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Effects of Long and Sprint High-Intensity Interval Training on Body Mass Composition, Aerobic Capacity, and Biochemical Markers of Metabolic Syndrome and Liver Damage in Physical Activity Practitioners Adults

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SUMMARY

Background. Highlights High-Intensity Long Interval Training (HILIT) and Sprint Interval Training (SIT) to morpho functional improvement and reduce effects of Metabolic Associated Fatty Liver Disease (MAFLD) and the Metabolic Syndrome (MS).
Objective. This study aims to verify the effects of HILIT and SIT on physiological and pathological markers of MS and liver health in adults submitted to 12 weeks of training.
Methods. A randomized clinical trial was carried out with a design for two groups, HILIT and SIT Groups. The sample consisted of 38 physical activity practitioners male adults aged between 30 and 55 years (42.75 ± 8.26). Body composition assessments, cardiac stress tests, measurements of blood pressure (BP), and blood samples were analyzed: triglycerides (TRIG), high-density lipoprotein (HDL-C) and glucose (GLU) and liver damage: Albumin (ALB), Bilirubin (BIL), Aspartate Aminotransferase (AST), Alamine Aminotransferase (ALT), Gamma Glutamyl Transferase (GGT).
Results. For HILIT there was a significant intragroup improvement in the parameters of fat mass, lean mass, body mass index (BMI), visceral adipose fat (VAT), GLU, ALB, Direct Bilirubin (DB), distance run, and oxygen consumption (VO2). For SIT there was a significant intragroup improvement in the parameters of VAT, GLU, ALB, DB, GGT, and distance run. There was a significant difference in the intergroup comparison only for BP in favor of the SIT group.
Conclusions. We conclude that 12 weeks of HILIT and SIT interval training were able to produce positive effects on body composition variables, aerobic capacity, Metabolic Syndrome, and Liver Health in physical activity practitioners adult men, with better results for HILIT in this population.

KEY WORDS

Metabolic syndrome; metabolic associated fatty liver disease; high-intensity long interval training; sprint interval training; training impulse.

INTRODUCTION

High-Intensity Interval Training (HIIT) is characterized by short, intermittent exercises of vigorous activity interspersed with periods of passive or active recovery (1, 2). It is considered an efficient alternative to improve conditioning and reduce overweight and obesity (3). Due to the excellent adherence of HIIT in society, the experiment focuses on High-Intensity Long Interval Training (HILIT) and Sprint Interval Training (SIT) (4, 5).

HILIT is proposed in the running modality on flat ground with sprints over 1 minute considered long duration with power or speed between the second ventilatory threshold and maximum oxygen consumption (VO_2max) (4,5). About SIT method is also in the running modality on flat terrain. It is performed with sprints lasting less than 1 minute and with a power or speed above those associated with VO_2max (4, 5).

Several studies indicate that running appears to be more effective in reducing total fat mass, including visceral adipose tissue (VAT). However, there are not many studies carried out outdoors using an athletics track, which would encourage the applicability of the method (6, 7).

In the context of prescribing the intervention, based on the variables obtained in the cardiac stress test, it was decided to use Banister's Training Impulse (TRIMP) formula, dimensioning the training in the intervention sessions in a balanced way (8).

Le Jemtel *et al.* (9) showed HIIT as a method to reverse visceral adipose tissue, reducing cardiovascular risk and improving body composition. In the same direction, other training methods studied such as resistance training, aerobic training and combined exercises aimed Metabolic Syndrome (MS). Liang *et al.* (10) suggested that combined exercise is the most effective choice in improving the MS and cardiovascular risk parameters, whereas aerobic exercise reveals the minimum effect. These studies suggest health beneficial effects as body composition, aerobic capacity, lean mass, and blood biomarkers.

Zhou *et al.* (11) suggest positive effects on the liver health using aerobic training, resistance training, and aerobic training with resistance training. Therefore, the HILIT and SIT methods will be investigated to improve body composition, improve VO_2 capacity and reduce MS and liver markers. Through HILIT and SIT, the aim is to reduce risk factors for MS and Metabolic Associated Fatty Liver Disease (MAFLD).

MS is a major challenge for global public health, with important risk factors for cardiovascular diseases (CVD) and type 2 diabetes (DMT2) (12). Diagnosed in the presence of three of the five metabolic measurements: waist circumference (WC) > 90 cm, triglycerides (TRIG) > 100 mg/dL, HDL-C < 40 mg/dL, systolic blood pressure (SBP) > 130 and/or diastolic blood pressure (DBP) > 85 mmHg and glucose (GLU) > 150 mg/dL (13). In Brazil the prevalence of MS is 38.4% with emphasis on increased WC (65.5%) and low HDL cholesterol (49.4%) as the most prevalent components, including in young individuals (14).

MAFLD is the hepatic expression of MS with a diagnosis of fatty liver by histology (biopsy), imaging or blood biomarker, in addition to at least one of the three dangerous criteria of overweight or obesity, the presence of DMT2 or evidence of metabolic dysregulation (15, 16).

This study is justified by the gap in the literature in knowing the effects of High-intensity interval training on long and sprint variations in individuals at risk of developing metabolic syndrome and liver disease. This type of intervention can reduce or even regress this pathological condition. The general hypothesis of this study is that HILIT and SIT can improve the health of physical activity practitioners adults.

Therefore, this study aimed to verify the effects of long and sprint high-intensity interval training on body mass composition, aerobic capacity, and biochemical markers of metabolic syndrome and liver damage in physical activity practitioners adults undergoing 12 weeks of training.

