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Original Article

Aerobic and Strength Exercises on Fatigue and Lipid Profile Post Liver Transplantation

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Abstract

Background: Among patients suffering from end-stage liver disease, liver transplantation (LT) is the therapy of choice; nonetheless, post -liver transplantation fatigue is a significant concern, and its prevalence didn't decline in the two years following surgery. Even though hyperlipidemia is prevalent following liver transplantation (affecting as many as 71% of patients).

Purpose: To assess the combinational effect of aerobic and strength exercises on fatigue and lipid profile post–liver transplantation.

Materials and Methods: the study design was a pre–test post–test design. Subjects who participated in this study were 40 patients (31 males,9 female) who had liver transplantation for ≤ 1 year of transplantation and Their ages ranged from 20 to 65. Interventions received by patients were aerobic exercises in the form of (a cycle ergometer) for 30 minutes in addition to a strength exercises program for large muscle groups such as (quadriceps femoris, biceps brachii, gluteus maximus, as well as abdominal muscles) for another 30 minutes for 12 consecutive weeks, patients also received traditional medical treatment. The Outcome measures of study were functional capacity, fatigue severity, and lipid profile which were measured pre-treatment and 12-week post-treatment by 6MWT, (Fatigue Severity Scale, and Visual Analogue Scale), and blood analysis respectively.

Results: The 6MWT distance increased significantly, the FSS and VAS scores decreased significantly, and the levels of total cholesterol, triglycerides, and LDL decreased significantly (P=0.001). In contrast, the HDL level increased significantly (p=0.007) and the percent of change for each was 24.80%, 41.72%, as well as 15.77%, respectively, after treatment in comparison with before treatment.

Conclusion: Combinational application of aerobic and strength exercises had a positive effect on fatigue and hyperlipidemia post-liver.

Keywords: Aerobics exercises; Strength exercises; Fatigue; Lipid Profile; Liver Transplantation.

Introduction:

For individuals with end-stage liver disease, liver transplantation (LT) is the recommended course of treatment in order to maximize survival as well as quality of life. For individuals with end-stage liver disease, whether acute or chronic, it has proven to be a beneficial therapy. Premature mortality was high because transplantation was first thought to be the last therapeutic choice for patients who suffered from extremely critical clinical conditions at the time of surgery. However, at one year and five years following transplantation, survival rates in the range of 90–95% and 70%, respectively, are anticipated at this time **(1).**

One of the primary problems after LT is fatigue. Twenty percent of liver transplant recipients in previous long-term research reported feeling fatigued forty percent reported feeling extremely fatigued, and forty percent reported not feeling fatigued at all. Over the course of the two-year follow-up, this prevalence didn't decline, indicating that fatigue is a persistent issue after liver **(2).**

Following a liver transplant, hyperlipidaemia is highly prevalent and can be seen in as many as 71% of patients. These individuals' lipid problems have a complex aetiology, with varying lipid profiles seen based on the immunosuppressive medications used and the existence of extra risk factors like obesity, diabetes mellitus, as well as diet **(3).**

Strength training maintains muscle mass, but aerobic exercise alters the body's metabolism for the better and causes fat loss. Resistance training, including weightlifting, improves strength, muscle mass, as well as myofibrillar protein production **(4).**

So, the current study was carried out to assess the impact of aerobic and strength exercises on fatigue as well as lipid profile post-liver transplantation.

Materials and Methods:

