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Original Article

ACUTE EFFECTS OF DIFFERENT INTENSITIES RESISTANCE TRAINING ON INFLAMMATORY MARKERS OF WOMEN WITH SEVERE OBESITY

EFEITOS AGUDOS DE TREINAMENTO DE FORÇA COM DIFERENTES INTENSIDADES SOBRE MARCADORES INFLAMATÓRIOS DE MULHERES COM OBESIDADE SEVERA

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RESUMO

Este estudo objetivou comparar os efeitos agudos entre uma sessão de treinamento de força de alta versus moderada intensidade sobre marcadores inflamatórios em mulheres com obesidade severa. Estudo experimental do tipo cross-over, realizado com mulheres adultas com obesidade severa (IMC ≥ 40,0 kg/m²; idade ≥ 18 anos). Cada participante realizou uma sessão de treinamento de força de alta e de moderada intensidade (HIRT e MIRT, respectivamente) com intervalo de 7 dias entre as sessões. Quatro exercícios foram realizados em ambos os protocolos, com volume total de treino equalizado. O MIRT consistiu em 3 séries de 8 repetições cada, com intensidade de 75% de 1RM, enquanto o HIRT consistiu em 2 séries de 6 repetições, seguidas de um descanso de 20 segundos, com nova execução de 2 a 3 repetições, com mais um descanso de 20s e finalização com mais 2 a 3 repetições, com intensidade de 85% de 1RM. Amostras de sangue foram coletadas antes, 15 minutos após e 24 horas após ambos os protocolos de treino. Os marcadores inflamatórios analisados foram IL-2, IL-4, IL-6, IL-10, TNF-α e IFN-γ. Nove participantes completaram a intervenção (n=9; 35,2 ± 10,93 anos; IMC = 48,3 ± 5,06 kg/m²). O teste U de Mann-Whitney mostrou que não houve diferença significativa entre HIRT e MIRT na concentração dos marcadores. O teste de Friedman não mostrou diferenças significativas entre as medidas intragrupo para HIRT e MIRT. Esta pesquisa sugere que uma única sessão de treinamento de força de alta ou moderada intensidade não altera o estado inflamatório de mulheres com obesidade severa.

Palavras-chave: obesidade mórbida. treinamento de força. citocinas. inflamação. saúde da mulher.

ABSTRACT

This study objective to compare the acute effects between one resistance training bout with high versus moderate intensities on inflammatory markers in women with severe obesity. Experimental crossover study, performed with adult women with severe obesity (BMI ≥ 40.0 kg/m²; age ≥ 18 years old). Each participant performed a high and moderate intensity resistance training (HIRT and MIRT, respectively) with an interval of 7 days between bouts. Four exercises were performed in the both protocols, with total training volume equalized. MIRT consisted of 3 sets of 8 repetitions each, with an intensity of 75% of 1RM, while HIRT consisted of 2 sets of 6 repetitions, followed by a 20-second rest, with a new performance of 2 to 3 repetitions, with one more rest of 20s and finishing with 2 to 3 more repetitions, at an intensity of 85% of 1RM. Blood samples were collected before, 15 minutes after and 24 hours after both training protocols. The inflammatory markers analyzed were IL-2, IL-4, IL-6, IL-10, TNF-α and IFN-γ. Nine participants have completed the intervention (n=9; 35.2 ± 10.93 years old; BMI = 48.3 ± 5.06 kg/m²). The Mann-Whitney U test showed that there was no significant difference between the HIRT and MIRT in the concentration of markers. Friedman's test did not report significant differences between intragroup measures for the HIRT as well as MIRT. This research suggests that a single session of high or moderate intensity resistance training does not change the inflammatory status of women with severe obesity.

Keywords: severe obesity; resistance training; cytokines; inflammation; women's health.

