The Influence of the HIIT and Aerobic Training Programs on Body Composition

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ABSTRACT

Purpose: According to studies, the increasing risk of obesity in the general population is mainly caused by insufficient physical activity. The main goal of this study was to compare the effect of two types of endurance training. High-intensity interval training (HIIT) and moderate-intensity continuous training and their effect on chosen aspects of body composition. Methods: This study included women (n = 14; 32 years old; height 166.3cm; weight 62.5kg) divided into two groups of seven participants. A deliberate selection of 7 participants selected the tested groups. The women trained three times a week for ten weeks. Pre-test and post-test were conducted in the week before the beginning and the end of these ten weeks using non-invasive techniques (anthropometric measurements, body composition analysis – bioimpedance analysis). Parameters were analyzed using the pair T-test. Factual significance was evaluated using Cohens d. Results: Despite the relatively small number of participants, it can be stated that the group that trained using the high-intensity interval training showed better results. However, the final data could not be used to compare the statistically relevant efficiency of the two methods in body fat loss. The changes in studied parameters were, therefore, marked as statistically insignificant. Conclusion: Despite the relevant results, the HIIT program showed better results. It is crucial to expand the testing group and consider the subjects' eating regimen, motivation, and readiness for testing to continue. High-intensity interval training is shown to be a promising training program for body composition alternation due to its variability and low time consumption.

Keywords: body composition; intensity; interval training; physical exercise; bioimpedance analysis.

INTRODUCTION

Most of the adult population does not achieve recommended levels of physical activity, which negatively contributes to the global epidemic of overweight/obesity and related cardiovascular diseases. Physical activity is essential to weight loss programs and is integral to obesity treatment. Endurance training has an irreplaceable place in sports training, especially in terms of body fat percentage. Physical activity has many health benefits, such as positive effects on weight loss and even breaking down body fat with the added benefit of retaining muscle mass and total body weight. (Bellicha et al., 2021). Moderate-intensity continuous training (MICT) is often recommended for its greater ability to break down fat storage and higher energy output compared to anaerobic training, as an example stated by Geliebter et al., already in 1997. Currently, it is recommended to train at least 150 minutes of medium-intensity exercise or 75 minutes of high-intensity exercise three days a week to achieve a positive change in the physical performance and overall health of an individual (Sultana et al., 2019). Doing this type of exercise can offer several health benefits, such as cardiorespiratory health, metabolic health, and musculoskeletal health (Scoubeau, 2022), which is closely tied to a decrease in body fat. Most exercises specifically targeting weight loss in adults and individuals suffering from adiposity are recommended to include continual medium-intensity training (Sultana et al., 2019). Not having enough time to exercise is considered to be a frequent reason for the lack of physical activity in the general population (Keating et al., 2014). High-intensity interval training (HIIT) could offer comparable health benefits more time-efficiently than regular aerobic exercise, more commonly referred to as MICT of published research abroad. Moreover, it is applicable to the general public. HIIT is characterized as an exercise alternating between intervals of high intensity and either low intensity or a complete rest. De Feo (2013) characterizes HIIT as a repetitive high-intensity exercise for 30 seconds to several minutes, separated by 1 to 5 min of recovery.

On the contrary, MICT, generally referred to as aerobic training, lasts for a longer time period. According to WHO (2020), aerobic activity can be defined as endurance activity improving cardiorespiratory ability. Walking, jogging, swimming, or cycling can be used as examples of such activity. Aerobic exercise contributes to clinically significant loss of fat and muscle gain and decreases the risk of cardiovascular diseases (de Oliveira, 2020). The study of Stevenson et al. (2009) defines aerobic training as a type of endurance training that gradually hastens metabolism and stimulates the body to burn fat intensively, similar to HIIT training. On the contrary, HIIT is an efficient tool for body weight decrease. It also improves endurance and, in some cases, even increases the amount of muscle mass. It can be considered one of the most efficient training methods, even though the exercise lasts a relatively short time. However, in contrast to other MICT and strength training activities, HIIT is not based on low intensity. As the name suggests, it is a type of interval in which high-intensity intervals follow low-intensity intervals. Recently, the general population became aware of these high-intensity educational programs. Despite the initial positive feedback, the realization of these programs is quite problematic due to the already-mentioned requirements of high intensity. The study by Amaro-Gahete (2019) states that HIIT is turning out to be a time-efficient strategy to improve body composition. It systematically describes

