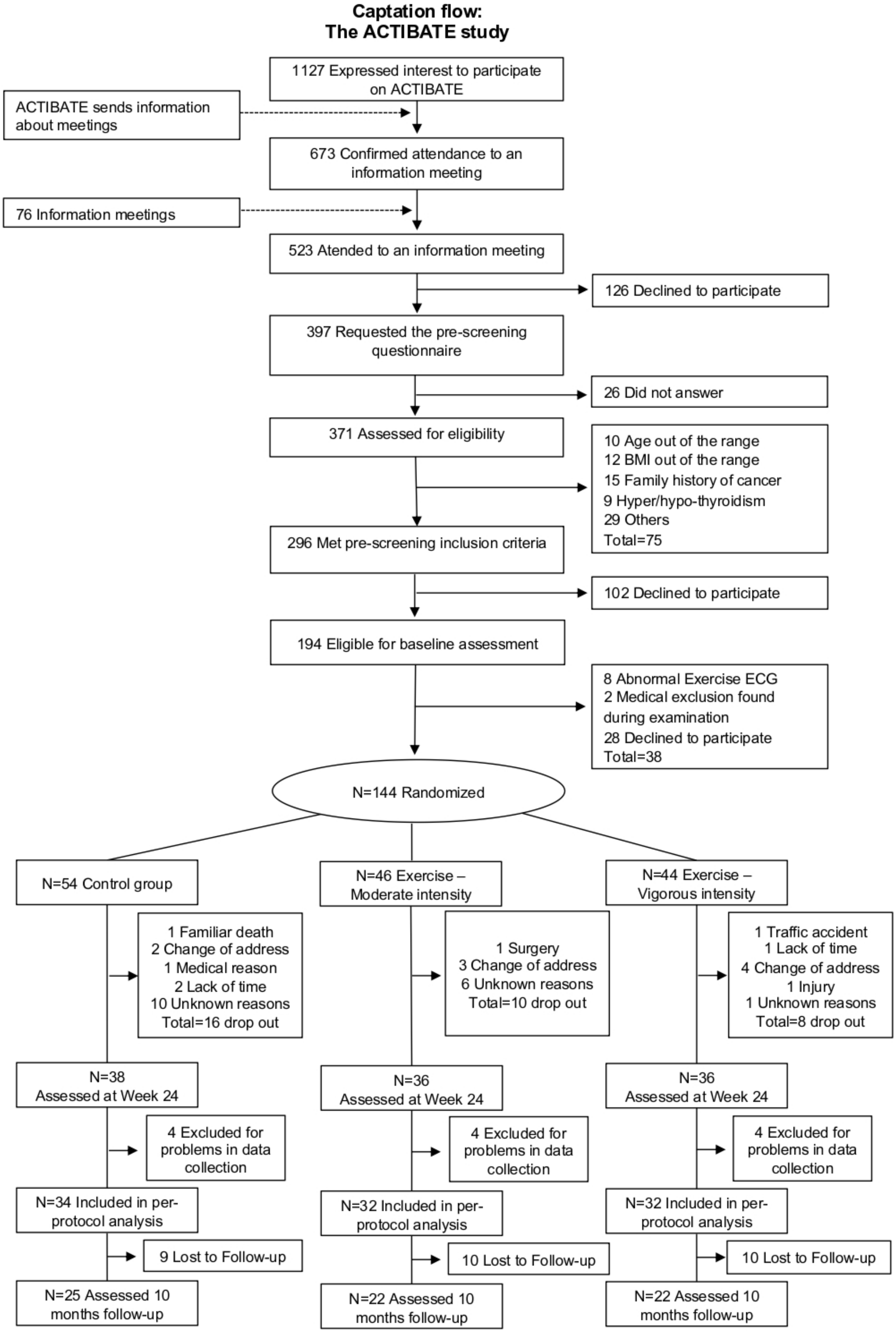

Figure 1: Flow-chart diagram. Abbreviations: BMI; body mass index, CDV; cardiovascular, ECG; electrocardiogram.

