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- **Title:** Effect of Moderate Versus Vigorous Exercise Intensity on Body Composition in Young Untrained Adults : The Activating Brown Adipose Tissue Through Exercise (ACTIBATE) Randomized Controlled Trial

Year: 2023

Version: Accepted version (Final draft)

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Please cite the original version:

Amaro-Gahete, F. J., Ruiz-Ruiz, M., Cano-Nieto, A., Sanchez-Delgado, G., Alcantara, J. M. A., Acosta, F. M., Labayen, I., Ortega, F. B., & Ruiz, J. R. (2023). Effect of Moderate Versus Vigorous Exercise Intensity on Body Composition in Young Untrained Adults : The Activating Brown Adipose Tissue Through Exercise (ACTIBATE) Randomized Controlled Trial. International Journal of Sport Nutrition and Exercise Metabolism, 33(6), 331-341. https://doi.org/10.1123/ijsnem.2023-0085

SPORT NUTRITION and EXERCISE METABOLISM

Title: Effect of moderate vs. vigorous exercise intensity on body composition

in young untrained adults: The ACTIBATE randomized controlled trial

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Running Head: Moderate vs. vigorous exercise intensities for body composition

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Word count: 3912

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).

1 INTRODUCTION

The prevalence of overweight and obesity has dramatically increased in most countries over 2 the last decades, reaching pandemic proportions (Elagizi et al., 2018; Skinner et al., 2015). 3 4 Previous studies have reported a higher prevalence of hypertension, coronary heart disease, or 5 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., 6 7 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 8 9 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 10 al., 2017; Wajchenberg, 2000). Concretely, an excess of visceral adipose tissue (VAT) has 11 12 been better correlated with increased risk of cardiovascular disease and premature death than the whole-body FM (Ladeiras-Lopes et al., 2017; Wajchenberg, 2000). 13 Sedentary lifestyles and low physical activity levels increase obesity incidence and decrease 14 lean mass (LM) in healthy individuals and patients (Polyzos & Margioris, 2018). Taking 15 these facts into account, numerous studies have been conducted to determine the best type of 16 exercise training capable of improving body composition, i.e., decreasing FM while 17 preserving or incrementing LM (Petridou et al., 2018; Westerterp, 2018). 18 Aerobic training reduces whole body and visceral adiposity (McTiernan et al., 2007), and 19 20 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 21

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 31 (WHO) (Bull et al., 2020) and by the US Department of Health and Human Services (Piercy 32 33 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 34 combined with muscle-strengthening activities at moderate or greater intensity on 2 or more 35 36 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, 37 also achieving a healthier body weight and composition (Bull et al., 2020; Piercy et al., 38 2018). Several studies have reported a significant improvement of body composition after the 39 40 application of an aerobic + resistance training program in sedentary men (Ghahramanloo et 41 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 42 43 exercise training program, but also to maintain the adherence to an active lifestyle, since 44 physiological improvements produced by exercise could be lost following a detraining period (Davitt et al., 2014). 45

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

50 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 51 intensity long-term aerobic + resistance training program (matching training time) based on 52 53 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 54 effects of long-term detraining after an aerobic + resistance training program in untrained 55 young adults of both sexes. Therefore, this work aimed to investigate the effect of a 24-weeks 56 aerobic + resistance training programs at moderate vs. vigorous intensity on body 57 58 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. 59

60 **METHODS**

61 Experimental design

The present study includes a secondary analysis from the single-center ACTIBATE 62 randomized controlled trial (Sanchez-Delgado, G, Martinez-Tellez, B, Olza, J, Aguilera, CM, 63 Labayen, I., Ortega, FB, Ruiz, 2015), a 24-week exercise intervention conducted according to 64 the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al., 2010; 65 Welch et al., 2017) (see Supplementary Table S1). The participants were evaluated at the 66 baseline, after 12-weeks of the intervention, at the end of the 24-weeks of the intervention, 67 and 10 months after the end of the training program (follow-up). The participants were 68 randomly assigned to either an aerobic + resistance training program based on the 69 international physical activity recommendations at moderate intensity (Ex-Moderate group), 70 71 or at vigorous intensity (Ex-Vigorous group), or a control group (no exercise training). The randomization process was conducted after the baseline assessment. 72