that medium-intensity training programs show similar results to HIIT programs, both leading to the decrease of body fat (FFM- fat-free mass) in individuals leading a sedentary lifestyle and individuals suffering from overweight/obesity. The difference is that HIIT shows the same results while saving about 40% of time invested in exercise weekly. It can be concluded that HIIT is a more time-efficient alternative to basic aerobic training. The study of Amaro-Gahete (2019) also mentions the positive but inconclusive results of HIIT's effects on body composition parameters in individuals with a wide age range and varied biological factors. Despite that, HIIT is still the most modern, time-effective method of exercise at the moment. There are other alternative programs to this type of exercise being developed constantly.

A wide range of medical examinations revealing shortcomings and possible health problems can be used to prevent obesity. InBody device is one of the technologies specializing in obesity diagnosis. This device can calculate the body composition using a tetrapolar arrangement of electrodes, which send electric signals through the human body. After determining body fat percentage, bioimpedance analysis is often used. The most common indicator of excess body weight is BMI (body mass index). According to Cacek et al. (2014), the amount of excess body fat is one of the most important aspects of obesity. It describes the health risks for the individual and informs about the physical state and performance.

This study focused on two types of endurance training: moderate-intensity continuous training (MICT) and High-intensity interval training (HIIT). The continual method is primarily used for the development of aerobic endurance during a continual strain of a cyclic character, otherwise known as a periodic exercise that lasts for a longer period (Máček et al., 2011). As a study by Novotný et al. (2008) states, aerobic training with a continuous load and low intensity is long-term slow movement training over a longer distance (Novotný, 2008). On the other hand, interval methods alternate between intervals of load and rest. During the rest phase, the heart rate and ventilation do not recover completely, which is characteristic of this type of method. This variable method progressively enhances the endurance of an individual (Bernacíková et al., 2017).

The main goal of this study was to compare the impact of the two types of training load, HIIT and MICT, and their effect on body composition in women by using a 10-week intervention program. Based on the previous studies, we assume that MICT will show lower effectiveness on body composition than HIIT.

METHODS

Participants

All participants were healthy female recreational athletes performing aerobic sports activity up to 150 minutes per week (n = 14; women; average: 32 years old; height 166.3cm; weight 62.5kg). Participants were selected through purposive sampling. Women must be pre-menopausal, have no injuries, not take any medication, and be non-smokers. They were randomly divided into two groups of seven subjects. Pre-test and post-test were conducted using non-invasive techniques (anthropometric measurements, body composition analysis - bioimpedance analysis).

Procedures

The MICT and HIIT training program lasted for ten weeks with a frequency of three times a week (30 training units total).

Training protocol

The intervention program (Table 1.) was composed of an exercise unit performed three times a week for 10 weeks. A 5-minute warmup was initiated in every unit. It finished with an individual stretching. The training sessions of the MICT group lasted for 60 minutes and took place on a treadmill. The maximum heart rate (HRmax) was determined to be around 60–75 % of an individual HRmax. Training sessions of HIIT groups were split into three times repetition short intervals (30 s bouts and 30 s rest) Both of the protocols. MTF was set to 85–95% HRmax. The equation for calculating HRmax = 208 – (0.7 × age) (Tanaka et al., 2001). Heart rate was monitored using a Polar Heart Rate monitor (Polar® RS800sd Kempele, Finland) and was recorded at the completion of each high-intensity interval, and reported as percentage of age-predicted HRmax.