Introduction

Obesity is a clinical condition characterized by an excess of visceral and subcutaneous fat, usually associated with a sedentary lifestyle[1]. Several studies have associated obesity with the existence of a low-grade chronic inflammation[2], showing a two-to-four-fold increased pro-inflammatory cytokine concentrations, such as C-reactive protein, tumour necrosis factor alpha (TNF-α) and interleukin 6 (IL-6), and lower concentrations of anti-inflammatory biomarkers, such as interleukin 10 (IL-10) and adiponectin[3]. Such condition leads to an increased risk of the development of chronic illness such as cardiovascular diseases, type two diabetes,

atherosclerosis, hepatic steatosis and some forms of cancer[4–7]. The prevalence of people with obesity has grown alarmingly in Brazil, data from the National Health Survey[8] showed that in 2019, 25.9% of the Brazilian population were obese, with the prevalence among men and women being 21.8 and 29.5%, respectively. Brazilian women also demonstrate worse trends in prevalence of severe obesity, growing from 1.3% in 2006 to 1.9% in 2017[9].

Previous studies have shown that the practice of physical exercise can play a beneficial anti-inflammatory role in the most varied populations[10,11]. That positive exercise-induced effects resulted, in part, from a cumulative acute adaptation[12]. Thus, it is important to investigate the acute responses to exercise aim to understand its consequences. The muscle contraction in the exercise results in the synthesis and secretion of myokines, cytokines produced by the skeletal muscle, especially IL-6, which trigger an anti-inflammatory pathway, stimulating the secretion of interleukin 1 (IL-1) receptor agonist and IL-10 from monocytes and lymphocytes[3,12]. Previous studies evaluated the acute effects of exercise with different intensities protocols over inflammatory markers in healthy subjects and observed that the concentrations of IL-6 can increase up to 100-fold after exercise but decrease about basal levels after approximately 60 minutes[3,12]. Adolescents with obesity also demonstrate increases in the IL-6 concentrations after a moderate intensity aerobic training[13]. However, the acute inflammatory exercise-induced responses in adult people with obesity remains unclear.

Those who investigated the effect of exercise on inflammatory markers (IM) mostly used aerobic exercise as a training protocol. The effects of resistance training (RT) on these variables still have unclear, especially in populations at risk of developing chronic diseases associated with inflammation, such as individuals with obesity[14,15]. Researches that applied RT to assess the effects on IM in individuals with obesity used moderate intensity RT protocols, generally following the American College of Sports Medicine (ACSM) recommendations[16–18]. High intensity RT protocols have been shown to be an excellent time-efficient strategy, with positive results in physiological parameters and body composition, being considered safe in untrained individuals[19,20]. In this regard, there is a lack of evidence about the safety of the application of high intensity RT protocols in people with low-chronic inflammation conditions, such people with obesity. Furthermore, due to the singular characteristics of the high intensity RT, such as high lactate production and increases in resting energy expenditure[20], and the elevated muscle damage, the possibility to find alterations in inflammatory markers associated 24hs after an exercise bout needs to be explored.

Due to the necessity to investigate the best therapeutic strategies that help to attenuate chronic low-grade inflammation in people with obesity, this research aimed to compare the acute effects between one resistance training bout with high versus moderate intensities on inflammatory markers in women with severe obesity. Additionally, we aimed to evaluate the feasibility of a high intensity resistance training bout in women with severe obesity.

Methods

Sample

The research was carried out in a referral university hospital in bariatric surgery (BS), located in an urban area of northeastern Brazil. The population consisted of adult women and classified with severe obesity. The cohort was recruited for convenience through an invitation made during the visit of the BS candidates in the Quality of Life and Health Promotion Service, which is part of the Multidisciplinary Program of Bariatric Surgery (MPBS) of the hospital. It was included adult women (age ≥ 18 years old), with grade 3 obesity classification (body mass index [BMI] ≥ 40 kg/m²), who had not practiced regular physical exercises in the last 3 months, without presence of musculoskeletal injury that compromised the practice of exercises and did not use drugs that affect physical performance or IM values, such as beta-blockers and

corticosteroids. Additionally, it was requested the presentation of a medical certificate that allowed the performance of physical exercise of moderate to vigorous intensity. Nine women met the criteria and agreed to participate in the research (n=9). All procedures involving the participants were performed according to the principles in the Declaration of Helsinki and the study was approved by the local Ethics Committee (protocol 2.973.988/2018; CAEE 00863718.8.0000.5208). Informed consent was obtained from all participants included in the study.