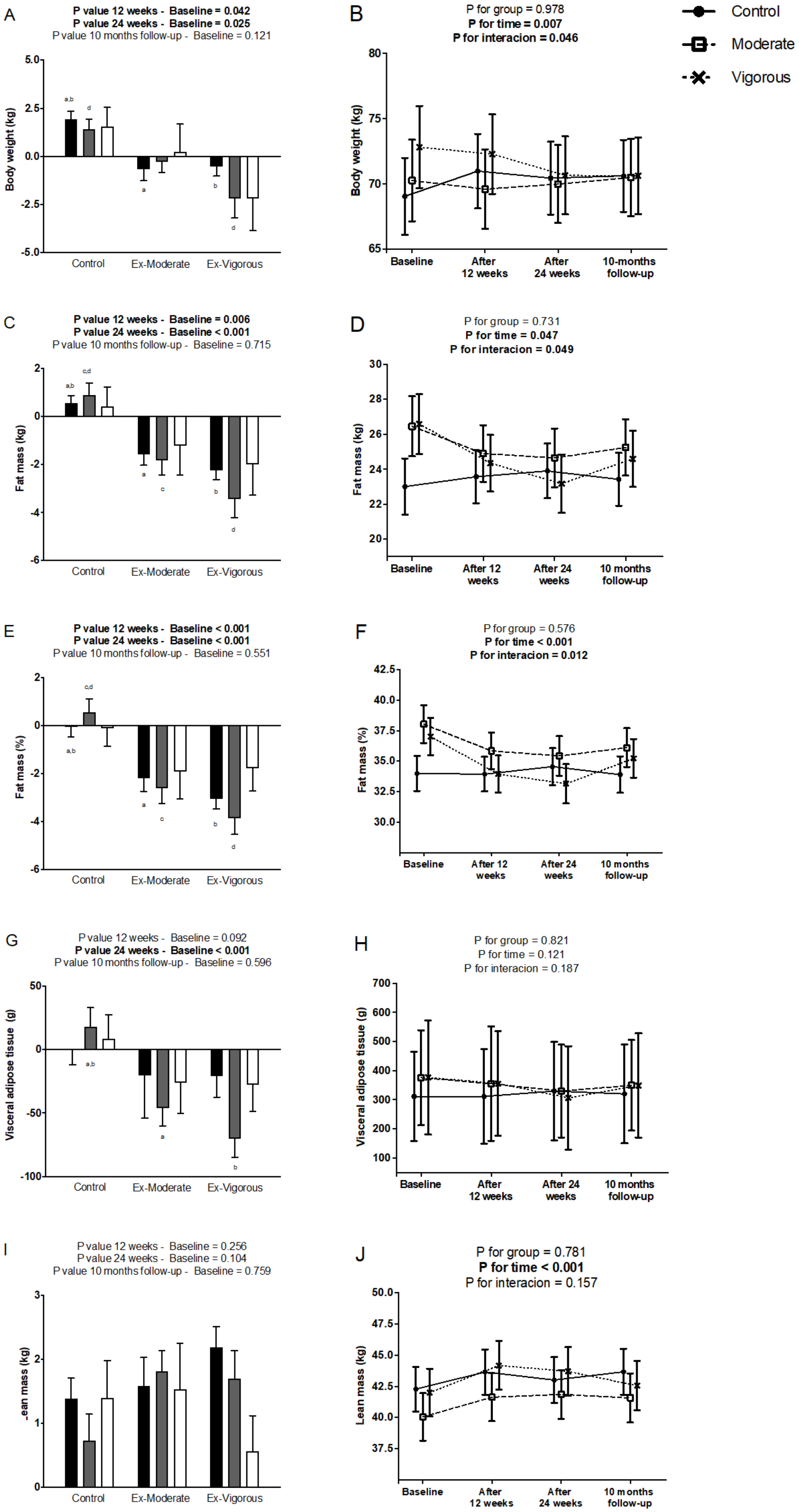
Control
Moderate
Vigorous
A
P value 12 weeks - Baseline = 0.042
P value 24 weeks - Baseline = 0.025
P value 10 months follow-up - Baseline = 0.121
Body weight (kg)
Control
Ex-Moderate
Ex-Vigorous
B
P for group = 0.978
P for time = 0.007
P for interacion = 0.046
Body weight (kg)
Baseline
After 12 weeks
After 24 weeks
10-months follow-up
C
P value 12 weeks - Baseline = 0.006
P value 24 weeks - Baseline < 0.001
P value 10 months follow-up - Baseline = 0.715
Fat mass (kg)
Control
Ex-Moderate
Ex-Vigorous
D
P for group = 0.731
P for time = 0.047
P for interacion = 0.049
Fat mass (kg)
Baseline
After 12 weeks
After 24 weeks
10 months follow-up
E
P value 12 weeks - Baseline < 0.001
P value 24 weeks - Baseline < 0.001
P value 10 months follow-up - Baseline = 0.551
Fat mass (%)
Control
Ex-Moderate
Ex-Vigorous
F
P for group = 0.576
P for time < 0.001
P for interacion = 0.012
Fat mass (%)
Baseline
After 12 weeks
After 24 weeks
10 months follow-up
G
P value 12 weeks - Baseline = 0.092
P value 24 weeks - Baseline < 0.001
P value 10 months follow-up - Baseline = 0.596
Visceral adipose tissue (g)
Control
Ex-Moderate
Ex-Vigorous
H
P for group = 0.821
P for time = 0.121
P for interacion = 0.187
Visceral adipose tissue (g)
Baseline
After 12 weeks