MATERIALS AND METHODS

Design

This is experimental research with a design for two groups that will be evaluated pre-intervention and post-intervention period (17).

Participants

The sample was made up of 38 physical activity practitioners adult men Army soldiers from a military music band, between 30 and 55 years old. The sample size calculation indicated by the GPower program was estimated at 36 individuals (18), using the following information: ANOVA with repeated measures, effect size of 0.25, alpha error of 0.05, power of the experiment of 0.80 and correlation between measurements of 0.5 for two groups at two measurement times (19). The following inclusion criteria were adopted: 1) male, 2) military personnel belonging to military music bands, 3) submitted to a dietary recall and meals in the headquarters barracks (20). The exclusion criteria involved: 1) military personnel who underwent any type of abdominal surgery, with some type of osteoarticular or musculoskeletal injury and other clinical conditions that prevented them from carrying out training or any of the assessments, which limited movements or undergoing restrictive medical treatments, 2) military personnel who were using any substance or drug capable of altering test results, 3) who were unable to attend all stages of data collection or considered physically unfit by a prior medical assessment, mainly assessment of cardiopulmonary health. After the sampling process the participants were randomly distributed into two groups HILIT and SIT (**figure 1**) using the random function of the Excel software.

All 38 individuals agreed to participate in the present study and signed the Informed Consent Form (ICF), respecting the ethical aspects of research involving human beings in resolution 466/12 of the National Health Council, at which time it was clarified to them that their identities would be preserved, in accordance with the ethical standards provided. The study was also submitted to an ethics and research committee (ERC) through the Brazil platform with approval from the ERC of the Army Physical Training Center under registration CAAE: 52772121.3.0000.9433 – Date of approval: May 27, 2022.

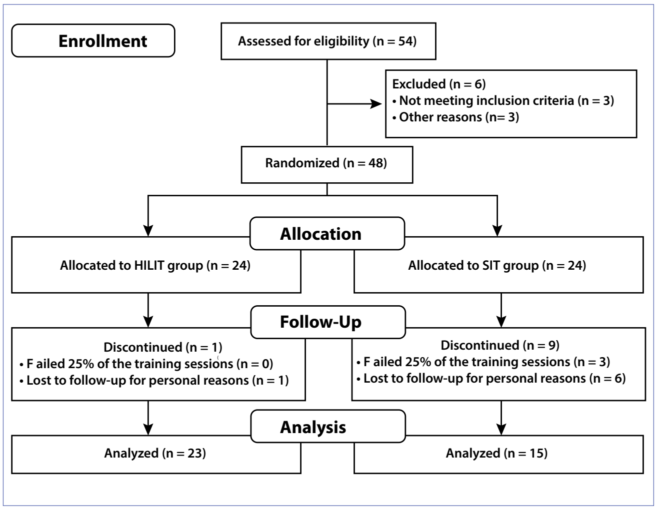

Figure 1. Study random process

Study organization

Participants were evaluated at two different moments with a 12-week interval between them (**figure 2**). At first, each participant underwent body composition assessment using the dual-emission X-ray absorptiometry device (DXA) and a biochemical blood test, followed by the cardiac exercise test (CET) to assess aerobic capacity. In the second moment, the volunteers were randomized and divided into two groups, a HILIT group and a SIT group, carried out a planned 12-week intervention, being prescribed in an equalized way according to the TRIMP equation proposed by Banister, the groups carried out running training in athletics track or football field and it was common in the training session, for both groups, the warm-up and the 10 exercises for neuromuscular strengthening of the CORE, being the differentiating factor to the specific prescription of HILIT and SIT. In the third moment, the pre-tests carried out in the first moment were all repeated (DXA, biochemical and CST).

All tests, pre-experiment and post-experiment, were carried out at the Army Physical Training Center and the training sessions were carried out in a guided and assisted manner in the respective military organizations where the soldiers were based.

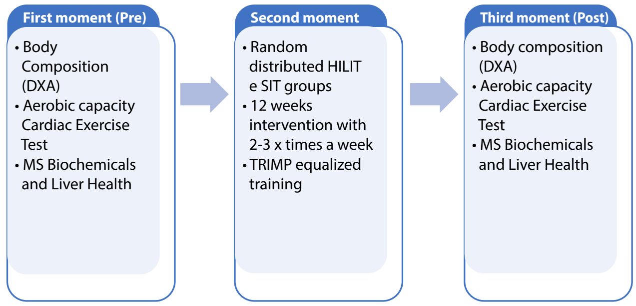

Figure 2. Flowchart study organization.

Data collection procedure

On the first visit, the study procedures were explained to everyone. The informed consent form (ICF) was completed, and the PAR-Q pre-exercise screening and anamnesis were carried out (21). The PAR-Q is a questionnaire composed of 7 questions with the aim of detecting possible risks when carrying out any physical activity. If the response was positive, the individual was advised not to carry out the activity and was suggested to undergo a medical evaluation (21).

Participants then underwent 12 weeks of specific HILIT and SIT intervention for each group and finally a new data collection of all study variables.

Nutrition

Before the start of the experiment, lectures were given to volunteers about nutritional guidance and healthy eating. There was no proposed diet for the experiment and nutritional control was carried out through dietary recall, where three meals were eaten in the headquarters barracks (20).

The procedures for planning and conducting the nutritional guidance lectures and their respective analyzes were conducted pre-intervention by the nutritionist from the Army Physical Training Research Institute (APTRI) in Rio de Janeiro, RJ.