Study Design

To reach the objective of the research an experimental crossover study was conducted[21]. Initially, the candidates of participate in the study underwent a preliminary assessment consisting of a questionnaire, to access biopsychosocial data, anthropometric measurements, measurement of body composition and familiarization with the equipment that was used in the training sessions. After an interval of 24 to 48 hours, strength tests were performed. At least 72 hours after the test, the participants underwent a high-intensity RT (HIRT) session followed by a moderate-intensity RT (MIRT) session, with an interval of 7 days between them in order to avoid cumulative effects over the participants IM. Immediately before (PRE), 30 minutes (POST) and 24 hours after (POST-24) the training bouts, blood samples were collected for IM analysis. Participants were instructed to not perform other exercises and to avoid alcohol, caffeine and anti-inflammatory drugs before the preliminary assessments and during the intervention period. A summary of the study design is presented in Figure 1.

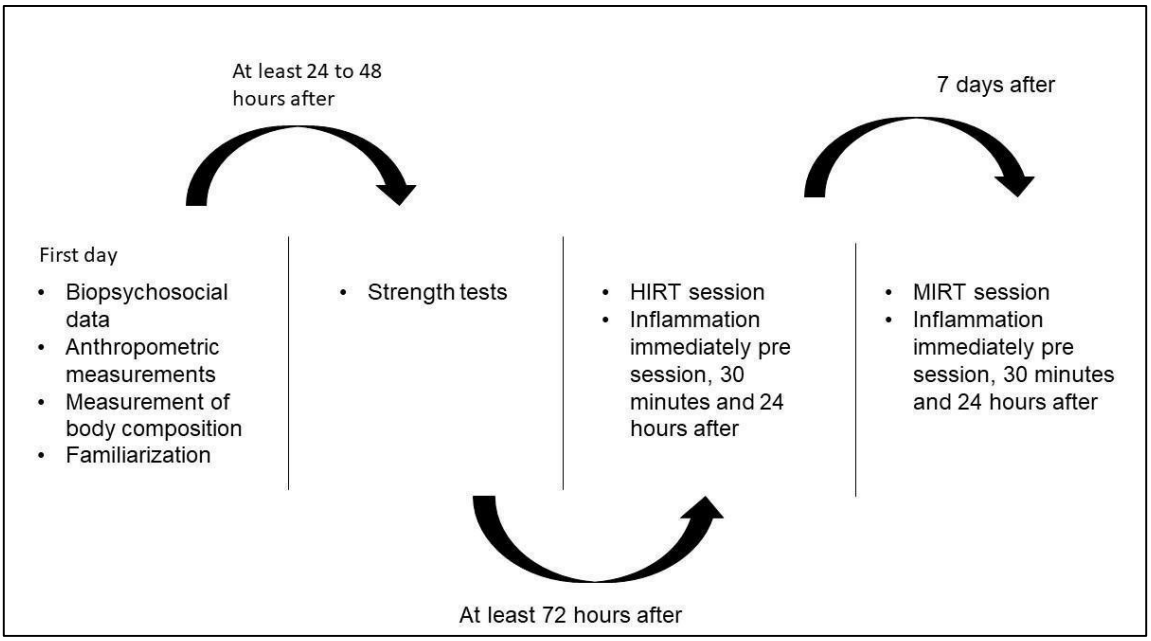

Figure 1. Summary of study design. HIRT: high intensity resistance training. MIRT: moderate intensity resistance training