After 24 weeks
10 months follow-up
I
P value 12 weeks - Baseline = 0.256
P value 24 weeks - Baseline = 0.104
P value 10 months follow-up - Baseline = 0.759
Lean mass (kg)
Control
Ex-Moderate
Ex-Vigorous
J
P for group = 0.781
P for time < 0.001
P for interacion = 0.157
Lean mass (kg)
Baseline
After 12 weeks
After 24 weeks
10 months follow-up

Figure 2. Changes in body weight (A and B), fat mass (C and D), fat mass percentage (E and F), visceral adipose tissue mass (G and H) and lean mass (I and J) at baseline, after 12 weeks, after 24 weeks and 10 months follow-up of the intervention among the three groups applying the per-protocol analysis. Data are shown as means ± standard error. P value of analysis of covariance adjusting by baseline values, with post hoc Bonferroni-corrected (similar letters indicate significant differences) between after 12 weeks (black bars; n=98), after 24 weeks (grey bars; n=98), and after 10 months follow-up (white bars; n=71) of the intervention compared with baseline values, respectively (Panels A, C, E, G, and I). P values (time, group, and interaction [time x group]) obtained from mixed-effects regression models analyses (Panels B, D, F, H, and J). Abbreviations: Ex-Moderate, moderate intensity group; Ex-Vigorous, vigorous intensity group.