Patients

A total of forty patients, who had received a liver transplant, at least 1Year prior to study initiation, patients were selected from outpatient clinics of Mansoura Hepatology and Gastroenterology Hospital between October 2023 to January 2024. Patients who fulfilled the following criteria were involved in the study: (1) patients had fatigue (as measured by a Fatigue Severity Scale [FSS] score of 4 or above). (2) Individuals who were 20 to 65 years old. (3) A liver transplant must have been performed at least one year before the start of the study. (4) BMI of all patients was 25 kg/m. (5) Patients were selected from both sexes (31 males and 9 females). (6) All patients enrolled to the Study had their informed consent. Those who met any of the following criteria were not allowed to participate: (1) Transplantation of many organs. (2) Extensive co-morbidities (such as cancer or recurrent cholangitis) (3) Arabic language proficiency was inadequate (4) Diseases that prevent exercise or the progressive maximal cycle ergometer test from being useful, such as heart disease. (5) Uncontrolled blood pressure. (6) Inability to understand the written and verbal instructions. the study design was a pretest-posttest design. Forty patients enrolled in one group, this group received aerobic exercises in form of (cycle ergometer) and strength exercises in the form of free weights and resistance bands (leg curl strength by weight, quadriceps strength by bands، bridging exercise) in addition to their medical treatment at rate of 2 sessions per week and for 12 weeks. In order to prevent type|| error, the sample size was calculated. A total of 40 participants were included in the study after the G*POWER statistical program (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) was used for the purpose of sample calculation. The parameters used for the calculation are α=0.05, power = 90%, along with effect size = 0.53.

Figure 1 illustrates the flow chart of the individual's recruitment through the study fifty-one subjects were evaluated for eligibility; six were excluded (four individuals didn't meet the eligibility criteria while two subjects declined to take-part in the study). Forty participants involved in one group.

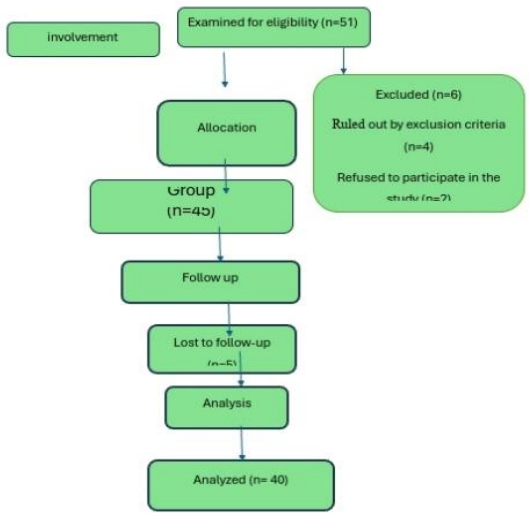

Figure 1. Flowchart of participants through the study.

Outcome measures

All measurements were done: (1st measure) one week prior to starting rehabilitation program (pre–treatment). (2nd measure) was done after 12 weeks of aerobic exercise and strength training program (post– treatment) as following; The six–minute walk test (IV): Subjects in this study completed the 6MWT on a pathway that was 20 meters long and 2 meters wide. The goal of the 6-minute walk was to see how far the subjects could go. They could rest if they wanted to, but they had to get back on their feet as soon as they felt ready. In cases of dyspnea, leg cramps, pale skin, or chest pain, it is essential to discontinue a 6MWT immediately **(3).**

Fatigue severity scale: The FSS, a validated 9-item questionnaire that measures how fatigue affects a person's ability to carry out about their everyday tasks, was utilized to discover the intensity of the fatigue. A scale from 1 to 7 is used. A score of 5.1 or higher was considered "severe fatigue," whereas a score among 4.0 and 5.1 was considered "fatigue"[2] . The following statements were given to each patient, and they were asked to circle the number among 1 and 7 that they believed best matched. This pertains to your typical routine for the past seven days. A score of 1 means "strongly disagree," while a score of 7 means "strongly agree." Following that, after every single one read and Marked a number after reading it. strongly disagree → strongly Agree **(5).**

Visual analogue fatigue scale (VAS): Over the past 3months, we evaluated overall fatigue using a horizontal VAS. The VAS was a 100-mm line where 0 meant "no fatigue experienced" while 100 meant "the most severe fatigue." Scores above 50 indicate extreme fatigue.