Source: authors

Procedures

Both training sessions consisted of the vertical bench press, leg extension, lat pull-down and leg press exercises, performed in this order, using the Matrix Fitness USA equipment (WI, USA). The HIRT consisted of a modified version of the rest-pause method, used in previous studies[19,20]. The participants performed 2 sets of 6 repetitions with a load of 6 repetition maximum (RM) followed by an interval of 20 seconds, then repetitions to failure with the same

load (usually 2 or 3 repetitions) followed by a new interval of 20 seconds and then again reps to failure (1 or 2 reps). This sequence corresponds to one set. The interval between sets and between exercises was 2.5 minutes. The rest-pause method was chosen because it is a high-intensity strategy (~85% of 1 RM) and because it has a shorter duration than the MIRT, proving to be a good time-efficient alternative. Also, the rest-pause have demonstrated to be a safe protocol to cardiovascular outcomes[22], and was previously applicated in special populations, like older adults[19]. MIRT was performed according to the guidelines of the ACSM for RT in untrained adult subjects[18]. Three sets of 8 repetitions were performed, with a load of 75% of 1 RM. The interval between sets and between exercises was 2 minutes. The total training volume was similar between the two protocols, as well as the total rest time during exercises. For example, using the formula (sets x repetitions x load) to measure the total training volume, considering that an individual's 1RM load is 100 kg, the total volume with HIRT will be 1870 kg (2 x (6+ ~3+ ~2) x 85 kg), while with MIRT will be 1800 kg (3 x 8 x 75 kg). The total volume of the HIRT may vary slightly between individuals, due to the need to perform repetitions to failure (generally between 2 and 4 repetitions) after the first 6 repetitions, as observed by Moro et al[19]. Rest times were also equalized, being the total rest time in an exercise in MIRT and HIRT was 240 and 230 seconds, respectively, in the latter case intra and inter sets intervals were added. Before and after each exercise session blood pressure of all participants was measured to guarantee their safety. A summary of both protocols adopted in the study is presented in Figure 2.