73 Participants

74 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, 75 Martinez-Tellez, B, Olza, J, Aguilera, CM, Labayen, I, Ortega, FB, Ruiz, 2015), which was 76 77 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 78 Helsinki, and was approved by the Human Research Ethics Committee of both University of 79 Granada (n° 924) and Servicio Andaluz de Salud (Centro de Granada, CEI-Granada) [0838-80 N-2017]. The participants were recruited through social networks, local media and posters 81 82 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 83 84 to carry out a detailed explanation of the study objectives, assessments to be undertaken, 85 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 86 kg/m2, (iii) not engaging in a regular physical activity programme (>20 min on >3 87 88 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 89 90 medication for chronic diseases, (vi) not consuming tobacco, and (vii) signing a written informed consent form. 91

92 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

99 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, 100 the Ex-Vigorous group completed 75 min/week at 60% of heart rate reserve (moderate 101 102 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 103 reserve. The resistance training was performed at 50% of one repetition maximum for the Ex-104 Moderate group, and at 70% of one repetition maximum for the Ex-Vigorous group. Different 105 ergometers were used to do the aerobic training (i.e., treadmill, cycle ergometer, and elliptical 106 107 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., 108 109 bench press, lateral pull down, squat, dead lift and hip thrust among others). Compensatory 110 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 111 frequency was 3-4 sessions/week at the participant's choice. We adjusted the length of the 112 training sessions to ensure that all participants had the same weekly dose. Resistance training 113 was performed 2 out of these 3 or 4 sessions/week, thus 1 or 2 sessions/week consisted solely 114 on aerobic training. A standardized warm-up was performed at the beginning of each training 115 session, and an active global stretching protocol was conducted as a cooling-down phase. The 116 heart rate was continuously monitored. All sessions were performed in reduced groups and 117 118 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 119 asked to replace these sessions on alternative days, or were invited to train on their own when 120 121 attending was not possible.

122 The participants randomly assigned to the control group received verbal information about123 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).

126 Measurements

Body weight and height were assessed using an electronic scale and analogue stadiometer 127 (SECA, model 799, Electronic Column Scale, Hamburg, Germany), with a precision of 0.1 kg 128 and 0.1 cm, respectively. The participants were evaluated barefoot with light clothes and 129 standing at the base of the stadiometer, positioning their head in the Frankfort plane. After that, 130 the BMI was calculated as body weight(kg)/body height(m)². Body composition outcomes (i.e., 131 FM and FM percentage, VAT, LM [total, legs and arms LM], bone mineral content [BMC] and 132 bone mineral density [BMD]) were determined by a whole-body dual-energy X-ray 133 absorptiometry scanner (Hologic Wi, Hologic Inc., Bedford, MA, USA). VAT was estimated 134 135 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. 136 All DXA assessments followed the manufacturer's recommendations. 137

138 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.

143 Descriptive parameters are expressed as mean \pm standard deviation unless otherwise stated. We 144 checked the normality of our data by the Shapiro-Wilk test, visual check of histograms, and Q-145 Q plots. We analysed the Sex \times Time interaction effects on body composition outcomes by a 146 mixed model including Sex and Time as fixed effects. Given that there was no Sex interaction 147 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 148 methods were applied. We calculated different differences for each outcome as: (i) week 12 -149 value minus baseline value, (ii) week 24 value minus baseline value, and (iii) 10 months after 150 the program value minus baseline value. To examine the influence of the intervention on body 151 weight and composition outcomes (dependent variable in all time-points [i.e., changes after 12-152 weeks of the intervention, changes after 24-weeks of the intervention, and changes after a 10 153 154 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 155 156 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 157 analysis: (i) mixed-effects regression models with random intercepts to the primary outcomes 158 159 (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 160 attendance and a minimum of 40% of adherence to the pre-determined intensity fixed for each 161 exercise group. Pearson's correlation analysis was used to correlate attendance to the exercise 162 training program and adherence to the pre-determined intensity pre-determined for each 163 exercise group with changes in anthropometric and body composition parameters. 164

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.