Lipid profile: Our bodies had lipids and cholesterol, which were similar to fat. A lipid profile, often known as a cholesterol test, measures the amount of lipids and cholesterol within your blood. The following parameters were assessed by a lipid profile blood test: (1) The overall blood cholesterol level. A person's HDL-cholesterol level (high-density lipoprotein, or "good cholesterol"). (3) The amount of low-density lipoprotein cholesterol, often known as "bad" cholesterol. (4), triglycerides, which are another form of fat located in the body **(2).** The overall study measures were performed before and after 12 weeks of treatment.

Treatment

The following was part of the 12-week rehabilitation program: 24 sessions of strength as well as aerobic training, each lasting an hour and held two times per week. There were three parts to each exercise: warming up, training, and cooling down **(6).** Just before you begin exercising. The patient's clinical status, including symptoms related to cardiovascular disease, blood pressure, heart rate, as well as shortness of breath, was also evaluated by the physicians during this time. The research assistant made sure the individual was safe by taking their vitals every 5 to 10 minutes before the session started. Any participant whose systolic or diastolic blood pressure was greater than 180/95 mm Hg or whose heart rate was less than 60 beats/min was not allowed to participate in the exercise session **(2).**

Preparations: The warm–up phase: The warm up protocol was consisted of stretching exercises in addition to slowly running on treadmill at lowest speed (1 km ph) for 5 minutes. Then, the warm–up phase was followed by the training phase. Cool down phase was like the warm up phase 5 minute at lowest speed 1 km ph at all sessions.in addition to stretching exercises.

Aerobic training: The aerobic exercise included 30 minutes of ergometer cycling with an intensity ranging from 40% to 50% of HRR (heart rate reserve) utilizing the Karvonen method, and then gradually rising to 70% to 80% of HRR. Throughout the 12-week program, we aimed to accomplish an average target intensity of 60% of HRR, following the criteria set by the American College of Sports Medicine (ACSM) **(2).** Starting with 20 W(kgm/min), the resistance upon the cycle ergometer was raised by 15 or 20 W(kgm/min) each minute, according to the individuals' abilities. That was 60 revolutions per minute. Utilizing the Borg Category Scale for Rating of Perceived Exertion **(2),** participants rated the intensity of their training from 0 (no effort) to 10 (maximum effort) following each session **(2).**

Strength exercises: Regular 30-minute strength training sessions targeted the development of key muscular groups, including the gluteus maximus, biceps brachii, quadriceps femoris, as well as abdominal muscles in the form of free weights and resistance bands (leg curl strength by weight, quadriceps strength by bands، bridging exercise). From a low of 10–15 reps at 30% of 1RM to a moderate of a total of three sets of 20 reps at 60% of 1RM, the intensity, as well as number of repetitions were progressively raised over the course of the 12 weeks **(2).**

Ethical consent:

With the number P.T.REC/012/004837, the Ethical Committee of Cairo University's Faculty of Physical Therapy gave its approval to this research. Each participant in the study gave their written, informed consent before taking part in the study. All procedures used in this study were consistent with the World Medical Association's (WMA) Declaration of Helsinki, which governs research involving human subjects.

Statistical analysis:

To reflect the characteristics of the study group's subjects, descriptive statistics were performed using frequency, standard deviation, as well as mean. Serum lipid profile, 6MWT, FSS, along with VAS mean values before and after exercise were compared using a dependent t-test. All statistical tests were set to have a significance level of $p < 0.05$. For this study, we used SPSS 25 for Windows (IBM SPSS, Chicago, IL, USA) to conduct all statistical analyses.

Results:

Forty patients underwent liver transplantation, one year before, took-part in this study. Data obtained from the study group regarding 6MWT), FSS, VAS and serum lipid profile pre and post 12 weeks of exercises program were compared.

General characteristics of the subjects:

Age: With ages ranging from 20 to 65, the mean ± standard deviation of the study group was 44.88 ± 12.42 years **(Table 1, Figure 2).**

Gender distribution: The gender distribution of the research participants was as follows: 31 men (77.5%) as well as 9 females (22.5%) **(Table 1, Figure 3).**

Table 1. Descriptive statistics for age and sex distribution of study group.