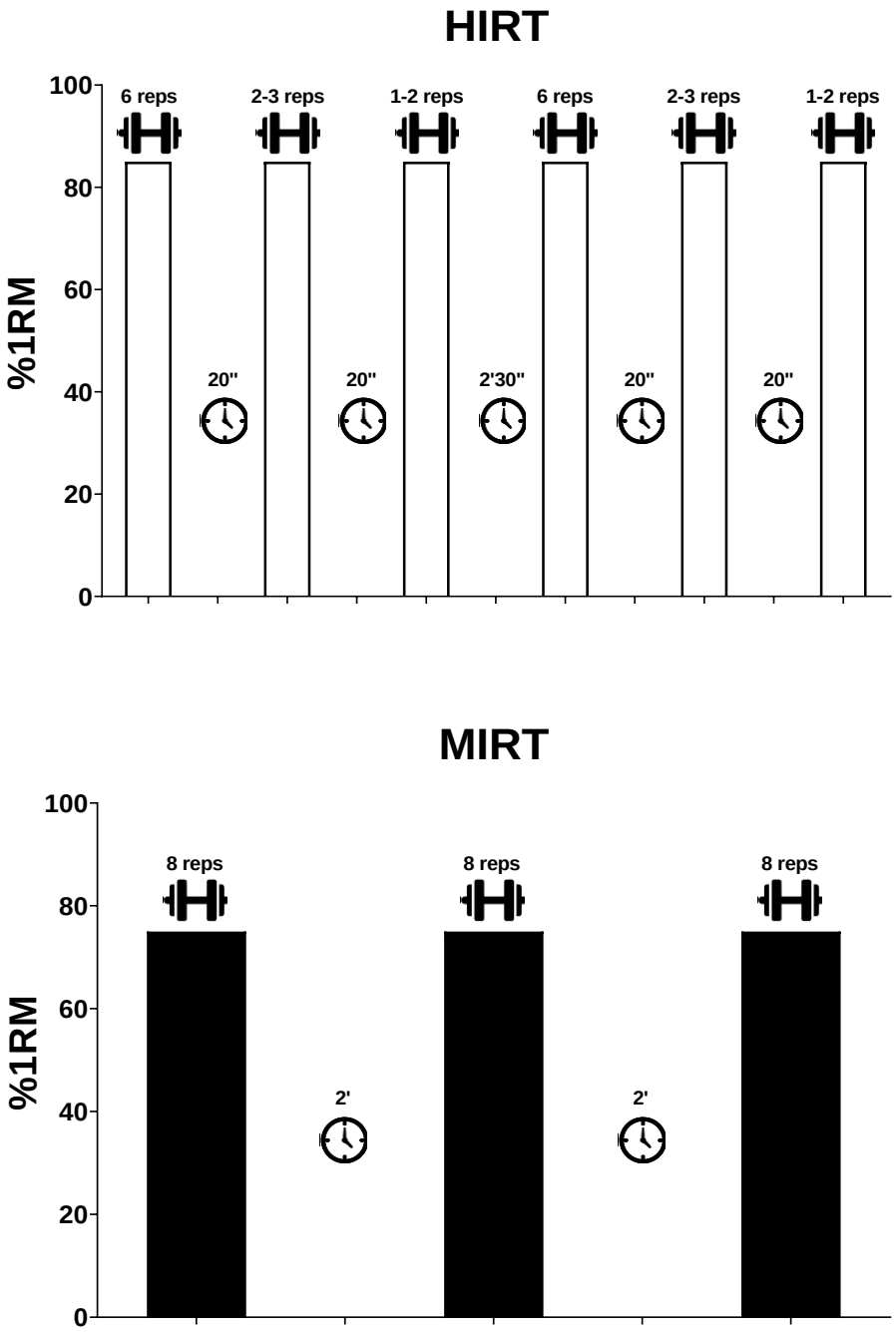

Figure 2. Summary of training bouts protocol

Notes: HIRT protocol consisted of 2 series at, approximately, 85% of 1RM in which subjects were instructed to perform repetitions to exhaustion three different times in each series, with 20″ rest between the 1st and 2nd efforts and the 2nd and 3rd efforts. Rest periods of 2′30″ were allowed between sets and exercises. TRT protocol consisted of 3 sets of 8 repetitions at 75% 1RM, with 2′ rest between sets and exercises

Source: authors

Anthropometric Measures

Height and body weight values were measured with the Filizola scale (SP, Brazil). BMI was calculated using the formula BMI = body weight (kg) / height² (m²).

Inflammatory Markers

Immediately before (PRE), 30 minutes (POST) and 24 hours after (POST-24) the both training bouts, blood samples of 6 ml were collected from the participants in the antecubital vein and stored in tubes containing coagulation activator (BIOCON, MG, Brazil). After collection, the samples were centrifuged in a rotation of 4000 rotation per minute and then stored at a temperature of -20 °C until further analysis. The IM interleukins 2 (IL-2), 4 (IL-4), 6 (IL-6), 10 (IL-10), tumor necrosis factor alpha (TNF-α) and interferon gamma (IFN-γ) were analyzed in blood serum using traditional ELISA kits from USCN (Wuhan, China), Millipore (MA, USA) and Phoenix Pharmaceuticals, Inc. (CA, USA).

Strength

Strength was measured through the 6 repetitions maximum (6RM) test in the bench press, leg extension, lat pull-down and leg press exercises, performed in this order, using equipment from Matrix Fitness USA (WI, USA). The values obtained in the test were used to determine the appropriate load for each participant in the intervention protocols performed. The 6 RM test was used because it is more suitable in untrained individuals and demonstrate high reproducibility in previous studies[19,20,23].

After performing a specific warm-up for each exercise, 12 repetitions with light effort, a certain load was stipulated based on the instructor's experience, so that a first attempt was performed, if the number of repetitions exceeded or was below the 6 desired repetitions, the load would be increased or reduced, respectively, until failure occurred exactly after the sixth repetition, without compromising correct exercise technique and without any assistance. Three minutes intervals were performed between each attempt and 5 minutes intervals were respected between each exercise. The value of 1 RM was determined using the Brzycki formula[24].