Body composition

Body composition is assessed using a DXA (GE Healthcare, Madison, WI, USA) in measurements of total mass, lean mass, fat mass, visceral adipose tissue (VAT) (22).

The DXA evaluation procedures and their respective analyzes were carried out during an 8-hour fast, conducted by a team of qualified military professionals with laboratory experience, radiology technicians and doctors belonging to APTRI in Rio de Janeiro, RJ.

Aerobic capacity

VO2*max* aerobic fitness was indirectly assessed using a CET assisted by a cardiologist. The CET protocol was carried out on an Inbramed treadmill model ATL Super (Cascavel, Paraná, Brazil) using Heartware's ErgoMet13v1 0.3.6 software until the participant was exhausted, in progressive phases lasting 120 seconds and an initial speed of 4 km/h with an increment of 2 km/h and a constant inclination of 1%. The recovery phase was performed at a speed of 40% of the maximum speed reached for one minute to observe cardiopulmonary behavior returning to rest (23).

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) variables, heart rate during effort, maximum distance covered and estimated VO_2 achieved by each participant were measured (24).

The aerobic capacity assessment procedures and their respective analyzes were carried out by a cardiologist and an auxiliary team belonging to APTRI in Rio de Janeiro, RJ.

Blood collection

Blood collections were conducted to evaluate the biochemical markers of MS (25) of liver damage (26): GLU, HDL-C, LDL-C, TRIG, AST, ALT, GGT, ALB and BIL. Blood samples (14 ml) from the individuals were collected via the antecubital vein, with the individuals remaining in a sitting position. Immediately after collection, the blood was centrifuged, and the plasma or serum was frozen and stored at -80 °C for subsequent analysis of clinical biomarkers in the APTRI Exercise Biochemistry laboratory. After the pre-analytical procedures, the BT 3000 automated biochemical analyzer, manufactured by the Wiener Lab Company (Wiener Lab, Rosário, BA, Argentina) was used. All biochemical marker tests were duplicated, and the coefficient of variation (CV) was less than 3%.

The blood sample collection procedures and their respective analyzes were carried out by a team of pharmaceutical or biochemical professionals or a biochemistry technician with experience in the area at the APTRI Biochemistry Laboratory, Rio de Janeiro, RJ. All materials used in blood collection was disposable and followed the criteria for disposal of biological waste and sharps. After completing all blood sample analysis procedures, leftover laboratory samples containing blood were discarded in accordance with National Health Surveillance Agency (ANVISA) Legislation – RDC 306 of December 7th, 2004, which provides for technical regulations for waste management and health services.

Intervention

A 12-week longitudinal design was chosen to prescribe the HILIT and SIT intervention with two to three running sessions were conducted per week and total training session time ranged from 27 to 50 minutes (**table I**) (27), using the running modality, which was based on individualized aerobic capacity data obtained by the CET.

The exercise sessions were conducted by a physical education professional, holder of the Army Physical Education School Course or a degree in Physical Education.

The first two weeks of intervention, to minimize musculoskeletal injuries and consequent sample loss, involved adaptation to high-intensity training, where the volume was reduced to 50% based on the calculation of the prescribed

Table I. High-intensity training session.

Item	Content	Time (min)
Dynamic warm up	2 - 3 min light running; and 9 (nine) localized effects exercises in movement.	6-8
Pentagon	10 (ten) exercises, being dynamic and calisthenics with their load based on number of repetitions and execution time; and 5 (five) exercises for CORE region.	8-10
HILIT or SIT	HILIT: 2 - 12 shots of 80 to 90% HRmax lasting 60 to 120 seconds, with active interval at 50% HRmax lasting 60 to 120 seconds; and SIT: 1 to 8 sprints shots at 160% vVO2max with an effort time of 10 to 20 seconds and also a 4 minutes active interval at 50% HRmax between each shot.	8-27
Calm down	Stretching and relaxation exercises involving the joints and muscles involved in the proposed intervention.	5
	Total time of training session	27-50

HILIT: High-Intensity Long Interval Training; SIT: Sprint Interval Training; min: minute; CORE: body center; HR*max*: Maximum Heart Rate; vVO_2max: maximum speed reached at the moment of maximum oxygen consumption.

training, aiming for better neuromuscular adaptation. From the 3rd week until the 12th week, once adaptation to training has been made, we follow the proposal of 100% prescription volume of the individualized intervention.

The training session was composed based on the Brazilian Army (EB) doctrine prescription, for both groups and in a centralized way, consisting of a dynamic warm-up, a series of calisthenic exercises and exercises from the CORE called Pentagon, and of HILIT or SIT session (randomized groups) and after that the calm down session (28).

The dynamic warm-up aimed to improve performance, increase body temperature, muscle extensibility and increase heart rate, consisting of a light intensity run of 2 to 3 minutes and subsequently with 9 (nine) exercises with localized effects in movement, like: running with rotation of the arms, abduction and adduction of the arms horizontally, alternating extension of the arms vertically, jumping jacks, running with trunk twisting, lateral running, running with extending the leg forward, running with elevating the heels and running with knee elevation (28).

After the end of the warm-up, with the purpose of complementing and maintaining the common physical standards required of Brazilian Army personnel, Pentagon calisthenics training was carried out, consisting of 10 exercises that include exercises for the upper and lower limbs and the CORE region (oblique abdominal , rectus abdominis and lumbar region), being dynamic and calisthenics with their load based on number of repetitions and execution time: 30 (thirty) jumping jacks, 5 (five) vertical jump lunges, 10 (ten) lunge squats, stationary running with raising the knees and heels (coordination), and 15 (fifteen) seconds of 5 (five) exercises for the CORE region: isometric bipedal bridge, front plank, triangle with arm support (side plank), single-leg reverse support, abdominal supra, ankle proprioception (28, 29).

