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Calisthenics Exercise Versus High-Intensity Interval Training on Health-Related Outcomes in Non-Alcoholic Fatty Liver Patients: a Comparative Study

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ABSTRACT

INTRODUCTION. Regular physical activity is strongly recommended to cope with non-alcoholic fatty liver disease (NAFLD).
AIM. To examine the impact of an eight-week calisthenics exercise versus high-intensity interval training (HIIT) in NAFLD patients.
MATERIALS AND METHODS. At Cairo University's Faculty of Physical Therapy-Outpatient Clinics, 32 male and female NAFLD patients were randomly divided between HIIT (n = 16) and calisthenics exercise (n = 16) for three days per week for the period of eight weeks, all patients in two groups receiving the appropriate medication (Statins 5 mg). The outcome measures were liver ultrasonography and serum lipid profile.
RESULTS AND DISCUSSION. Following eight weeks of intervention, the analysis of data indicated that calisthenics and HIIT had no significant differences in their effects on plasma lipids and liver US results ($p < 0.05$).
CONCLUSION. No significant differences were noted in lipid profiles and liver US results between the exercise groups, implying that both calisthenics and HIIT could serve as effective treatment strategies for NAFLD.

REGISTRATION: Clinicaltrials.gov identifier No. NCT06032650; registered 11.09.2023.

KEYWORDS: lipid profile, aerobic exercise, liver ultrasonography, resistance exercise

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Сравнение физических упражнений и высокоинтенсивных интервальных тренировок с точки зрения влияния на здоровье пациентов с неалкогольной жировой болезнью печени: сравнительное исследование

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РЕЗЮМЕ

ВВЕДЕНИЕ. Регулярная физическая активность настоятельно рекомендуется, чтобы справиться с неалкогольной жировой болезнью печени (НАЖБП).

ЦЕЛЬ. Изучить влияние физических упражнений и высокоинтенсивных интервальных тренировок (ВИИТ) в течение восьми недель на пациентов с НАЖБП.

МАТЕРИАЛЫ И МЕТОДЫ. На факультете физиотерапии Каирского университета в амбулаторных клиниках 32 пациента с НАЖБП мужского и женского пола были рандомизированы на две группы, занимающиеся в течение трех дней в неделю в течение восьми недель ВИИТ ($n = 16$) и физическими упражнениями ($n = 16$). Все пациенты получали соответствующие лекарства (статины по 5 мг). Конечными показателями были ультразвуковое исследование (УЗИ) печени и липидный профиль сыворотки крови пациентов.

РЕЗУЛЬТАТЫ И ОБСУЖДЕНИЕ. После восьми недель лечения анализ данных показал, что физические упражнения и ВИИТ не имели существенных различий в их влиянии на уровень липидов в плазме крови и результаты УЗИ печени ($p < 0,05$).

ЗАКЛЮЧЕНИЕ. Не было отмечено существенных различий в липидном профиле и результатах УЗИ печени между группами, что означает, что как физические упражнения, так и ВИИТ могут служить эффективными стратегиями в лечении НАЖБП.

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КЛЮЧЕВЫЕ СЛОВА: липидный профиль, физические упражнения, ультразвуковое исследование печени, высокоинтенсивные тренировки

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INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) represents a highly widespread chronic hepatic disorder, marked by unusual fat accumulation in the liver without substantial alcohol intake [1]. NAFLD is frequently related to metabolic risk factors like diabetes, obesity, dyslipidemia, and hypertension [2]. A meta-analysis reveals that NAFLD now affects 32.4 % of the population globally, which is tremendously costly to society [3]. Nowadays, NAFLD is the eighth most significant contributor to global mortality, resulting in 1.2 million deaths per year [4]. In most people with NAFLD is asymptomatic [5]. Using either imaging or a liver biopsy, NAFLD is diagnosed when steatosis infiltrates at least 5 % of hepatocytes [6]. Lifestyle changes and increasing physical activity levels in NAFLD patients are a significant element that impacts metabolism regulation [7]. Current research highlights offers greater benefits for treating NAFLD [8]. Repetitive short sprints at maximum effort are part of the High-Intensity Interval Training (HIIT) regimen. These are followed by moderate-intensity exercise or rest. The sprint and recovery intervals last anywhere from six seconds to four minutes. Compared to other conventional aerobic exercise programs, this kind of exercise suggests a noticeably lower training volume to elicit adaptations and health advantages [9]. In NAFLD patients, HIIT may be enhancing cardiopulmonary, abdominal fat, and intrahepatic triglyceride levels [10]. Calisthenics exercise is a sort of exercise that includes different body motions that may be practiced without the use of instruments, but it only depends on body weight for resistance. Swinging, twisting, jumping, kicking, and bending are all activities intended to develop body flexibility and strength [11]. Also, it significantly reduces body weight, cholesterol, triglycerides, and low-density lipoprotein (LDL), and increases high-density lipoprotein (HDL) [12].