169 **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

172	(N=44). A total of 36 participants (\sim 78%) finished the intervention program in the Ex-
173	Moderate group, while 36 participants (~82%) finished the intervention program in the Ex-
174	Vigorous group, and 33 participants (~75%) finished the 24-week participation in the control
175	group. The attendance average at the exercise sessions was \sim 95% for the Ex-Moderate group,
176	and ~96% for the Ex-Vigorous group. We registered a loss to the 10-month follow-up of 30%
177	in the control group, 22% in the Ex-Moderate group, and 19% in the Ex-Vigorous group.
178	***Figure 1***
179	Table 1 shows the baseline descriptive characteristics of the study participants together and
180	separated by groups.
181	***Table 1***
182	Effect of aerobic + resistance training on body weight and composition after 12-weeks of
183	intervention
184	Participants of the Ex-Moderate and Ex-Vigorous significantly decreased their body weight,
185	FM, and FM percentage as compared with the control group (all P<0.042; Figure 2A, 2C, and
186	2E), while no significant between-group differences were noted on changes in VAT mass and
187	LM (all P>0.09; Figure 2G and 2I; Table 2). We did not observe differences in changes in body
188	weight and composition between the Ex-Moderate and Ex-Vigorous groups (all P>0.3; Figure
189	2A, 2C, 2E, 2G and 2I; Table 2).
190	***Table 2***
191	Effect of aerobic + resistance training on body weight and composition after 24-weeks of
192	intervention
193	Participants of the Ex-Moderate and Ex-Vigorous significantly decreased their body weight,
194	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 $P \ge 0.5$, Figure 2; Table 2).

204

Figure 2

205 Effect of aerobic + resistance training on body weight and composition after 12-weeks, 206 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

12

219 follow-up of the intervention study (data not shown). However, while no significant betweengroup differences were noted on changes in LM after 12 weeks of the intervention (all P>0.09; 220 Figure 3A), the participants of the Ex-Moderate and Ex-Vigorous significantly increased their 221 222 LM as compared with the control group (P<0.001; Figure 3A). Nevertheless, these exerciserelated changes in LM were not maintained in both intervention groups 10 months after 223 completing the training program (all P>0.4; Figure 3A). Importantly, these results did not 224 change neither after performing the mixed-effects regression models analyses (Figure 3B) or 225 after controlling the analyses by sex and age (data not shown). 226

227

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 $P \ge 0.05$).

231 DISCUSSION

The main findings of the present study were that 24 weeks of aerobic + resistance training 232 based on current WHO' physical activity guidelines improved body weight and composition 233 (i.e., FM, FM percentage and VAT mass) in young untrained adults - independently of the 234 predetermined exercise intensity (moderate vs. vigorous intensity; training time-matched) -, 235 while no significant between-group differences were noted on changes in LM. Importantly, 236 237 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 238 exercise program (except for VAT mass that was only decreased after 24 weeks of aerobic + 239 resistance training, independently of the exercise intensity). However, the above-mentioned 240 positive changes did not persist 10 months after the completion of the training program. 241

242 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 243 decrease of $\sim 9\%$) compared with the control group, with no differences between both exercise 244 groups. These findings concurred with those obtained by previous studies which applied 245 slightly different aerobic + resistance training programs in young sedentary men (a FM 246 decrease of ~20%) (Ghahramanloo et al., 2009; Shaw et al., 2010), in sedentary middle-aged 247 men (a FM decrease of \sim 5%) (Michell et al., 2014), and in active young women (a FM decrease 248 of ~5%) (Davis et al., 2008). However, Davitt et al. reported that an 8-weeks aerobic + 249 resistance training program did not produce significant improvements of FM in college 250 251 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) 252 (Ghahramanloo et al., 2009; Michell et al., 2014; Shaw et al., 2010), the results reported by 253 254 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., 255 2009; Michell et al., 2014; Shaw et al., 2010). In addition, they also recognized that the 256 participants of their study were instructed to maintain their regular nutritional habits during the 257 intervention program, and it has been previously described that a FM gain is typically seen in 258 college underclassmen (Cluskey & Grobe, 2009; Gillen & Lefkowitz, 2011). 259

It is well-known the clinical relevance of VAT, since numerous studies have demonstrated a 260 strong association between VAT mass and greater risk of metabolic syndrome, heart failure, 261 262 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 263 endurance and resistance training are able to reduce VAT mass (Keating et al., 2015; Strasser 264 265 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 266 estimated by waist circumference (a decrease of $\sim 3\%$) after 8-weeks of aerobic + resistance 267

268 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 269 VAT mass in both untrained young men and women. In the current study, we showed, for the 270 271 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, 272 estimated by DXA, in young untrained adults, independently of the exercise intensity applied 273 (a decrease of ~15% in both Ex-Moderate and Ex-Vigorous groups). Moreover, we also 274 observed that 12 weeks of aerobic + resistance training seems not to be time enough to induce 275 276 VAT mass reductions in untrained healthy adults of both sexes.