HILIT was prescribed in the zone of 80 to 90% of HR*max* with shots lasting 60 to 120 seconds, in an active interval at 50% HR*max* lasting 60 to 120 seconds on athletics track with monthly training monitoring using First Beat software for load monitoring and load adjustment (4, 5).

In the same way, SIT prescribed the intervention based on individualized VO_2max data from the CET, to calculate the maximum speed of maximum oxygen uptake (vVO_2max). SIT protocol ranged from 1 to 8 short sprints at 160% vVO_2max with a shots time of 10 to 20 seconds in duration and a 4-minute active interval at 50% HR*max* between sprints, in running mode on athletics track with monthly training monitoring with First Beat software for monitoring and adjusting the load (4, 5, 30).

Previously, the experimental phase of training, with the aim of better controlling and adjusting workloads during the experiment, was calculated based on the participant's individual CET result, accounting for data on HR*max*, exertional heart rate (EHR), frequency resting heart rate (RHR) and the execution time of high-intensity training and its intervals that resulted in a number of arbitrary units (AU) of Training Impulse measurement (TRIMP) proposed by Banister with the formula (**figure 3**) (31).

After the randomized division of groups into HILIT and SIT, applying the TRIMP formula, the average TRIMP UA of each group was calculated for comparison and equalization of training, resulting in HILIT and SIT groups with balanced TRIMP UA providing a comparison more isonomic of the effort expended in the training session between the intervention groups (32).

TRIMP BANISTER:

Females:

$$TRIMP = T \times \left[(HR_{ex}-HR_{rest})/(HR_{max}-HR_{rest})\right] \times 0.86e^{1.672\left[(HR_{ex}-HR_{rest})/(HR_{max}-HR_{rest})\right]}$$

Males:

$$TRIMP = T \times \left[(HR_{ex}-HR_{rest})/(HR_{max}-HR_{rest})\right] \times 0.64e^{1.92\left[(HR_{ex}-HR_{rest})/(HR_{max}-HR_{rest})\right]}$$

T: exercise duration (minutes); HR*ex*: average heart rate during exercise; HR*rest*: *resting heart rate; and HRmax: maximal heart rate.*

Figure 3. TRIMP formula proposed by Banister.

Data analysis

The data were analyzed using the IBM SPSS Statistics 25 for Windows program and presented as mean and standard deviation. The normality and sphericity of the sample data were analyzed using the Shapiro-Wilk and Bartlett tests, respectively. To determine the effect of the independent variables (HILIT and SIT training) on the outcome variables (Biochemical tests, body composition and TEC), an ANOVA with repeated measures (2 × 2) was performed, followed by the adjusted Bonferroni *post-hoc*, for the comparison of the study's dependent variables and between the assessments of the independent variables arising from the HILIT and SIT groups (33). Cohen's effect size (d) was calculated to analyze the clinical impact of the different interventions on the study variables and interpreted according to the following correlation standardization: 0 to 0.2 weak; 0.3 to 0.7 moderate; and equal or above 0.8 strong. The value of $p < 0.05$ was adopted for statistical significance (34).

RESULTS

Table II presents the characterization of the sample by groups, in mean and standard deviation values regarding height, age, total body mass and BMI. Student's t test for independent samples showed that the groups were similar at the beginning of the study, as there was no difference ($p > 0.05$) between the variables analyzed (33).

In **table III**, the average values of the data obtained in the assessment of body composition by DXA were analyzed. In the intragroup comparison of HILIT there was a significant reduction in the variables of fat mass, BMI and VAT, and there was also a significant increase in lean mass after 12 weeks of training. In the SIT group, a significant reduction in TAV was only found.

In **table IV**, the average values of the data obtained in the assessment of aerobic capacity by CET were analyzed. After 12 weeks of training, in the HILIT group there was an improvement in the aerobic capacity variables (distance covered and VO_2) and in the SIT group there was only an increase in the distance covered variable. There was an improvement in the intergroup comparison for the DBP variable.

In **table V**, the average values of the data obtained in the biochemical evaluations of the blood were analyzed. In the intergroup comparison, there was a significant reduction in the variables of GLU, ALB, DB for the HILIT group and for the SIT group there was a significant reduction in the variables of GLU, ALB, DB and GGT.

In **table VI**, the average values of the data obtained in the MS assessment were analyzed. Although there was no significant improvement in the analysis of the categorical variable metabolic syndrome, there was a percentage reduction from 39.1% to 17.4% of people with the disease in the HILIT group and 6.6% in the SIT group, as well as a reduction in the means in the GLU variables in intragroup comparisons in both groups and in the SBP variable in the intergroup interaction.

Table II. Basic characteristics of participants.

	HILIT (n = 23)	SIT (n = 15)	P-value
Height (m)	1.72 ± 6.39	1.74 ± 7.63	0.986
Age (years)	42.75 ± 8.26	38.88 ± 6.35	0.100
TBM (kg)	84.15 ± 15.56	83.89 ± 14.10	0.236
BMI (kg/m²)	28.46 ± 4.25	27.48 ± 3.67	0.154

TBM: Total Body Mass; BMI: Body Mass Index.

Table III. Analysis of body composition between groups HILIT e SIT.