Statistical Analysis

For tabulation, construction of the database and preparation of tables, Excel 2013 software (Microsoft Corporation) was used. Data analysis was performed using SPSS 25.0 software (Statistical Package for the Social Sciences). The IM values were expressed as median and interquartile range. The Shapiro-Wilk test was performed to verify the normality of the data. Due to the non-normal distribution of the IM concentrations, the Friedman test was chosen to compare the IM values in the PRE, POST and POST-24 moments for each one of the protocols applied. The Mann-Whitney U test was used to compare the IM concentrations, for each specific moment, between the HIRT and MIRT groups. For all tests, a significance level of 5% was considered.

Results

Nine participants have completed the intervention [n=9; 35.2 (18 to 49; SD = 10.93) years old; body mass = 121.0 (101.2 to 143.0; SD = 13.01) kg; BMI = 48.3 (40.1 to 56.5; SD = 5.06) kg/m²]. Four participants were 40 years or older. Regarding the comorbid, two individuals had high levels of total cholesterol. No training-related injuries or discomfort were identified.

The Mann-Whitney U test showed that there was no significant difference between the HIRT and MIRT in the concentration of the most of the IM, except for the IL-4 value which was significantly higher in the HIRT group at PRE (U = 11.000; p = 0.008), but without significant differences in the other moments [POST (U = 40.000; p = 1.000); POST-24 (U = 20.000; p = 0.077)]. Friedman's test did not report significant differences between intragroup measures for the HIRT as well as MIRT (Table 1). The percentage change in IM between POST and POST-24 in relation to PRE for each participant are shown in Figure 3.

Table 1. Friedman's test. Serum concentration of the inflammatory markers investigated in the PRE, POST and POST-24 for HIRT and MIRT (n = 9)

	PRE	POST	POST-24	p
HIRT				
IL-2	65.51 [1.42]	65.76 [1.56]	65.86 [1.12]	0.459
IL-4	33.25 [2.29]	31.83 [3.03]	32.46 [4.04]	0.368
IL-6	75.36 [3.76]	78.09 [3.71]	75.50 [7.73]	0.368
IL-10	58.93 [0.87]	59.11 [1.34]	59.38 [3.85]	0.895
TNF-α	55.05 [1.41]	54.77 [1.91]	54.49 [5.13]	0.895
IFN-γ	137.74 [4.98]	137.61 [3.62]	138.27 [4.01]	0.895
IL-10/TNF- α	1.08 [0.02]	1.09 [0.02]	1.09 [0.08]	0.368
MIRT				
IL-2	65.45 [0.51]	65.49 [1.49]	65.35 [1.24]	0.459
IL-4	31.22 [1.07]	31.39 [3.24]	31.36 [1.49]	0.368
IL-6	72.68 [7.09]	78.08 [9.04]	75.83 [6.71]	0.459
IL-10	58.86 [2.40]	58.87 [8.38]	59.33 [9.61]	0.368
TNF-α	54.76 [0.80]	54.45 [7.03]	54.03 [0.96]	0.641
IFN-γ	137.58 [0.48]	137.94 [7.61]	137.29 [2.13]	0.121
IL-10/TNF- α	1.09 [0.03]	1.08 [0.09]	1.10 [0.10]	0.121

Note: *HIRT: high intensity resistance training; MIRT: moderate intensity resistance training. Data are presented as median [interquartile range].*
Source: Authors