	$\bar{X}$ ±SD	Minimum	Maximum
Age (years)	**44.88±12.42**	**20**	**65**
Sex distribution	**N**	**%**	
Females	**9**	**22.5**	
Males	**31**	**77.5**	

$\bar{X}$ **:** Mean, SD: Standard Deviation.

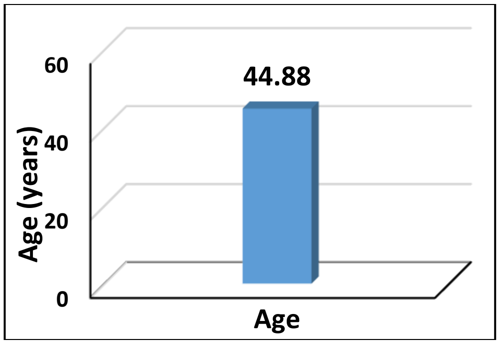

Figure 2. Mean age of study group.

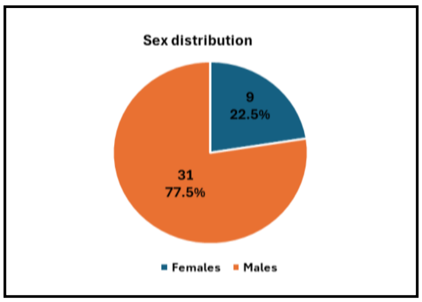

Figure 3. Sex distribution of study group.

I. Comparison of 6MWT between before and after exercises:

The mean ± SD of 6MWT of study group pre-exercise was 413.38 ± 50.19 m and that post exercise was 515.88 ± 62.25 m. The change percentage was 24.8 percent, while the mean difference was -102.5 m. When comparing 6MWT before and after exercise, a statistically significant rise was observed (p = 0.001) **(Table 2, Figure 4).**

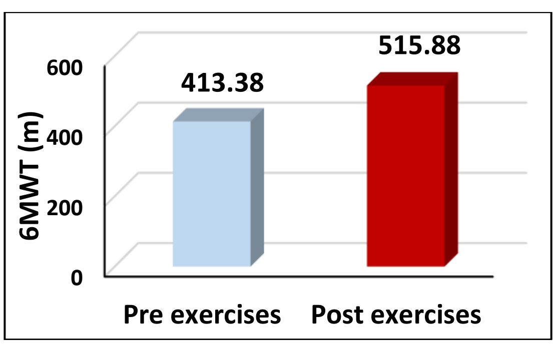

Figure 4. Mean 6MWT pre and post exercises of study group.

II. Comparison of FSS between before and after exercises:

After exercise, the study group's mean ± SD of FSS was 2.84 ± 0.55, compared to 4.89 ± 0.54 before exercise. A change of 41.72% was accompanied by a mean difference of 2.04. When comparing FSS levels before and after exercise, a statistically significant reduction was seen (p = 0.001) **(Table 3, Figure 5).**

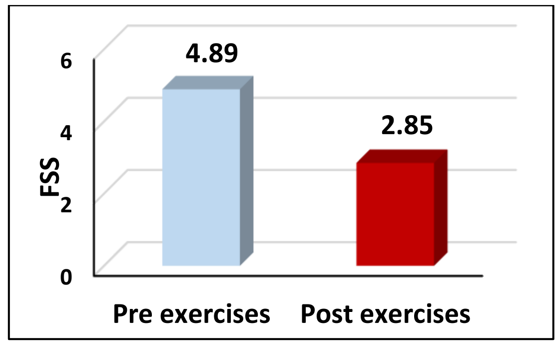

Figure 5. Mean FSS pre and post exercises of study group.