Variable	Group	Mean pre ± SD	Mean post ± SD	Δ%	d	P-value*	P-value†
Fat Mass (kg)	HILIT	25.74 ± 8.81	24.36 ± 8.40	-5.38	-0.16	**0.002**	0.610
	SIT	23.61 ± 8.40	22.94 ± 8.12	-2.81	-0.08	0.205	
Lean Mass (kg)	HILIT	55.45 ± 8.42	56.04 ± 8.43	1.06	0.07	**0.002**	0.565
	SIT	57.15 ± 7.31	57.59 ± 7.42	0.77	0.06	0.052	
WC (cm)	HILIT	93.33 ± 10.59	92.55 ± 9.84	-0.83	-0.07	0.251	0.701
	SIT	92.19 ± 8.73	91.35 ± 8.41	-0.91	-0.10	0.316	
BMI (kg/m²)	HILIT	28.47 ± 4.25	28.14 ± 4.03	-1.16	-0.08	**0.046**	0.548
	SIT	27.48 ± 3.66	27.36 ± 3.62	-0.44	-0.03	0.548	
VAT (g)	HILIT	1,358.00 ± 684.53	1,251.61 ± 653.65	-7.83	-0.16	**0.013**	0.120
	SIT	1,044.13 ± 566.53	941.60 ± 462.42	-9.82	-0.18	**0.048**	

*$p < 0.05$; pre *vs* post; †$p < 0.05$; HILIT post *vs* post SIT; d: effect size (Cohen); SD: Standard Deviation; BMI: Body Mass Index; WC: Waist Circumference; VAT: Visceral Adipose Tissue.

Table IV. Analysis of aerobic capacity between groups HILIT e SIT.

Variable	Group	Mean pre ± SD	Mean post ± SD	Δ%	d	P-value*	P-value†
Distance (m)	HILIT	1321.78 ± 415.98	1424.00 ± 417.56	7.73	0.25	**0.005**	0.177
	SIT	1491.33 ± 378.24	1607.87 ± 376.08	7.81	0.31	**0.009**	
VO_2 (mL/kg·min)	HILIT	44.59 ± 6.78	47.02 ± 6.66	5.46	0.36	**0.002**	0.155
	SIT	49.23 ± 5.20	50.17 ± 6.30	1.90	0.18	0.307	
SBP Rest (mmHg)	HILIT	122.00 ± 15.79	116.00 ± 11.52	-4.92	-0.38	0.051	0.356
	SIT	115.73 ± 16.21	112.40 ± 11.72	-2.88	-0.21	0.371	
DBP Rest (mmHg)	HILIT	78.35 ± 10.73	78.87 ± 10.73	0.66	0.05	0.804	**< 0.001**
	SIT	70.40 ± 7.53	67.47 ± 7.07	-4.16	-0.39	0.265	

*p < 0.05, pre *vs* post; †p < 0.05; HILIT post *vs* post SIT; d: effect size (Cohen); SD: Standard Deviation; VO_2: Oxygen Consumed; SBP Rest: Resting Systolic Blood Pressure; DBP Rest: Resting Diastolic Blood Pressure.

Table V. Biochemical blood analysis between groups HILIT e SIT.

Variable	Group	Mean pre ± SD	Mean post ± SD	Δ%	d	P-value*	P-value†
TRIG (mg/dl)	HILIT	135.96 ± 74.91	126.30 ± 87.60	-7.10	-0.13	0.431	0.270
	SIT	95.73 ± 30.61	98.13 ± 51.76	2.51	0.08	0.874	
HDL (mg/dl)	HILIT	51.43 ± 8.40	53.87 ± 11.67	4.73	0.29	0.193	0.957
	SIT	52.60 ± 8.02	54.07 ± 9.32	2.79	0.18	0.523	
GLU (mg/dl)	HILIT	99.52 ± 15.71	95.00 ± 17.54	-4.54	-0.29	**0.011**	0.160
	SIT	94.00 ± 8.12	88.20 ± 6.43	-6.17	-0.71	**0.009**	
ALB (g/dL)	HILIT	4.27 ± 0.15	3.89 ± 0.42	-9.05	-2.51	**< 0.001**	0.702
	SIT	4.23 ± 0.14	3.94 ± 0.41	-6.93	-2.10	**0.014**	
DB (mg/dl)	HILIT	0.13 ± 0.07	0.20 ± 0.10	56.16	0,95	**0,002**	0.853
	SIT	0.11 ± 0.09	0.20 ± 0.08	81.07	1.02	**0.001**	
TB (mg/dl)	HILIT	0.50 ± 0.31	0.57 ± 0.33	13.41	0.22	0.376	0.579
	SIT	0.58 ± 0.52	0.63 ± 0.29	7.94	0.09	0.622	
AST (U/L)	HILIT	25.35 ± 7.68	24.26 ± 9.15	-4.29	-0.14	0.624	0.475
	SIT	26.73 ± 13.13	22.00 ± 9.89	-17.71	-0.36	0.091	
ALT (U/L)	HILIT	30.83 ± 11.87	31.57 ± 14.57	2.40	0.06	0.740	0.587
	SIT	32.80 ± 31.95	28.33 ± 21.90	-13.62	-0.14	0.112	
GGT (U/L)	HILIT	35.35 ± 18.09	35.96 ± 15.61	1.72	0.03	0.807	0.512
	SIT	39.67 ± 35.73	31.73 ± 23.76	-20.00	-0.22	**0.014**	

*p < 0.05; pre *vs* post; †p < 0.05; HILIT post *vs* post SIT; d: effect size (Cohen); SD: Standard Deviation; TRIG: triglycerides; HDL: high-density lipoprotein; GLU: glucose; ALB: Albumin; DB: Direct Bilirubin; TB: Total Bilirubin; AST: Aspartate Aminotransferase; ALT: Alamine Aminotransferase; GGT: Gamma Glutamyl Transferase.