277 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 278 279 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 280 increase of ~2%) (Ghahramanloo et al., 2009), in sedentary middle-aged men (a LM increase 281 of ~1%) (Michell et al., 2014), in sedentary young women (a LM increase of ~2%) (Davitt et 282 al., 2014), and in active young women (a LM increase of ~3%) (Davis et al., 2008). An 283 284 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 285 recommendations provided by the WHO (Bull et al., 2020), and also nutritional advices based 286 287 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 288 modified their nutritional habits during the intervention study. Considering that young 289 290 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 291 differences in LM changes between the experimental groups and the control group could be 292

293 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 294 same analysis excluding these participants, and we found significant differences in LM 295 296 between both Ex-Moderate and Ex-Vigorous groups compared with the control group after a 24-weeks aerobic + resistance training program (an increase of $\sim 5\%$ in both cases), while only 297 the Ex-Vigorous group showed a significant improvement in LM compared with the control 298 group after 12-weeks of the intervention program (an increase of $\sim 4\%$). These results suggest 299 that the training program induced a 2-fold higher increase in LM as compared with those 300 301 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. <16-302 weeks), a higher total training volume (150 minutes/weeks vs. <120 minutes/week of aerobic 303 304 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 305 results. 306

Taking into account the findings obtained in our study, we suggest that a 12 to 24-weeks 307 aerobic + resistance training program is an effective strategy to improve body composition in 308 309 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 310 311 lifestyle, since exercise-induced adaptations could be lost following a detraining period (Davitt 312 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 313 returned to pre-training values after 6 months (Rossi et al., 2017). These findings concur with 314 315 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 10 316 months after completing the intervention. Therefore, future studies are needed to investigate 317

the application of different strategies that promote regular physical activity habits after a 318 aerobic + resistance training intervention. Curiously, we observed a slightly lower dropouts' 319 rates in the Ex-Vigorous group compared with the Ex-Moderate (82% vs. 78%, respectively). 320 321 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., 322 2020) ("WHO | Global Recommendations on Physical Activity for Health," 2015) and also 323 nutritional advices based on the traditional Mediterranean diet patterns (Estruch & Bach-Faig, 324 2018), caloric restriction(He et al., 2021), or time-restricted eating (Zhang et al., 2022) might 325 326 be a correct approach to maintain and/or improve the body composition changes obtained during an aerobic + resistance training intervention (Donnelly et al., 2009). 327

The limitations of this study need to be considered when interpreting the findings. The high 328 329 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 330 comparison between groups difficult to interpret. The follow-up time may have been 331 insufficient to well-understand the evolution of body composition changes in response to a 332 free-living period, thus future studies should include different follow-up measurements (i.e., 3-333 334 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., 335 336 magnetic resonance imaging) for this purpose would be desirable in future studies. Finally, we 337 only recruited untrained young adults aged between 18 to 25 years, thus we cannot extend these results to younger, older, or trained individuals. 338

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 trainingprogram.

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.

352

Acknowledgements: This study was performed as part of a PhD thesis conducted within the
Biomedicine Doctoral Studies Program of the University of Granada, Spain.

Authorship: FAG, JMA, FMA, FBO and JRR conceived the study; FAG, JMA, FMA and
JRR performed data collection; FAG conducted statistical analysis; FAG drafted the
manuscript; All authors revised and approved the final version of the manuscript.

358 **Conflict of interest:** The authors declare that they have no conflicts of interest.

Funding sources: This study was funded by the Spanish Ministry of Economy and 359 Competitiveness via the Fondo de Investigación Sanitaria del Instituto de Salud Carlos III 360 (PI13/01393; J.R.R.) and PTA-12264I, Retos de la Sociedad (DEP2016-79512-R; J.R.R.) and 361 European Regional Development Funds (ERDF; J.R.R.), the Spanish Ministry of Education 362 (FPU13/04365 (G.S.D), FPU14/04172 (F.A.G.) and FPU15/04059 (J.M.A.)), the Fundación 363 Iberoamericana de Nutrición (FINUT; JRR), the Redes Temáticas de Investigación 364 Cooperativa RETIC (Red SAMID RD16/0022; J.R.R.), the AstraZeneca HealthCare 365 Foundation (J.R.R.), the University of Granada Plan Propio de Investigación 2016 - Excellence 366 actions: Unit of Excellence on Exercise and Health (UCEES) (J.R.R.), the Junta de Andalucía, 367 Universidades Consejería Conocimiento, Investigación 368 de У (ERDF; ref. SOMM17/6107/UGR; JRR), the Junta de Andalucía, Consejería de Economía, Conocimiento, 369 Empresas y Universidad (ref. P18-RT-4455; J.R.R.) and by the CIBEROBN, Centro de 370 Investigación Biomédica en Red (CB22/03/00058), Instituto de Salud Carlos III, Ministerio de 371 Ciencia e Innovación and Unión Europea – European Regional Development Fund (J.R.R.). 372 The funding agencies had no role in study design, data collection and analysis or manuscript 373 374 writing.