AIM

This study was conducted to examine the effect of an eight-week calisthenics exercise versus HIIT in NAFLD patients.

MATERIALS AND METHODS

Ethics

Participants in this clinical study gave their consent, and the authors received regional ethics approval. The university delivered the protocol approval number (P.T.REC/012/004531) and the consent. A detailed registration of the trial protocol (NCT06032650) can be found on www.clinicaltrails.gov.

Participants

From 15th October 2023 to 15th March 2024, thirty-two NAFLD patients were enrolled in either HIIT (group A) or calisthenics exercise (group B), with 16 participants per group. Recruitment took place at Cairo University's Faculty of Physical Therapy-Outpatient Clinics, including patients of both genders. Inclusion criteria of the patients were mild NAFLD based on ultrasonography fatty liver indicator (US-FLI) scores of 2–4 [13], aged 35–50, BMI 30–40 kg/m^2, dyslipidemia (triglyceride (TGL) > 150 mg/dl, total cholesterol (TCL) > 200 mg/dl, low-density lipoprotein (LDL) > 130 mg/dl, or HDL < 40 mg/dl), and liver size > 5 % above normal via ultrasonography without hepatocellular damage. The patient exclusion criteria were unstable cardiovascular issues, active Hepatitis C, uncontrolled diabetes (HbA1C > 7% to 8 %), hypertension (> 160/90 mmHg), active smoking, chronic respiratory conditions, use of steroids or other muscle-weakening medications, severe peripheral arterial disease with ankle-brachial pressure index less than 80 %, beta-blocker use, and severe anemia (HB < 8 g/dl).

Procedures

High-intensity interval training (HIIT)

Every patient in group A ran on a treadmill while doing low-volume HIIT for eight weeks, three sessions a week for 35 minutes in each session (5-minute warming up, 25-minute training, and 5-minute cooling down). The HIIT program consists of a 2-minute 'all out' against a sub-maximal workload at 85–90 % of peak HR. Subjects typically did four work bouts separated by 4 minutes of recovery at 60–70 % of peak HR, for a total of 8 minutes of strenuous exercise throughout a training session. Peak HRs were acquired following the modified Bruce protocol. Maximal activity was tested on a treadmill using a modified version of the Bruce protocol conducted in stages. The test has different exercise phases. At first, there was no elevation angle and a speed limit of 1.7 mph. Then the elevation and speed were increased every three minutes as detailed in the table 1 below [14].

The exercise continued until patients reached their self-determined maximum capacity or the physical therapist discontinued the test upon reaching the goal heart rate (at least 85 % of the predicted value based on age). Additionally, a decline in oxygen saturation, an excessive rise in blood pressure, moderately severe chest discomfort, or significant arrhythmia all resulted in the test being stopped [15].

Calisthenics exercise

During the eight-week calisthenics training program, every patient in group B performed one to three sets of eight exercise stations (crunches, push-ups, planks, front leg raises, upper back extensions, bicycle crunches, squats, and lunges). With a 10-second break in between stations, each exercise (exercise training) was done for 20 seconds. One set of callisthenic exercises lasted four minutes [16]. The workout intensity was determined by the number of sets, repetitions, and rest intervals. Every training session started at a low level and progressed to the training zone. Each workout included a warm-up and cool-down phase (5 to 10 minutes each), during which gentle stretching and walking activities were conducted to prevent injury. The training regimen included stretching, callisthenic exercises (25 minutes), cooling down, and warming up (10 min) [17].

Outcome measures

The study outcomes were related to:

1. Serum lipid profile: Venous blood samples were collected from the antecubital vein for all subjects after an overnight fasting period of at least 10 hours, one day before the study began and after eight weeks of the intervention.
2. Liver ultrasonography: It was conducted by an expert radiologist at baseline and after 8 weeks, using the USFLI scale (2–4) [13]. A Siemens ACUSON NX3 ELITE (German) ultrasound with a 10 MHz sonosite 180 plus scanner (2.2 cm penetration depth) assessed liver size, visceral fat thickness, and fat infiltration severity.

Statistical analysis

Version 22 of the SPSS software was utilized for all statistical analyses. To compare age, weight, height, and BMI between the groups, an unpaired *t*-test was used, and the Mann-Whitney U test was applied to compare the sex distributions. The data was homogeneous according to Leven's test, meanwhile normally distributed according to the Kolmogorov-Smirnov normality test. In addition, comparisons within a group were performed using the paired samples *t*-test for all variables, except for the severity grade, which was compared using the Wilcoxon test. The variables were then compared between groups using MANOVA. $p < 0.05$ was chosen as the significance threshold for each statistical test.