Table VI. Analysis of MS between groups HILIT e SIT.

Variable	Group	Mean pre ± SD	Mean post ± SD	Δ%	d	P-value*	P-value†
TRIG (mg/dl)	HILIT	135.96 ± 74.91	126.30 ± 87.60	-7.10	-0.13	0.431	0.270
	SIT	95.73 ± 30.61	98.13 ± 51.76	2.51	0.08	0.874	
HDL (mg/dl)	HILIT	51.43 ± 8.40	53.87 ± 11.67	4.73	0.29	0.193	0.957
	SIT	52.60 ± 8.02	54.07 ± 9.32	2.79	0.18	0.523	
GLU (mg/dl)	HILIT	99.52 ± 15.71	95.00 ± 17.54	-4.54	-0.29	**0.011**	0.160
	SIT	94.00 ± 8.12	88.20 ± 6.43	-6.17	-0.71	**0.009**	
WC (cm)	HILIT	93.33 ± 10.59	92.55 ± 9.84	-0.83	-0.07	0.251	0.701
	SIT	92.19 ± 8.73	91.35 ± 8.41	-0.91	-0.10	0.316	
SBP Rest (mmHg)	HILIT	122.00 ± 15.79	116.00 ± 11.52	-4.92	-0.38	0.051	0.356
	SIT	115.73 ± 16.21	112.40 ± 11.72	-2.88	-0.21	0.371	
DBP Rest (mmHg)	HILIT	78.35 ± 10.73	78.87 ± 10.73	0.66	0.05	0.804	**< 0.001**
	SIT	70.40 ± 7.53	67.47 ± 7.07	-4.16	-0.39	0.265	

*p < 0.05; pre *vs* post; †p < 0.05; HILIT post *vs* post SIT; d: effect size (Cohen); SD: Standard Deviation; triglycerides (TRIG); high-density lipoprotein (HDL); glucose (GLU); WC: Waist Circumference; SBP Rest: Resting Systolic Blood Pressure; DBP Rest: Resting Diastolic Blood Pressure.

DISCUSSION

This study, a randomized clinical trial, aimed to analyze the effects of long and sprint high-intensity interval training on body mass composition, aerobic capacity, and biochemical markers of metabolic syndrome and liver damage in physical activity practitioners adults undergoing 12 weeks of training. The data were discussed resulting from the statistical analysis of the crossing between the pre-test and post-test in the intragroup and intergroup conditions.

It was observed (**table II**) that there was a normal behavior of the statistical curve of the participants' basic characteristics, where the data on Total Body Mass (TBM) and the resulting mean BMI of the HILIT and SIT groups describe a mean of overweight sample (30 > BMI > 25). The groups were similar at the beginning of the study, with no difference between the variables analyzed (34).

Body composition was investigated in this study through DXA (35). In the intragroup comparison (**table III**) in the HILIT group there was a reduction in TBM, VAT and an increase in lean mass. Corroborating the present study, the work of systematic reviews and meta-analyses carried out by Bellicha *et al.* (36) analyzed 12 systematic reviews with meta-analysis that encompassed 149 evaluated studies, with adults over 18 years old, in a situation of obesity or overweight, which used HIIT exercise as an intervention, finding differences in VAT, with improvements in cardiometabolic health. Similarly, Taylor *et al.* (37), in a randomized controlled study with 38 adults performing a HIIT intervention and Continuous Moderate Intensity Training (CMIT), obtained significant results in reducing VAT.

In this way, the study by Irving *et al.* (38) investigated the effects of 16-week physical training intensity on abdominal VAT and body composition in 27 (51 ± 9 years) obese women with MS and reported that HIIT was more effective in reducing total abdominal fat, subcutaneous abdominal fat and VAT. Still about the body assessment, the reduction in VAT was identified (**table III**) in intragroup comparisons in both HILIT and SIT groups, with a mean difference of 1,358.00 ± 684.53 g to 1,251.61 ± 653.65 g for the HILIT group and 1,044.13 ± 566.53 g to 941.60 ± 462.42 g for the SIT group, which shows a significant reduction in body VAT behavior through training. Corroborating the present study, Khalafi *et al.* (39) in a systematic review with meta-analysis, where 10 studies investigated the effect of HIIT training on liver fat content in overweight or obese adults with metabolic disorders, observing VAT decrease which is directly correlated with the decrease in content fatty liver.

In addition, regarding the analysis of lean mass (**table III**), it was understood that in the HILIT group there was an increase that reflected in the difference in the average from 55.45 ± 8.41 kg to 56.04 ± 8.43 kg, indicating that the behavior of lean mass improved with training, reaching one of the most frequent objectives in exercise programs focused on health and aesthetics (40).

Especially, in the assessment of fat mass, there was a decrease (**table III**) in the HILIT group from 25.74 ± 8.81 kg to 24.36 ± 8.40 kg. This shows that body fat mass reduced with the proposed training, achieving another important objective of the study. It is important to highlight that the findings of reduction in fat mass (6, 7) and the increase in lean mass represented the definition of body recomposition resulting from a 12-week experiment without diet (40).

Comparatively, in the meta-analysis study by Maillard *et al.* (41), which evaluated 39 studies with 617 individuals with a mean age of 38.8 years ± 14.4, HIIT reduced total and abdominal fat mass and VAT, with no differences between the sexes. They also revealed that running was effective in reducing visceral and total fat mass and that HIIT above 90% of maximum heart rate was more successful than other intensities in reducing total body adiposity.