375 **Protocol:** https://pubmed.ncbi.nlm.nih.gov/26546068/

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377 **References**

- Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C.,
- 379 Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J.,
- 380 Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., ... Willumsen, J. F.
- 381 (2020). World Health Organization 2020 guidelines on physical activity and sedentary
- 382 behaviour. British Journal of Sports Medicine, 54(24), 1451–1462.
 383 https://doi.org/10.1136/bjsports-2020-102955
- 384 Carbone, S., Kirkman, D. L., Garten, R. S., Rodriguez-Miguelez, P., Artero, E. G., Lee, D. C.,
- 385 & Lavie, C. J. (2020). Muscular strength and cardiovascular disease: an updated state-of-the-
- art narrative review. Journal of Cardiopulmonary Rehabilitation and Prevention, 40(5), 302-
- 387 309. https://doi.org/10.1097/HCR.00000000000525
- Cluskey, M., & Grobe, D. (2009). College weight gain and behavior transitions: male and
 female differences. Journal of the American Dietetic Association, 109(2), 325–329.
 https://doi.org/10.1016/j.jada.2008.10.045
- Cronin, O., Keohane, D. M., Molloy, M. G., & Shanahan, F. (2017). The effect of exercise
 interventions on inflammatory biomarkers in healthy, physically inactive subjects: a systematic
 review. QJM: Monthly Journal of the Association of Physicians, 110(10), 629–637.
 https://doi.org/10.1093/qjmed/hcx091
- Davis, W. J., Wood, D. T., Andrews, R. G., Elkind, L. M., & Davis, W. B. (2008). Concurrent
 training enhances athletes' strength, muscle endurance, and other measures. Journal of Strength
 and Conditioning Research, 22(5), 1487–1502.
 https://doi.org/10.1519/JSC.0b013e3181739f08
- 399 Davitt, P. M., Pellegrino, J. K., Schanzer, J. R., Tjionas, H., & Arent, S. M. (2014). The effects
- 400 of a combined resistance training and endurance exercise program in inactive college female

- 401 subjects: does order matter? Journal of Strength and Conditioning Research, 28(7), 1937–1945. https://doi.org/10.1519/JSC.00000000000355 402
- Donges, C. E., Duffield, R., Guelfi, K. J., Smith, G. C., Adams, D. R., & Edge, J. A. (2013). 403
- 404 Comparative effects of single-mode vs. duration-matched concurrent exercise training on body

composition, low-grade inflammation, and glucose regulation in sedentary, overweight,

- middle-aged men. Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee,
- Nutrition et Metabolisme, 38(7), 779–788. https://doi.org/10.1139/apnm-2012-0443 407
- Donnelly, J. E., Blair, S. N., Jakicic, J. M., Manore, M. M., Rankin, J. W., & Smith, B. K. 408
- 409 (2009). Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention
- of Weight Regain for Adults. Medicine & Science in Sports & Exercise, 41(2), 459-471. 410
- https://doi.org/10.1249/MSS.0b013e3181949333 411

405

406

- Elagizi, A., Kachur, S., Lavie, C. J., Carbone, S., Pandey, A., Ortega, F. B., & Milani, R. V. 412 (2018). An Overview and Update on Obesity and the Obesity Paradox in Cardiovascular 413 Diseases. Progress in Cardiovascular Diseases, 61(2), 142–150. 414 https://doi.org/10.1016/j.pcad.2018.07.003 415
- 416 Estruch, R., & Bach-Faig, A. (2018). Mediterranean diet as a lifestyle and dynamic food pattern. European Journal of Clinical Nutrition, 5-7. https://doi.org/10.1038/s41430-018-417 0302-z 418
- Ghahramanloo, E., Midgley, A. W., & Bentley, D. J. (2009). The Effect of Concurrent Training 419
- 420 on Blood Lipid Profile and Anthropometrical Characteristics of Previously Untrained Men.
- 421 Journal of Physical Activity and Health, 6(6), 760–766. https://doi.org/10.1123/jpah.6.6.760
- Gillen, M. M., & Lefkowitz, E. S. (2011). The "freshman 15": trends and predictors in a sample 422
- multiethnic 423 of men and women. Eating Behaviors, 12(4), 261-266. 424 https://doi.org/10.1016/j.eatbeh.2011.07.008