Table 1. Modified Bruce protocol

Modified Bruce Treadmill Test Stages, Speeds, and Inclines		
Stage	**Treadmill Speed**	**Treadmill Incline**
0	1.7 mph	0 % grade
1/2	1.7 mph	5 % grade
1	1.7 mph	10 % grade
2	2.5 mph	12 % grade
3	3.4 mph	14 % grade
4	4.2 mph	16 % grade
5	5.0 mph	18 % grade
6	5.5 mph	20 % grade
7	6.0 mph	22 % grade

RESULTS AND DISCUSSION

According to Table 2 there was no significant difference in the participants' characteristics, including age, weight, height, BMI, and sex distribution (*p*-value was 0.497, 0.664, 0.779, 0.372, and 0.632, respectively). The flow of the participants is presented in (Fig. 1.)

Table 3 shows significant ($p < 0.05$) decreases in the mean values of TCL and LDL in both groups in favor of group B.

In addition, regarding TGL level, HIIT in group A caused a significant reduction ($p = 0.039$), while calisthenics exercise caused a non-significant reduction.

However, although both interventions increased HDL levels, there was no significant difference within or between groups.

Table 4 shows that the calisthenics exercise in group B had a significant ($p < 0.05$) high effect on the liver size and severity grade compared to group A. In addition,

Table 2. The comparison of patients' features between groups A and B

	Group A		Group B		*p*-value	*test*-value
	$\bar{x} \pm SD$		$\bar{x} \pm SD$			
Age (years)	42.6 ± 5.2		44 ± 6.1		0.497	0.688
Weight (Kg)	95.2 ± 13.2		97.4 ± 16.1		0.664	0.439
Height (cm)	161.3 ± 7.3		160.5 ± 8.1		0.779	0.283
BMI (kg/m²)	35.7 ± 3.7		37.1 ± 4.9		0.372	0.907
Sex	**Male**	**Female**	**Male**	**Female**	**0.632**	
	3(18.8 %)	**13(81.3 %)**	**2(12.5 %)**	**14(87.5 %)**		