As a point to be highlighted, the equalization is strategic and combines elements of intensity and duration of training in the unique concept of training load, which in the present study was carried out using the Banister equation, demonstrating that TRIMP brought more equality of effort between groups for results achieved, which at first sight could mean a scientific result more coherent and definitive (4, 5, 32). In this sense, the systematic review study with meta-analysis by Andreato *et al.* (42) corroborates the need for equality between interventions who meta-analyzed 48 studies aiming to evaluate the influence of high-intensity interval training (HIIT) on the anthropometric variables of 1,222 adults of both sexes, aged between 18 and 65 years, overweight or obese. This study showed that HIIT was effective in reducing body mass, BMI, waist circumference, Wast-to-Hip Ratio (WHR), body fat percentage and VAT area, however, when considering studies with training equalization, the only difference that remained was for body mass reduction.

In turn, the study by Andreato *et al.* (42) presented interesting data regarding the different choices of exercise modalities, showing that 30 studies adopted cycling and 18 studies chose running/walking, 12 of which were on a treadmill, 4 on an indoor sports court, 1 study performed exercise outdoors. and 1 in a court, where a reduction in VAT was observed in none of them for equalized studies.

As another point to be highlighted, liver markers are used because they are cheaper, less invasive, easy to manage and have moderate diagnostic accuracy, providing a relevant perspective on liver disease, such as cell damage or inflammation (43). Santos *et al.* (44) pointed out that physical exercise with resistance training, aerobic training and HIIT interventions favored the reduction of biochemical markers (AST, ALT, GGT, ferritin, indirect bilirubin, and ALP), and showed a reduction in ALT in the exercise groups.

In the same direction, the ALB behavior (**table V**) consolidates the statement that there was no diet or ALB supplementation, as a marker for evaluating the nutritional status important for the body, serum albumin serves as a test of liver synthetic function. However, low serum albumin is not specific for liver disease and may occur in other conditions such as malnutrition, infections, nephrotic syndrome, or protein-losing enteropathy (45).

Specially about our findings regarding ALB, the averages were within the reference limits between 3.9 and 4.9 g/L, with results (**table V**) demonstrating that the HILIT exercise reduced the average by 4.27 ± 0.15 g/L to 3.89 ± 0.42 g/L and in the SIT group it decreased from 4.23±0.14 g/L to 3.94±0.41 g/L, depicting a decrease in their values, leaving a central average trend and approaching the lower value of the reference (46).

In addition, about GGT result were observed a significant reduction ($p < 0.05$) in SIT (**table V**), in the mean from 39.67 ± 35.73 U/L to 31.73 ± 23.76 U/L, although the means were within normal limits between 11 and 50 U/L (46), this demonstrates that exercise in the SIT modality produced an effect on improving hepatic metabolism of GGT, with beneficial effects on health. Increased serum GGT is a sensitive indicator of the presence of damage to the bile ducts or liver (45).

Subsequently in the analysis of TB, the stability of Indirect Bilirubin (IB) was verified, its increase refers to the increase in the function of DB, for both groups, which translates into an increase in the conjugation function of Bilirubin to its more soluble form, which correlates with the bile formation activities and intestinal function (45).

Furthermore, our study showed an increase in DB, being a specific phase of bilirubin in a more soluble format to later be transported to the bile to aid intestinal functions of absorption of fat and other substances. In the HILIT group it ranged from 0.13 ± 0.07 mg/dL to 0.20 ± 0.10 mg/dL and in the SIT group from 0.11 ± 0.09 mg/dL to 0.20 ±

0.08 mg /dL which is still within the normal limits established by hepatology (46). Such findings can be explained by the increase in physiological stress caused by exercise in the hemolysis process, leading to an increase in the conjugation function of Bilirubin (45).

As an important point to be highlighted, the study by Bellicha *et al.* (36) emphasized, in the same way as the present study, the use of CET in cardiovascular safety for prescription and initiation of high-intensity interval training. Also in the same direction as the present study and valuing cardiopulmonary assessment, the study by Mayorga *et al.* (47) meta-analyzed 123 studies examining the criterion validity of walking or running tests based on distance and time to estimate cardiorespiratory fitness among apparently healthy children and adults, providing strong evidence that cardiorespiratory fitness constitutes an important predictor of morbidity and mortality, being considered one of the most powerful health markers, with relevance over other traditional indicators, such as weight status, blood pressure or cholesterol level.

In another perspective, Taylor *et al.* (48), in a 12-month longitudinal study with one hundred adults with heart disease, corroborated the safety of using HIIT and the results of improvements in VO_2 peak due to the powerful exercise stimulus provided during high-intensity interval periods, believing that higher intensities invoke greater aerobic and cardiovascular adaptation than low to moderate intensities. There was no record of accidents during the pre, and post CET performed, and all participants completed the CET on a treadmill until exhaustion, with no cardiac anomaly that would contraindicate the participant.

In addition, the protocol used tested in a pilot study, estimated VO_2 (mL/kg × min) through an indirect test with good association with the Rating Perceived Exertion (RPE) presented by the study participants. Moreover, recent studies suggest the establishment an additional verification phase in the CET to obtain true VO_2 (49).