Table 1. Training protocol of the MICT and HIIT groups

Group	Number of participants	Duration	Intervention including warm up and cool down	% HRmax
MICT	7 women	3x per week 10 weeks at all	65min walking/running motorized treadmill	60-75% HRmax
HIIT	7 women	3x per week 10 weeks at all	3x (30s running, whole-body exercise, 30s rest), 1:1 35min per session	85-95% HRmax

Anthropometric characteristics and body composition measurements

Complete body composition analysis was undertaken using Inbody720 (Biospace, South Korea) segmental Body Composition Analyzer. Body height (cm) was measured by a stadiometer with 0.1 cm precision. Participants stood upright and barefoot by a wall, wearing thin sports clothes. Heels, behind, and shoulder blades were touching the wall. Bioelectric impedance analysis InBody was used for measuring body fat, muscle mass, waist-to-hip ratio, area of visceral fat, and mass.

Methods of data collection, data processing, and evaluation

Basic theoretical and practical preparations were conducted, undesirable elements were removed, and personal analysis was performed. All the women from both intervention programs went through a complete body analysis (Inbody 720), both at the start and at the end of the whole program. Pre-test and post-test were conducted 6 days before and 6 days after the 10- week intervention at the Faculty of Sports Studies. On the day of testing and the day previously, they had not completed any training, and according to the set measurement schedule, they came on an empty stomach. Before starting the measurement by InBody, the participants were familiarized with the measurement procedure, and they were the examiner conditions for the accuracy of the measured values to be ensured. Changes in the body composition were acquired. The main goal was to study changes in body fat and muscle mass. The secondary parameters were body mass and body mass index (BMI). The range of the effect changes between the HIIT and MICT was assessed by pair testing – Cohen

d. The results were transferred into tables and graphs for better illustration. Statistical significance was defined as $p < 0,05$ and was tested using the Wilcoxon paired test.

RESULTS

From both of the study groups, 7 women finished the intervention program. The changes in body composition of the HIIT group are shown in Table 2. Values of body fat, muscle mass, body mass, body fat percentage, and BMI were compared.

Table 2. Personal characteristics of group HIIT, pre- and post-testing.

Woman	Weight (kg)		Body fat (kg)		Muscle Mass (kg)		Body fat percentage (%)		BMI (kg/m2)	
	pre	*post*	*pre*	*post*	*pre*	*post*	*pre*	*post*	*pre*	*post*
TW1	75.6	76.9	20.7	22.3	30.64	30.33	27.42	28.98	25.26	25.69
TW2	57.3	57.3	14.1	13	23.65	24,35	24.52	22.71	19.83	19.86
TW3	71.4	71	22.8	22.4	26.68	26.77	31.99	31.53	24.71	24.57
TW4	63.4	67.3	11.7	12.9	28.69	30.09	18.48	19.19	21.31	22.62
TW5	53.2	52.6	14.4	12.2	21.12	22.03	27.06	23.25	22.14	21.89
TW6	60	58.2	17.8	15.3	23.11	23.59	29.69	26.33	24.03	23.31
TW7	79.1	77.1	28.4	25.8	28.09	28.52	35.92	33.43	28.03	27.32

Legend:TW = Tested woman

The expected progress after the HIIT intervention was primarily in decreased stored body fat and increased muscle mass. The results show that the changes that took place mainly were individual. Five women (TW 2, 3, 5, 6, 7) both decreased their body fat percentage and increased their muscle mass. In these instances, either a drop or a constant value of total body weight was recorded. Despite regular exercise, a rise in both body fat percentage and total body weight was recorded in two cases (TW 1, 4).

As it is shown in Table 3., the results in these cases are incredibly different. Unlike in HIIT, the primary assumption was decreased total fat without increasing additional muscle mass. However, this occurred only in two cases (TW 5, 7). In two instances (TW 3, 6), both a decrease in total fat and an increase in muscle mass were recorded. The rest of the subjects (TW 1, 2, 4) showed an increase in muscle mass but also an increase in body fat.

Table 3. Personal characteristics of group MICT, pre-and post-testing.