Note: *$\bar{x}$ — Mean, SD — Standard deviation, p-value — Probability value.*

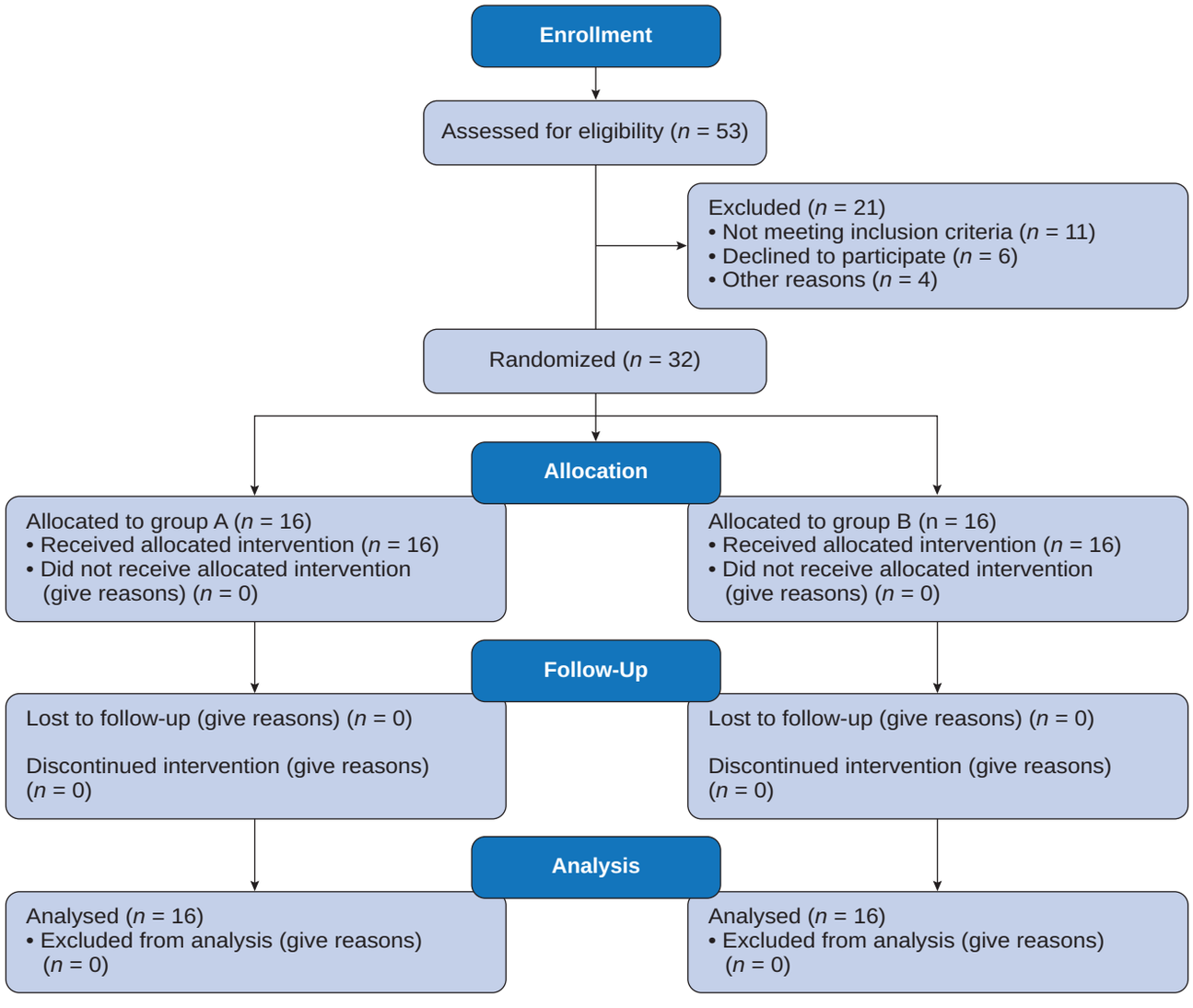

Fig. 1. The study flow chart

group A had a greater percentage of reduction regarding the visceral fat thickness compared with group B based on the analysis of the results of our study.

This study aimed to find out the impact of calisthenics exercise versus HIIT on plasma lipids (TCL, TGL, HDL, and LDL) and liver US (liver size, visceral fat thickness, and severity grade) in thirty-two NAFLD patients of both genders. After 8 weeks of interventions, HIIT and calisthenics showed a significantly decrease of serum lipid levels. HIIT and calisthenics protocols also alleviate the thickness of visceral fat and liver size, with both calisthenics and HIIT decreasing the degree of severity of NAFLD. Therefore, a lack of physical activity and a sedentary lifestyle increase the thickness and storage of visceral adipose fat in the liver, leading to pathological changes in the liver and increasing the severity of fatty liver.

Table 3. The comparison of lipid profile changes between groups A and B

		Group A	Group B	F-test value	*p*-value
		$\bar{x}$ ± SD	$\bar{x}$ ± SD		
TCL mg/dl	**Pre-intervention**	205.2 ± 48.3	190.2 ± 38.6	0.943	0.339
	Post-intervention	180.3 ± 36.5	161.9 ± 37.1	2.009	0.167
	% of change	12.1%	14.9%		
	Within group comparison	0.013*	0.001*		
LDL mg/dl	**Pre-intervention**	142 ± 36.4	122.1 ± 40.7	2.127	0.155
	Post-intervention	117.7 ± 29.6	97.5 ± 39.8	2.645	0.114
	% of change	17.1 %	19.9 %		
	Within group comparison	0.011*	0.004*		
HDL mg/dl	**Pre-intervention**	36.4 ± 10.8	40.7 ± 10.8	1.271	0.268
	Post-intervention	38.6 ± 9.9	44.6 ± 13.5	2.005	0.167
	% of change	6.3 %	9.6 %		
	Within group comparison	0.117	0.201		
TGL mg/dl	**Pre-intervention**	135.5 ± 51.7	130.3 ± 58.3	0.071	0.792
	Post-intervention	119.7 ± 46.4	118.5 ± 30.4	0.007	0.932
	% of change	11.7 %	9.1 %		
	Within group comparison	0.039*	0.301		

Note: *$\bar{x}$ — Mean, SD — Standard deviation, p-value — Probability value, * — significance, % — percentage; TCL — total cholesterol, LDL — low-density lipoprotein, HDL — high-density lipoprotein, TGL — triglyceride.*

Table 4. The comparison between groups A and B relative to liver ultrasonography parameters