In particular about the distance reached assessment (**table IV**), there was an increase in the difference in the mean distance achieved in the CET protocol from 1,321.7 ± 415.98 m to 1,424.0 ± 417.56 m for HILIT group and for the SIT group, the increase was from 1,491.3 ± 378.24 m to 1,607.8 ± 376.07 m, which reveals that the behavior of the distance achieved in the CET improved the conditioning and running performance in both exercise groups. The improvement in the VO_2 variable the HILIT group 44.59 ± 6.78 to 47.02 ± 6.66 demonstrates a specific development of the running modality. In the same direction, Oliveira-Nunes *et al.* (50) in the meta-analysis study compared HIIT and SIT methodologies, they showed similar gains in cardiorespiratory fitness.

In the case of BMI result (**table III**), the HILIT group the average went from 28.46 ± 4.25 kg/m² to 28.14±4.03 kg/m², being an important factor that contributes to improved health. Correspondingly, the study by Fortes *et al.* (51) focusing on the average BMI 25.1 ± 3.4 kg/m², proved to be a good predictor of change in physiological markers of MS. A decrease in BMI is strongly associated with physiological markers of health.

Another important topic: according to Kumari *et al.* (52) the decrease of hypertension is identified as the main risk factor for mortality, and which ranks third as a cause of reduced years of life due to disability, also being a common manifestation of metabolic disorders associated with insulin resistance and hyperinsulinemia. In the study by Fortes *et al.* (51) it was found cross-sectionally in 2,719 Brazilian Army soldiers that the mean SBP 120.3 ± 10.1 was quantitatively like the means found in this study.

Specifically, about DBP was found that the means were within the reference limits of 85.0 mmHg (26), but there was a significant improve intergroups. In the same direction, Fortes *et al*. (51) found similar DBP means 77.2 ± 8.8.

The present study filled an important gap in the scientific literature by carrying out the running intervention outdoors (53). According to Andreato *et al*. (42) who verified the influence of HIIT on the anthropometric variables of overweight or obese adults, evaluating 48 studies with 1,222 people, showed that in relation to the HIIT modality there were around 30 studies that adopted ergometric cycling, 18 that adopted running or walking, 12 used the treadmill, 3 used the indoor sports court, 1 used in the court and 1 single outdoor study.

According to Foster *et al*. (32) about use of technology to monitor load, it contributes to safety in carrying out training for experiment participants and controlling important training variables. During the training sessions of the present study, physical activity practitioners participants had their heart rates monitored by the First Beat software, which contributed during the training execution to adjust the load and check the HILIT and SIT target zones, and it was observed that the SIT monitoring is more complex due to the late heart rate response recorded on the devices and the difficulty in monitoring maximal or submaximal efforts in sprints (4, 5, 32).

Singularly enriching our discussion, studies indicate a better use of SIT when the individual has a profile of physical qualities more focused on explosion than endurance (4, 5). The active interval at 50% HR*max* between high-intensity interval bursts was used as a common aspect for both the HILIT and SIT groups. In the same direction, Mello *et al*. (54) verified in an experimental study with 15 military men from the Brazilian Army with excellent physical

conditioning, the contribution of the active interval as a choice capable of promoting less muscle damage and that for the present study there was an improvement in VO_2 and a good adaptation of participants to the HILIT and SIT methods. The studies by Germano *et al.* (55) corroborate the active recovery intervals that have greater potential for reaching and remaining at a high percentage of $\dot{V}O_2max$ and HR*max*. In contrast, other studies have suggested that the passive recovery interval can induce higher VO_2 (4).
In the context of choosing the SIT method, it appears that the sprint and the gain in aerobic capacity were important gains from this study with excellent potential to be developed, if stratified within the age ranges of interest, and for both sexes, which reflect a trend (56). Furthermore, they also have engagement and applicability in team sports such as football and others (57).
In the comparison between the proposed methods HILIT and SIT, the present study indicates a better result for HILIT. In the same way, Rosenblat *et al.* (58), in a meta-analysis, systematically reviewed six randomized studies, with moderately trained adults between 18 and 45 years old, determining which mode of interval training, HIIT *versus* SIT, showed HILIT as an ideal form of interval training to improve performance.
The strengths of the present study were a more complete approach with load equalization using different participant assessment methods: body composition, physical load test, and blood biochemical markers. As mentioned before, regarding the intergroup comparison arising from exercise, the discussion reveals that there was an improvement in important parameters of MS, liver health and aerobic capacity. However, there were limitations in the study that must be taken into consideration, such as the impossibility of controlling the feeding variable and the use of the ramp CET. In the future, CET studies may establish a verification phase to obtain true VO_2, which was also not part of this study due to logistical circumstances to enable tests for the experimental sample and ergospirometric material.

CONCLUSIONS

Considering the results found, the present study showed the positive effects of HILIT and SIT on physiological and pathological markers of MS and liver health in in activity practitioners adults. In the SIT method, there was an improvement in the parameters VAT, GLU, ALB, DB, GGT, and distance running. HILIT proved to be more efficient than SIT, and provided improvements in liver health, body composition and aerobic capacity in the health parameters fat mass, lean mass, BMI, VAT, GLU, ALB, DB, distance covered and VO_2.
Thus, the study has applicability to society in general, specifically to the military population and physical activity practitioners adults. Future studies involving the use of a gold standard non-invasive liver imaging instrument such as elastography are recommended. It would also be interesting to investigate the relations between HILIT and SIT, MS and liver health correlated with circadian cycle behavior, and epigenetics.

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DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

SLL: writing – original draft, project administration, conceptualization. B-PCJ, SATB, CMASP, RSE, FMSR, NRAM, CJBP, LDG, SAOB, CLS: project administration. VRGS: conceptualization.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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