Woman	Weight (kg)		Body fat (kg)		Muscle Mass (kg)		Body fat percentage (%)		BMI (kg/m2)	
	pre	*post*	*pre*	*post*	*pre*	*post*	*pre*	*post*	*pre*	*post*
TW1	71.6	73.3	21.7	23.1	28.04	28.22	30.25	31.45	27.28	27.93
TW2	63	65.3	16.7	17.2	25.64	26.53	26.46	26.33	22.32	23.14
TW3	60.9	61.4	14.1	14	25.99	26.35	23.16	22.82	21.07	21.25
TW4	67.8	69	22.9	24	24.61	24.77	33.85	34.84	24.6	25.04
TW5	75.8	75.2	24	23.8	28.55	28.37	31.72	31.7	25.62	25.42
TW6	51.5	51.4	15.3	13.9	19.44	20.15	29.66	26.98	21.16	21.12
TW7	72.9	72.2	24.6	24.4	26.67	26.48	33.69	33.76	26.14	25.89

Legend: TW = Tested woman

During Wilcoxon body fat testing, the significance value was $p < 0.5$ (Table 4.). Even though in 5 cases, there was a decrease in body fat recorded, we can conclude that the changes in the total body fat were insignificant. Regarding muscle mass (Table 5.), there was an increase recorded in 6 cases. Due to the fact that the studied group was small, the value of the increase in muscle mass was considered a statistically significant $p = 0.043$.

Table 4. Wilcoxon paired test for body fat - HIIT

Pair of Variables	Wilcoxon Matched Pairs Test (X1_Spreadsheet3) Marked tests are significant at p< .05			
	Valid N	T	Z	p-value
Fat before (kg)& Fat after (kg)	7	7	1.183	0.237

Table 5. Wilcoxon paired test for muscle mass – HIIT

Pair of Variables	Wilcoxon Matched Pairs Test (X1_Spreadsheet3) Marked tests are significant at p< .05			
	Valid N	T	Z	p-hodnota
Muscle mass before (kg)& Muscle mass after (kg)	7	2	2.023	0.043

When performing a statistical evaluation of MICT, the situation was similar to that of HIIT, as there were no significant changes in body fat in the tested subjects (Table 6). In this case, there were no statistically significant changes in the amount of skeletal muscle mass (Table 7).

Table 6. Wilcoxon paired test for body fat - MICT

Pair of Variables	Wilcoxon Matched Pairs Test (data) Marked tests are significant at p < .05			
	Valid (N)	T	Z	p-value
Body fat pre and post (kg)	7	12	0.338	0.735

Table 7. Wilcoxon paired test for muscle mass -MICT

Pair of Variables	Wilcoxon Matched Pairs Test (data) Marked tests are significant at p < .05			
	Valid (N)	T	Z	p-value
Body mass pre and post (kg)	7	6.5	1.268	0.205

The effect of both groups, MICT and HIIT (Table 8., Table 9.), on BMI is very small (d_{MICT}0.091; d_{HIIT}=0.003) as well as body weight (d_{MICT}0.073, d_{HIIT}=0.006) and body fat d_{MICT}=0.034, d_{HIIT}=0.150). A minimal effect was recorded on the body fat percentage in the MICT group (d_{MICT}=0.031), and a higher value was recorded in the HIIT group (d_{HIIT}=0.258). In both groups, there were small but positive changes (increase) in muscle mass (MM-kg) when comparing participants in the groups (d_{MICT}=0.095, d_{HIIT}=0.157).

Table 8. Group MICT – Comparison pre- and post-selected variables

	MICT		**Effect**
	M	**SD**	**Cohen´s d**
BMI_pre	24.03	2.53	0.091
BMI_post	24.26	2.53	
PBF_pre	29.83	3.89	0.031
PBF_post	29.70	4.40	
BW_pre	66.21	8.40	0.073
BW_post	66.83	8.32	
BF_pre	19.90	4.40	0.034
BF_post	20.06	4.84	
MM_pre	25.56	3.02	0.095
MM_post	25.84	2.79	

Legend: M- Mean, SD- standard deviation, BMI- Body Mass Index, PBF- Percentage of Body Fat, BW- Body Weight, BF- Body Fat, MM- Muscle Mass.