- Häkkinen, K., Alen, M., Kraemer, W. J., Gorostiaga, E., Izquierdo, M., Rusko, H., Mikkola,
 J., Häkkinen, A., Valkeinen, H., Kaarakainen, E., Romu, S., Erola, V., Ahtiainen, J., &
 Paavolainen, L. (2003). Neuromuscular adaptations during concurrent strength and endurance
 training versus strength training. European Journal of Applied Physiology, 89(1), 42–52.
 https://doi.org/10.1007/s00421-002-0751-9
- 430 Harber, M. P., Konopka, A. R., Undem, M. K., Hinkley, J. M., Minchev, K., Kaminsky, L. A.,
- 431 Trappe, T. A., & Trappe, S. (2012). Aerobic exercise training induces skeletal muscle
 432 hypertrophy and age-dependent adaptations in myofiber function in young and older men.
 433 Journal of Applied Physiology, 113(9), 1495–1504.
 434 https://doi.org/10.1152/japplphysiol.00786.2012
- He, S., Wang, J., Zhang, J., & Xu, J. (2021). Intermittent Versus Continuous Energy Restriction
 for Weight Loss and Metabolic Improvement: A Meta-Analysis and Systematic Review.
 Obesity, 29(1), 108–115. https://doi.org/10.1002/oby.23023
- Jeukendrup, A. E., Saris, W. H., & Wagenmakers, A. J. (1998). Fat metabolism during
 exercise: a review. Part I: fatty acid mobilization and muscle metabolism. International Journal
 of Sports Medicine, 19(4), 231–244. https://doi.org/10.1055/s-2007-971911
- Kaminsky, L. A., Lavie, C. J., Flint, K., Arena, R., & Bond, S. (2022). Working toward optimal
 exercise prescription: strength training should not be overlooked. Journal of cardiopulmonary
 rehabilitation and prevention, 42(2), E32-E33. https://doi.org/
 10.1097/HCR.00000000000696
- 445 Keating, S. E., Hackett, D. A., Parker, H. M., O'Connor, H. T., Gerofi, J. A., Sainsbury, A.,
- 446 Baker, M. K., Chuter, V. H., Caterson, I. D., George, J., & Johnson, N. A. (2015). Effect of
- 447 aerobic exercise training dose on liver fat and visceral adiposity. Journal of Hepatology, 63(1),
- 448 174–182. https://doi.org/10.1016/j.jhep.2015.02.022

- Kumar, V., Selby, A., Rankin, D., Patel, R., Atherton, P., Hildebrandt, W., Williams, J., Smith,
 K., Seynnes, O., Hiscock, N., & Rennie, M. J. (2009). Age-related differences in the doseresponse relationship of muscle protein synthesis to resistance exercise in young and old men.
- 452 Journal of Physiology, 587(1), 211–217. https://doi.org/10.1113/jphysiol.2008.164483
- 453 Ladeiras-Lopes, R., Sampaio, F., Bettencourt, N., Fontes-Carvalho, R., Ferreira, N., Leite-
- 454 Moreira, A., & Gama, V. (2017). The Ratio Between Visceral and Subcutaneous Abdominal
- 455 Fat Assessed by Computed Tomography Is an Independent Predictor of Mortality and Cardiac
- 456 Events. Revista Espanola de Cardiologia (English Ed.), 70(5), 331–337.
 457 https://doi.org/10.1016/j.rec.2016.09.010
- 458 Lavie, C. J., De Schutter, A., Parto, P., Jahangir, E., Kokkinos, P., Ortega, F. B., Arena, R., &
- Milani, R. V. (2016). Obesity and Prevalence of Cardiovascular Diseases and Prognosis-The
 Obesity Paradox Updated. Progress in Cardiovascular Diseases, 58(5), 537–547.
 https://doi.org/10.1016/j.pcad.2016.01.008
- Liu, Y., Lee, D. C., Li, Y., Zhu, W., Zhang, R., Sui, X., ... & Blair, S. N. (2019). Associations
 of resistance exercise with cardiovascular disease morbidity and mortality. Medicine and
 science in sports and exercise, 51(3), 499. https://doi.org/10.1249/MSS.00000000001822
- McTiernan, A., Sorensen, B., Irwin, M. L., Morgan, A., Yasui, Y., Rudolph, R. E., Surawicz,
 C., Lampe, J. W., Lampe, P. D., Ayub, K., & Potter, J. D. (2007). Exercise effect on weight
 and body fat in men and women. Obesity (Silver Spring, Md.), 15(6), 1496–1512.
 https://doi.org/10.1038/oby.2007.178
- 469 Michell, V., Samaria, C., Júnior Rudy, N., Danyela, V., & Dantas, E. (2014). Effects of a concurrent physical exercise program on aerobic power and body composition in adults. The 470 471 Journal of Sports Medicine and Physical Fitness, 54(4), 441-446. 472 http://www.ncbi.nlm.nih.gov/pubmed/25034548