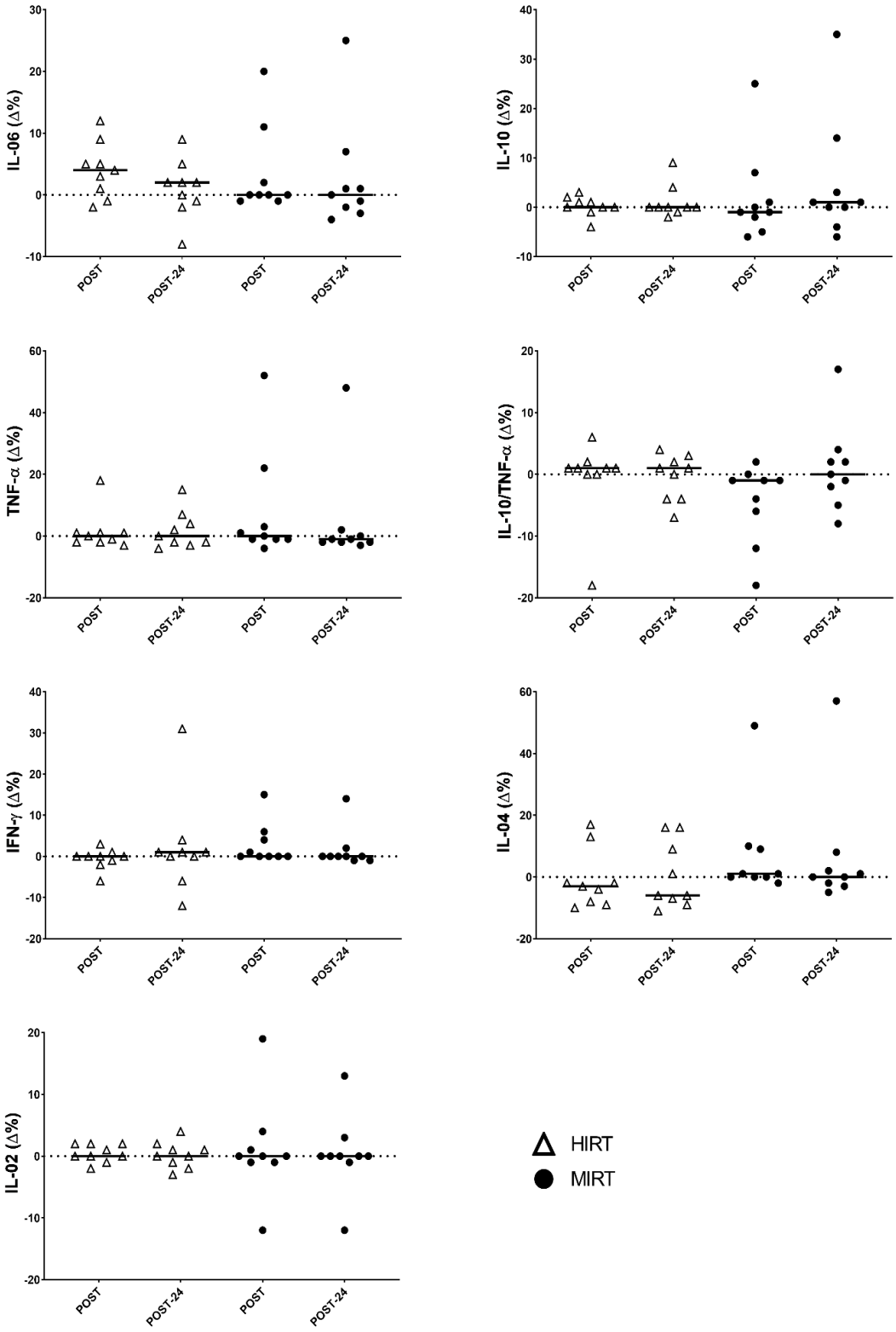

Figure 3. Percentage changes (Δ%) of the inflammatory markers between POST and POST-24 in relation to PRE for each participant. Bars represent the median of differences.
Source: Authors

Discussion

To the best of our knowledge, the present experiment was the first to verify the feasibility of a HIRT bout and to compare the responses of the IM after the performance of one bout of MIRT and HIRT in women with severe obesity. One session of HIRT proved to be viable and safe, in the inflammatory aspect, with no occurrence that compromised physical integrity of the participants. No significant differences were found in the plasma concentrations of IM in any of the analyzed moments, as well as there were no differences in the variations between the MIRT and HIRT protocols. Such findings demonstrate that both protocols can be applied acutely in women with severe obesity without producing aggravation of low-grade chronic inflammation.