Table 9. Group HIIT- Comparison pre and post-selected variables

	HIIT		**Effect**
	M	**SD**	**Cohen´s d**
BMI_pre	23.62	2.49	0.003
BMI_post	23.61	2.49	
PBF_pre	27.87	5.56	0.258
PBF_post	26.49	5.13	
BW_pre	65.71	9.79	0.006
BW_post	65.77	9.87	
BF_pre	18.56	5.83	0.150
BF_post	17.7	5.63	
MM_pre	26	3.45	0.157
MM_post	26.53	3.29	

Legend: M- Mean, SD- standard deviation, BMI- Body Mass Index, PBF- Percentage of Body Fat, BW- Body Weight, BF- Body Fat, MM- Muscle Mass.

The difference between BMI in the groups (Table 10.) according to the type of exercise was minimal before the exercise (d=0.164). After exercise, the difference between the groups according to the type of exercise increased (d=0.258). The difference between MM in the groups according to the type of exercise was minimal before the exercise (d=0.134). There was a slight difference in the comparison before the start of the research in BF (d=0.260). The post-exercise MM difference between groups by type of exercise increased (d=0.225), as did BF (d=0.449). When comparing both groups' pre-and post-testing, the difference in BW values was evaluated as very small (dpre=0.055, dpost=0.116).

Table 10. Comparison of pre and post-testing groups MICT and HIIT.

	MICT x HIIT d
BMI_pre	0.164
BMI_post	0.260
PBF_pre	0.410
PBF_post	0.670
BW_pre	0.055
BW_post	0.116
BF_pre	0.260
BF_post	0.449
MM_pre	0.134
MM_post	0.225

Legend: d- Cohen´s d, BMI-Body Mass Index, PBF- Percentage of Body Fat, BW- Body Weight, BF- Body Fat, MM- Muscle Mass.

Physical activity had a significantly higher effect when comparing both training groups on the percentage of body fat (PBF) at the post-test, where the value of Cohen's d gives the difference in the type of exercise as a medium effect (d=0.672).

DISCUSSION

The study aimed to compare the effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on body composition in adult women active in sports. The results show that the changes that have occurred are mostly insignificant. The only exception showing statistically significant change was the amount of muscle mass in women participating in HIIT training. Even though the individual training units were physically quite demanding (especially in HIIT), it is interesting that in some cases, there was an increase in total body fat recorded, even though the opposite was expected. The predicted phenomenon of the HIIT intervention was the reduction of total body fat and adding skeletal muscles. This occurred in 5 of the seven tested subjects. In the case of MICT, there was a drop in total body fat without increasing muscle mass in two cases. In the other two cases, there was an increase in total muscle mass and loss of total body fat recorded.

Excess body weight and obesity have become a serious global threat to all generations. Optimal cardiovascular physical activity – fitness is considered a protective factor, decreasing the risk of chronic diseases, mainly cardiovascular illnesses. According to the American Global survey by the Fitness College of Sports Medicine Trendy 2019, which focused on High-intensity training, HIIT was the most significant fitness trend from 2014 to 2018 (Scoubeau et al., 2022). Studies indicate that a higher intensity of exercise could be an effective alternative to improving cardiorespiratory functions and body composition by decreasing the amount of stored body fat. Therefore, finding an effective means to motivate the general public to exercise is crucial. The general public tends to be less active and, therefore, is susceptible to diseases connected to having higher amounts of body fat (Alves et al., 2021). Rossi et al. (2021) claim their studies describe HIIT as a more effective means to reduce body fat storage compared to endurance training of medium intensity. Despite that, a recent