		Group A	Group B	F test-value	*p*-value
		$\bar{x}$ ± SD	$\bar{x}$ ± SD		
Liver size (cm)	**Pre-intervention**	16.7 ± 1.9	17.1 ± 1.8	1.413	0.244
	Post-intervention	16.4 ± 1.4	15.7 ± 1.3	0.010	0.920
	% of change	4.5 %	8.4 %		
	In-between group comparison	0.005*	$p \leq 0.05$*		
Severity Grade	**Pre-intervention**	1.44 ± 0.5	1.38 ± 0.5	0.122	0.729
	Post-intervention	0.50 ± 0.5	0.37 ± 0.5	0.484	0.492
	% of change	65.3 %	73.2 %		
	In-between group comparison	$p \leq 0.05$*	$p \leq 0.05$*		
Visceral fat thickness (cm)	**Pre-intervention**	7.75 ± 1.4	7.23 ± 2.7	0.459	0.503
	Post-intervention	6.77 ± 1.5	6.52 ± 1.75	0.188	0.668
	% of change	12.6 %	9.8 %		
	In-between group comparison	0.001*	0.171		

Note: *$\bar{x}$ — Mean, SD — Standard deviation, p-value — Probability value, * — significance.*

Effect of calisthenics on serum lipids

Based on this finding, the reduction in serum lipids came in agreement with Turgut M. and Sarikaya M. [12], who indicated that following an 8-week calisthenics exercise regimen, there were notable reductions in cholesterol, triglycerides, HDL, and LDL. The finding of this present study was consistent with Wu G. and Qu H. [18], who detected that after calisthenics exercise, significant decreases in TG and LDL-C values were observed ($p < 0.05$). Ajayi-Vincent O.B. and Adesina M.O. [19] concluded that TG and LDL levels were significantly reduced by the end of the 8-week exercise intervention program.

Effect of HIIT on serum lipids

Relying on this finding, the present study agreed with Søgaard D. et al. [20], who reported that after six weeks of HIIT, plasma total cholesterol, visceral fat mass, and LDL levels proved lower in the study group. Similarly, Öner S. et al. [21] found notable improvements in lipid parameters and weight, supporting the present study's outcomes regarding HIIT's efficacy. These results contradicted those of da Silva M.R. et al. [22], who found that there had been no change in the lipid profile; this might be because they had maintained their poor eating habits during the study.

Effect of calisthenics on the liver ultrasound parameters

These findings align with Takahashi A. et al. [23], who noted a significant reduction in hepatic steatosis grade following 12 weeks of thrice-weekly resistance training for NAFLD patients. Consequently, Kong N. et al. [24] discovered that the calisthenic exercise group significantly reduced visceral fat area as compared to the control group or the period before the experiment. Accordingly, Hallsworth K. et al. [25] demonstrated that a 13% relative decrease in liver cholesterol was obtained after 8 weeks of resistance training (14.0 ± 9.1 vs. 12.2 ± 9.0; $p < 0.05$).

Effect of HIIT on the liver ultrasound parameters

Therefore, the results of this finding were confirmed by Hallsworth K. et al. [26], who observed that HIIT improves liver fat in addition to improving cardiac function in NAFLD patients. Furthermore, Abdelbasset W.K. et al. [27] found significant improvements in visceral lipids and all dimensions of health-related quality of life in the HIIT group ($p < 0.05$). Thus Khalafi M. and Symonds M.E. [10] demonstrated that HIIT effectively reduced liver fat [–0.51 (95 % CI: –0.85 to –0.17), $p = 0.003$] after analysis of ten studies involving 333 participants.

Finally, this trial is pioneering in comparing the effects of calisthenics exercise versus HIIT in NAFLD patients. Throughout the trial, 32 patients received the therapies, which were helpful and effective. The study's small sample size constrains the widespread applicability of its conclusions. Further investigations should consider expanding the sample size to further examine the benefits of both calisthenics and HIIT interventions.

Limitations

Finally, this trial is pioneering in comparing the effects of calisthenics exercise versus HIIT in NAFLD patients. Throughout the trial, 32 patients received the therapies, which were helpful and effective. The study's small sample size constrains the widespread applicability of its conclusions. Further investigations should consider expanding the sample size to further examine the benefits of both calisthenics and HIIT interventions.

CONCLUSION

Serum lipid levels and liver US outcomes did not differ significantly between the two groups. Hence, this research scoped the importance of using calisthenics and HIIT as routine and effective treatment programs to enhance liver health and blood serum lipids in NAFLD patients.

ADDITIONAL INFORMATION

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Ethical Approval. The authors declare that all procedures used in this article are in accordance with the ethical standards of the institutions that conducted the study and are consistent with the 2013 Declaration of Helsinki. The study was approved by the study was approved by the Local Ethics Committee of faculty of physical therapy Cairo University, Egypt, Protocol No. P.T.REC/012/004531 dated 05.04.2023.

Data Access Statement. The data that support the findings of this study are available on reasonable request from the corresponding author.

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