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., 473 Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M. E., Achoki, T., 474 AlBuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., Guzman, N. A., ... Gakidou, 475 E. (2014). Global, regional, and national prevalence of overweight and obesity in children and 476 adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. 477 Lancet (London, England), 384(9945), 766-781. https://doi.org/10.1016/S0140-478 6736(14)60460-8 479

- Okura, T., Nakata, Y., Lee, D. J., Ohkawara, K., & Tanaka, K. (2005). Effects of aerobic
 exercise and obesity phenotype on abdominal fat reduction in response to weight loss.
 International Journal of Obesity (2005), 29(10), 1259–1266.
 https://doi.org/10.1038/sj.ijo.0803013
- Petridou, A., Siopi, A., & Mougios, V. (2018). Exercise in the management of obesity.
 Metabolism: Clinical and Experimental, 163–169.
 https://doi.org/10.1016/j.metabol.2018.10.009
- Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A.,
 George, S. M., & Olson, R. D. (2018). The physical activity guidelines for Americans. JAMA
 Journal of the American Medical Association, 320(19), 2020–2028.
 https://doi.org/10.1001/jama.2018.14854
- 491 Polyzos, S. A., & Margioris, A. N. (2018). Sarcopenic obesity. Hormones (Athens, Greece),
 492 17(3), 321–331. https://doi.org/10.1007/s42000-018-0049-x
- 493 Rossi, F. E., Diniz, T. A., Neves, L. M., Fortaleza, A. C. S., Gerosa-Neto, J., Inoue, D. S.,
- Buonani, C., Cholewa, J. M., Lira, F. S., & Freitas, I. F. (2017). The beneficial effects of aerobic
- and concurrent training on metabolic profile and body composition after detraining: a 1-year
- follow-up in postmenopausal women. European Journal of Clinical Nutrition, 71(5), 638–645.

- 498 Sanchez-Delgado, G, Martinez-Tellez, B, Olza, J, Aguilera, CM, Labayen, I,... Ortega, FB,
- Ruiz, J. (2015). Activating brown adipose tissue through exercise (ACTIBATE) in young
 adults: Rationale, design and methodology. Contemporary Clinical Trials, 45, 416–425.
- 501 Schulz, K. F., Altman, D. G., Moher, D., Jüni, P., Altman, D., Egger, M., Chan, A., Altman,
- 502 D., Glasziou, P., Meats, E., Heneghan, C., Shepperd, S., Dwan, K., Altman, D., Arnaiz, J.,
- 503 Bloom, J., Chan, A., Cronin, E., Decullier, E., ... Moher, D. (2010). CONSORT 2010
- 504 Statement: updated guidelines for reporting parallel group randomised trials. BMC Medicine,
- 505 8(1), 18. https://doi.org/10.1186/1741-7015-8-18
- Shaw, B. S., Shaw, I., & Mamen, A. (2010). Contrasting effects in anthropometric measures
 of total fatness and abdominal fat mass following endurance and concurrent endurance and
 resistance training. The Journal of Sports Medicine and Physical Fitness, 50(2), 207–213.
 http://www.ncbi.nlm.nih.gov/pubmed/20585300
- Silva, N. L., Oliveira, R. B., Fleck, S. J., Leon, A. C. M. P., & Farinatti, P. (2014). Influence
 of strength training variables on strength gains in adults over 55 years-old: a meta-analysis of
 dose-response relationships. Journal of Science and Medicine in Sport, 17(3), 337–344.
 https://doi.org/10.1016/j.jsams.2013.05.009
- 514 Skinner, A. C., Perrin, E. M., Moss, L. A., & Skelton, J. A. (2015). Cardiometabolic Risks and
- 515 Severity of Obesity in Children and Young Adults. New England Journal of Medicine, 373(14),
- 516 1307–1317. https://doi.org/10.1056/NEJMoa1502821
- Strasser, B., Arvandi, M., & Siebert, U. (2012). Resistance training, visceral obesity and 517 inflammatory response: a review of the evidence. Obesity Reviews : An Official Journal of the 518 519 International Association for the Study of Obesity, 13(7), 578-591. 520 https://doi.org/10.1111/j.1467-789X.2012.00988.x