meta-analysis did not show any better results of HIIT on body fat reduction compared to medium-intensity continual training (Andreato et al., 2019; Keating et al., 2017; Sultana et al., 2019). Because of this, it is appropriate to continue to study and debate this topic. Including more variables that could impact body mass management in future studies, such as energy input and output, would be beneficial. Chao L. et al. (2022) also confirm changes in values of body composition. After the 8-week intervention program, there was an increase in muscle mass and a decrease in body fat percentage in both tested groups. A MICT group also showed positive changes in the amount of total fat and the visceral fat area. Our findings differ from the previous studies. The probable cause could be characteristics of the subjects. In the studies, a significant group of the subjects were untrained adults with excessive body weight or obesity. In our case, most subjects were already trained and used to frequent exercise. More studies are required to describe the mechanism. In his study, De Oliveira et al. (2020) stated that HIIT training protocols have similar effects on the human body as the MICT protocols in adults with sedentary lifestyles. In addition, the effects of HIIT rarely affect body composition or critical proteins related to muscle mass gain. Similar findings were described in the systematic overview and meta-analysis of Wewege et al. (2017), which studied the effects of a moderate-intensity continuous exercise program together with a high-intensity interval training program on fat mass in sedentary individuals, with the conclusion that both exercise programs have similar effects on fat mass. Likewise, a study by Keating S.E. et al. (2014) compared HIIT with MICT. During the first week, the intensity ranged from 30 minutes at 50% VO2 max. to 45 minutes at 65% VO2 max three times per week (total 108-114 minutes per week). After 12 weeks, there was no significant change in total weight ($p = 0.30$), but fat loss was statistically significant ($p < 0.05$) for both continuous training (-2.6%) and HIIT (-0.3%). Visceral fat loss was also highly significant ($p < 0,01$). On the other hand, the study of Heinrich, K.M. et al. (2014) did not register any effect of HIIT and MICT on BMI and body mass even after an 8-week intervention, which was carried out 3 times a week. An 8-week study was conducted in Iran, where the intervention group did MICT three times a week (50 minutes). The intensity was in the range of 60-85 % MTF (maximum heart rate). The final measurements and statistical analysis show that body fat and waist circumference decreased ($p < 0,05$). The control group, which did not train at all, showed no significant changes Rastegar et al. (2014). The research of Willis et al. (2012) laboratory compared three training groups, where one did aerobic training. There were both fat loss and body mass loss recorded in this group. D'aleva et al. (2023) state that HIIT and a combination of HIIT with MICT training improved anthropometry and cardiovascular parameters and the rate of fat oxidation to a similar extent. However, the combination of both the combined interval training and moderate-intensity continuous exercise was less intense than HIIT. Study has shown that the combination of low-volume HIIT with high-volume moderate-intensity training is an effective way to improve fat oxidation, metabolic rate, and body composition in obese individuals. In most cases, the authors agree on the positive effect of MICT and HIIT on fat loss. However, they do not concern themselves with increasing or maintaining muscle mass. In addition, HIIT can improve body composition and aerobic capacity (Adimi et al., 2022).

CONCLUSION

To conclude, comparing the effects of these types of training is quite relevant due to the achieved results. A limiting factor for the possibility of generalizing the results to a broader population is the small number of participants and their deliberate selection for this part of the research. Despite the small sample of women tested, better results were achieved in the HIIT intervention program, especially concerning body fat percentage (d=0,670). Here, the expected changes occurred in 5 subjects, in the MICT program, only in 4 subjects. An important argument for this statement is also the fact that there was an increase in body fat in three women attending the MICT program.

Intervention programs are known for their demands on the time of subjects, who, despite their busyness, try to regularly participate in the prepared program. However, from the data collected, it cannot be assessed if the positive impact of HIIT is more significant on body composition than MICT. In order to continue the research, it is necessary to obtain a more extensive test group and consider diet, preparation, and motivation, which could have influenced the results to an extent. It should be noted that although some individuals cannot or will not undergo this type of high-intensity exercise, the flexible nature of HIIT protocols (intensity, duration, effort, rest period, volume, modality, etc.) allows moderation of the training to their preferences and abilities. Due to the appropriate knowledge of this type of training, sports professionals who work with insufficiently active or overweight people can currently use HIIT modified with MICT aimed at fat loss, decreasing BMI, or improving energy balance.