Physical exercise has been shown to be effective in attenuating low-grade chronic inflammation, as it stimulates the production and release of cytokines from skeletal muscle into the circulation, called myokines, which play an important anti-inflammatory role[25]. One of the main agents of this action is the release of myokine IL-6, which induces the production of the cytokine IL-10, an anti-inflammatory agent[26]. The maintenance of IL-6 values in the HIRT and MIRT protocols is divergent of other studies with similar intervention when there were significant changes in the IM, however, such protocols were performed with eutrophic individuals, with overweight and with obesity grades 1 and 2, but never in individuals with grade 3 obesity[10,16,27,28]. Such results may not be related to the training protocols, but to the public investigated, which due to their high percentage of body fat and low muscle mass relative to body weight, has influenced the modulation of IL-6. On the other hand, high IL-6 values were used as a predictor of severe cases of the new coronavirus disease (COVID-19), in which infected individuals who had high IL-6 serum concentration were more likely to have respiratory failure and need the help of respirators[29]. Herold and colleagues[29] reported that after reaching an IL-6 plasma concentration value of 80 pg/mL, the median time to mechanical ventilation was 1.5 days. In normal conditions, healthy subjects presented values of basal IL-6 concentrations do not exceed 8 pg/mL[30]. The sample of the present research presented a basal concentration of IL-6 of 75.36 ± 3.76 pg/mL, highlighting the importance of to investigate training protocols that don't worsening their inflammatory status. In the present study, although both training protocols did not generate significant increases in anti-inflammatory cytokines investigated, they also did not contribute to the worsening of the low-grade chronic inflammation.

Regardless there were no significant differences between both RT protocols analyzed in the present study, intensity seems to play an important role in modulating the inflammatory profile. For aerobic exercises several studies suggest that exist a directly proportional relationship between the intensity of the exercise and the immune response[3,14,15]. The same directly proportional relationship occurs with RT of low and moderate intensity[16,17]. However, there are few studies that address high intensity RT. The research conducted by Phillips et al.[31], is one of the few that compares the acute effects of a MIRT (2 sets X 12 repetitions at 65% of 1RM) and a HIRT (2 sets of 8 repetitions at 80% of 1RM) on the inflammatory profile in trained subjects, investigating specifically about IL-6. The authors report higher IL-6 values immediately after MIRT (2.8 ± 0.6 to 3.0 ± 0.5 $pg.mL^{-1}$) and HIRT (2.4 ± 0.3 to 2.3 ± 0.4 $pg.mL^{-1}$), compared to the control group, which presented no difference with another groups in the baseline, whereas IL-6 concentration was greater after MIRT compared with HIRT. The authors attributed this difference between the interventions to the higher total training volume in the MIRT group. Such findings suggest that perhaps intensity influences IM differently between resistance and aerobic training protocols and in different populations regard training status.

The results of the present research demonstrate that a bout of HIRT does not aggravate the inflammatory status of women with severe obesity, presenting itself as an interesting alternative to the prescription by exercise professionals for this population, once in addition to being an acute protocol tolerable and feasible, other studies have shown a greater energy expenditure, glycemic control and reduction in fat mass, and improvement in biochemical variables when compared to MIRT[19,20,32].

The present research has some limitations. Due to the small sample size the results must be interpreted with caution. There was no randomization to determine which would be the first training performed, however the wash-out period was long enough to avoid any cumulative effects. There was no control over the menstrual period of the study participants, with the possibility of changes in the results. Although there are limitations, this is an innovative study that opens doors for future investigations. Further studies should analyze the chronic effects of different intensities of resistance training in people with severe obesity, as well as with higher training volumes.

Conclusion

The results of the present research suggest that a single session of high or moderate intensity resistance training does not change the acute inflammatory status women with severe obesity. Additionally, the investigation demonstrated that one session of supervised high-intensity resistance training is feasible and well-tolerated for the sample. More investigations are now needed to elucidate the chronic feasibility and effects of a HIRT in women with severe obesity. Future research should investigate the chronic effects of a HIRT protocol in women with severe obesity.

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