- 524 Welch, V. A., Norheim, O. F., Jull, J., Cookson, R., Sommerfelt, H., & Tugwell, P. (2017).
- 525 CONSORT-Equity 2017 extension and elaboration for better reporting of health equity in
- randomised trials. BMJ (Clinical Research Ed.), 359, j5085. https://doi.org/10.1136/bmj.j5085
- 527 Westerterp, K. R. (2018). Exercise, energy balance and body composition. European Journal
- 528 of Clinical Nutrition, 72(9), 1246–1250. https://doi.org/10.1038/s41430-018-0180-4
- 529 WHO | Global recommendations on physical activity for health. (2015). WHO.
- 530 Zhang, Q., Zhang, C., Wang, H., Ma, Z., Liu, D., Guan, X., Liu, Y., Fu, Y., Cui, M., & Dong,
- 531 J. (2022). Intermittent Fasting versus Continuous Calorie Restriction: Which Is Better for
- 532 Weight Loss? Nutrients, 14(9), 1781. https://doi.org/10.3390/nu14091781

	Ν	All	Ν	Control	Ν	Ex-Moderate	Ν	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	$40.4{\pm}8.0$	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

Table 1. Baseline descriptive characteristics of the study participants.

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

	Intervention			Mean Differe	nce (95% CI)		P value			
	Control (N-34)	Ex-Moderate (N=32) Median (SD)	Ex-Vigorous (N=32) Median (SD)	Ex-Moderate	Ex-Vigorous	Ex-Vigorous	Ex-Moderate	Ex-Vigorous	Ex-Vigorous	
	Madian (SD)			VS.	VS.	vs.	VS.	VS.	vs.	
	Median (SD)			Control	Control	Ex-Moderate	Control	Control	Ex-Moderate	
Weight (kg)	1.24 (2.73)	-0.40 (2.67)	-2.16 (4.61)	-1.56	-3.12	-1.57	0.342	0.007	0.375	
weight (kg)				(-3.94, 0.83)	(-5.52, -0.71)	(-4.03, 0.91)				
Fat mass (lsg)	0.57 (0.59)	-1.83 (0.62)	-3.27 (0.63)	-2.41	-3.85	-1.44	0.021	<0.001	0.315	
Fat mass (kg)				(-4.53, -0.28)	(-5.98, -1.71)	(-3.60, 0.71)				
$E_{-4} = (0/)$	0.30 (0.50)	-2.71 (0.63)	-3.84 (0.63)	-3.00	-4.14	-1.13	0.004	<0.001	0.622	
Fat mass (%)				(-5.18, 0.83)	(-6.29, -1.98)	(-3.32, 1.05)				
	10.73 (14.62)	-47.79 (15.44)	-77.26 (15.43)	-58.52	-87.99	-29.47	0.024	<0.001	0.540	
VAI (g)				(-111.16, -5.89)	(-140.61, -35.38)	(-82.91, 23.96)				
I	0.75 (0.37) 1.79 (0.39)	1 70 (0 20)	1.70 (0.39)	1.05	0.95	-0.09	0.172	0.248	1.000	
Lean mass (kg)		1.79 (0.39)		(-0.28, 2.37)	(-0.37, 2.27)	(-1.47, 1.27)				
\mathbf{I}	b) 0.83 (0.41) 1	1.02 (0.44)	1.82 (0.44)	1.10	0.99	-0.11	0 102	0.265	0.931	
Lean mass (%)		1.95 (0.44)		(-0.37, 2.79)	(-0.49, 2.81)	(-1.55, 1.38)	0.185			
	- (1) 0.27 (0.12)	0.62 (0.15)	0.59 (0.16)	0.35	0.32	-0.04	0.179	0.201	0.975	
Legs lean mass (kg)	0.27 (0.15)			(-0.13, 0.93)	(-0.16, 0.96)	(-0.52, 0.43)				
A 1	0.00 (0.04)	0.19 (0.05)	0.18 (0.06)	0.11	0.10	-0.01	0.107	0.252	0.925	
Arms lean mass	0.08 (0.04)			(-0.05, 0.34)	(-0.06, 0.32)	(-0.18, 0.14)	0.196	0.253		

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.

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.





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 \pm 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 \pm 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.