According to the systematic reviews and meta-analyses (Andreato et al., 2019; Keating et al.; Rossi et al., 2022; Scoubeau et al., 2022; Sultana et al., 2019; Wewege et al., 2017;), it can be claimed that both MICT and HIIT improve body weight and body composition in adults, not only overweight or obese. Benefits of exercise include reduction of mass, weight, total body fat, and visceral fat tissue. Even though the effect on weight and fat loss is relatively small, reducing visceral fat is probably related to improving cardiometabolic health in these individuals. It is important to add that loss of visceral fat can occur even if the participants experience little or no weight loss. HIIT allows the general population to adapt to their abilities and preferences (Neves et al., 2023). Thus, we can argue that HIIT provides beneficial changes for public health.

REFERENCES:

Adimi, S., Azarbayjani, M. A., Naderi, N., & Alizadehasl, A. (2022). Effects of 12 Weeks of Aerobic Exercise (High-Intensity Interval Training or Moderate Intensity Continuous Training) with and without Blood Flow Restriction on Anthropometric Indices in Women with Cardiotoxicity after Breast Cancer Treatment. *Iranian Journal of Breast Diseases*, *15*(2), 18-35.

Alves, A. R., Marinho, D. A., Pecêgo, M., Ferraz, R., Marques, M. C., & Neiva, H. P. (2021). Strength training combined with high-intensity interval aerobic training in young adults' body composition. *Trends in Sport Sciences, 28*(3), 187-193. doi:10.23829/TSS.2021.28.3-3

Amaro-Gahete, F. J., De-la-O, A., Jurado-Fasoli, L., Ruiz, J. R., Castillo, M. J., & Gutierrez, A. (2019). Effects of different exercise training programs on body composition: A randomized control trial. *Scandinavian journal of medicine & science in sports*, *29*(7), 968-979.

Andreato, L. V., Esteves, J. V., Coimbra, D. R., Moraes, A. J. P., & De Carvalho, T. (2019). The influence of high-intensity interval training on anthropometric variables of adults with overweight or obesity: a systematic review and network meta-analysis. *Obesity Reviews*, *20*(1), 142-155.

Bernacíková, M., Cacek, J., & Dovrtělová, L. (2020). Regeneration and nutrition in sports. Masaryk University.

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., ... & Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behavior. *British journal of sports medicine*, *54*(24), 1451-1462.

Cacek, J., Grasgruber, P., & Hlavoňová, D. (2014). Selected aspects of the fitness of the adult population of the Czech Republic. Masaryk University.

D'Alleva, M., Vaccari, F., Graniero, F., Giovanelli, N., Floreani, M., Fiori, F., ... & Lazzer, S. (2023). Effects of 12-week combined training versus high-intensity interval training on cardiorespiratory fitness, body composition, and fat metabolism in obese male adults. *Journal of Exercise Science & Fitness*, *21*(2), 193-201.

De Feo, P. (2013). *Is high-intensity exercise better than moderate-intensity exercise for weight loss?* Nutrition, Metabolism & Cardiovascular Diseases (2013) 23, 1037-1042.

Geliebter, A., Maher M. M., Gerace, L., Gutin, B., Heymsfield, S., B., Hashim, S. (1997). *Effects of strength or aerobic training on body composition, resting metabolic rate, and peak oxygen consumption in obese dieting subjects.* The American Journal of Clinical Nutrition 66:557-63.

Heinrich, K.M., Patel, P.M., O'Neal, J.L. & Heinrich, B.S. (2014). *High-intensity compared to moderate-intensity training for exercise initiation, enjoyment, adherence, and intentions: an intervention study*. BMC Public Health, 14: 789.

Keating, S.E., Machan, E.A., O'Connor, H.T., Gerofi, J.A., Sainsbury, A., Caterson, I.D. & Johnson N.A. (2014). *Continuous Exercise but Not High Intensity Interval Training Improves Fat Distribution in Overweight Adults.* Journal of Obesity (2014).