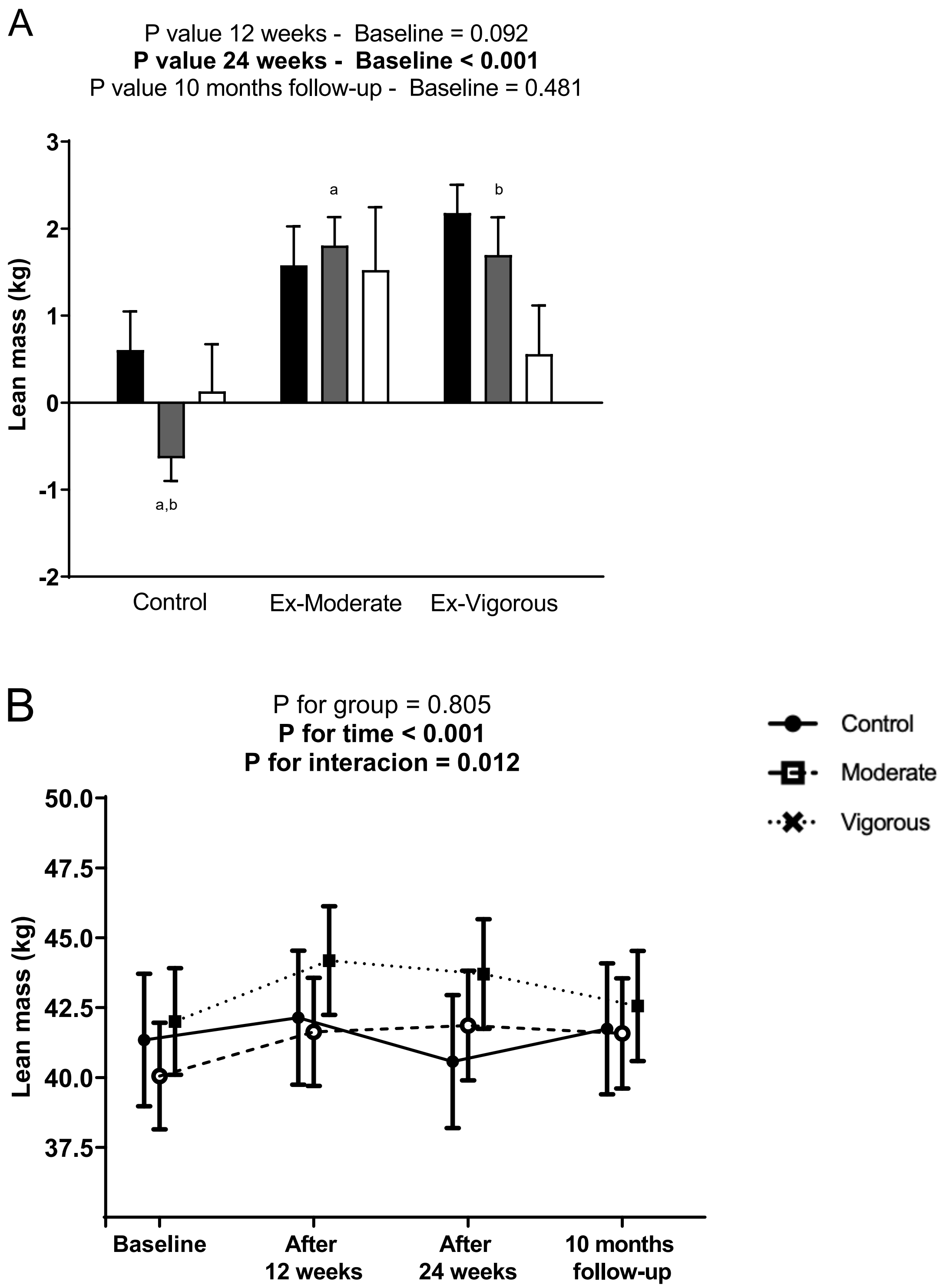

Figure 3. Changes in lean mass at baseline, after 12 weeks, after 24 weeks and 10 months follow-up of the intervention among the three groups excluding participants of the control group that reported to have performed an exercise program during the study and/or have modified their nutritional habits, and applying the per-protocol analysis. Data are shown as means ± standard error. P value of analysis of covariance adjusting by baseline values, with post hoc Bonferroni-corrected (similar letters indicate significant differences) between after 12 weeks (black bars; n=87), after 24 weeks (grey bars; n=87), and after 10 months follow-up (white bars; n=60) of the intervention compared with baseline values, respectively (Panel A). P values (time, group, and interaction [time x group]) obtained from mixed-effects regression models analyses (Panel B). Abbreviations: Ex-Moderate, moderate intensity group; Ex-Vigorous, vigorous intensity group.