Keating, S. E., Johnson, N. A., Mielke, G. I., & Coombes, J. S. (2017). A systematic review and meta-analysis of interval training versus moderate-intensity continuous training on body adiposity. *Obesity reviews*, *18*(8), 943-964.

Lan, C., Liu, Y., & Wang, Y. (2022). Effects of different exercise programs on cardiorespiratory fitness and body composition in college students. *Journal of Exercise Science and Fitness, 20*(1), 62-69. doi:10.1016/j.jesf.2021.12.004

Laskowski, E.R. (2012). *The Role of Exercise in the Treatment of Obesity.* The American Academy of Physical Medicine and Rehabilitation, 4, 840-844.

Máček, M., & Máčková, J. (2011). Comparison of the effectiveness of continuous, interval or cumulative training. For practice Voráčová, H., Šafářová, M.: Kneeling with palm support – a new test of postural stabilization. 31 Selected topics of postgraduate education Máček, M., Máčková, J.: Comparison of the effectiveness of continuous, interval or cumulative training 39 Personal reports, 39.

Neves, L. N. S., Gasparini-Neto, V. H., Leite, R. D., & Carletti, L. (2023). Acute Cardiopulmonary Response of High-Intensity Interval Training with Elastic Resistance vs. High-Intensity Interval Training on a Treadmill in Healthy Adults. *International Journal of Environmental Research and Public Health*, *20*(12), 6061.

Novotný, J., & Novotná, M. (2008). Physiological principles of training and tests of runners. Athletics, 60(11), 1-8.

de Oliveira França, G., Frantz, E. D. C., Bargut, T. C. L., Sepúlveda-Fragoso, V., Silvares, R. R., Daliry, A., ... & Borges, J. P. (2020). Effects of short-term high-intensity interval and continuous exercise training on body composition and cardiac function in obese sarcopenic rats. *Life Sciences*, *256*, 117920.

Rastegar, H., Zahra, H., Mehry, H. (2014). *Effects of aerobic exercise training on body composition and metabolic syndrome factors in obese male college student.* Biology of Exercise, 10.2, 57-68.

Rossi, P. A. Q., Panissa, V. L. G., Silveira, R., Takito, M. Y., Lima, F. S., Rossi, F. E., & Franchini, E. (2022). Post-exercise energy intake: do the intensity and mode of exercise matter? A systematic review and meta-analysis comparing high-intensity interval with moderate-intensity continuous protocols. *European Journal of Clinical Nutrition*, *76*(7), 929-942.

Sanal, E., Ardic, F., Kirac, S. (2013). *Effects of aerobic or combined aerobic resistance exercise on body composition in overweight and obese adults: gender differences. A randomized intervention study*. European Journal of Physical and Rehabilitation Medicine, 49, 1-11.

Scoubeau, C., Bonnechère, B., Cnop, M., Faoro, V., & Klass, M. (2022). Effectiveness of Whole-Body High-Intensity Interval Training on Health-Related Fitness: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health*, *19*(15), 9559.

Stevenson, R. (2009) Cardio training. *Fitness Management* [online]. 25(1), 42-49.

Sultana, R. N., Sabag, A., Keating, S. E., & Johnson, N. A. (2019). The effect of low-volume high-intensity interval training on body composition and cardiorespiratory fitness: a systematic review and meta-analysis. *Sports Medicine*, *49*, 1687-1721.

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology*, *37*(1), 153–156. https://doi.org/10.1016/s0735-1097(00)01054-8

Wewege, M., Van Den Berg, R., Ward, R. E., & Keech, A. (2017). The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis. *Obesity Reviews*, *18*(6), 635-646.

Willis, L., Slentz, C., Bateman, L., Shields, A.T., Piner, L., Bales, C., Kraus, W. (2012). *Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults.* Journal of Applied Physiology. 133, 6, 1831-1838.

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