III. Comparison of VAS between pre and post exercises:

The study group's mean ± SD of VAS before exercise was 8.85 ± 0.89, and after exercise, it was 2.38 ± 1.09. A change of 73.11% was indicated by a mean difference of 6.47. A statistically significant reduction in VAS was observed after exercise as compared to before (p = 0.001) **(Table 4, Figure 6).**

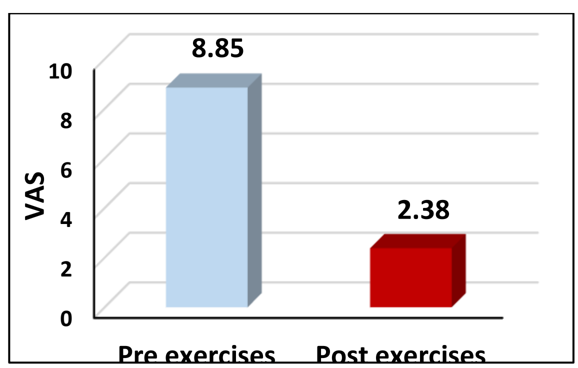

Figure 6. Mean VAS pre and post exercises of study group.

IV. Comparison of lipid profile between before and after exercises:

Total cholesterol: The mean ± SD of total cholesterol of study group pre-exercise was 196.65 ± 37.69 mg/dl and that post exercise was 165.63 ± 34.47 mg/dl. The mean difference was 31.02 mg/dl and the percent of change was 15.77%. A significant decline was detected in total cholesterol post exercise compared to pre-exercise (p = 0.001).

Triglycerides: The mean ± SD of triglycerides of study group pre exercise was 137.85 ± 60.76 mg/dl and that post exercise was 117.40 ± 50.40 mg/dl. The mean difference was 20.45 mg/dl and the percent of change was 14.83%. A significant decline was detected in triglycerides after exercise compared to pre exercise (p = 0.001).

LDL: The mean ± SD of LDL of study group pre exercise was 113.56 ± 39.55 mg/dl and that post exercise was 89.41 ± 32.81 mg/dl. There was a 21.27 percent change along with a mean difference of 24.15 mg/dl. When comparing LDL levels before and after exercise, a statistically significant reduction was seen (p = 0.001).

HDL: The mean ± SD of HDL of study group pre exercise was 47.54 ± 13.90 mg/dl and that post exercise was 52.77 ± 10.06 mg/dl. The mean difference was –5.23 mg/dl and the percent of change was 11%. A significant rise in HDL post exercise compared to pre exercise (p = 0.007) **(Table 5, Figure 7).**

Table 2. Comparison of 6MWT between before and after exercises.

	6MWT (m) $\overline{X} \pm SD$	MD	% of change	t– value	p– value	Sig
Pre exercises	**413.38 ± 50.19**	**–102.5**	**24.80**	**–21.05**	**0.001**	**S**
Post exercises	**515.88 ± 62.25**					

Table 3. Comparison of FSS between before and after exercises.

	FSS $\overline{X} \pm SD$	MD	% of change	t– value	p– value	Sig
Pre exercises	**489± 0.54**	**2.04**	**41.72**	**26.62**	**0.001**	**S**
Post exercises	**2.85 ± 0.55**					

Table 4. Comparison of VAS between before and after exercises.

	VAS $\overline{X} \pm SD$	MD	% of change	t– value	p– value	Sig
Pre exercises	8.85 ± 0.89	6.47	73.11	37.72	0.001	S
Post exercises	2.38 ± 1.09					

Table 5. Comparison of lipid profile between pre and post exercises.

Lipid profile (mg/dl)	Pre exercises $\overline{X} \pm SD$	Post exercises $\overline{X} \pm SD$	MD	% of change	t– value	p– value	Sig
Total cholesterol	**196.65±37.69**	**165.63±34.47**	**31.02**	**15.77**	**7.54**	**0.001**	**S**
Triglycerides	**137.85±60.76**	**117.40±50.40**	**20.45**	**14.83**	**3.70**	**0.001**	**S**
LDL	**113.56±39.55**	**89.41±32.81**	**24.15**	**21.27**	**6.31**	**0.001**	**S**
HDL	**47.54 ± 13.90**	**52.77±10.06**	**–5.23**	**11.00**	**–2.87**	**0.007**	**S**

x̄: Mean SD: Standard deviation MD: Mean difference t value: Paired t value p value: Probability value S: Significant

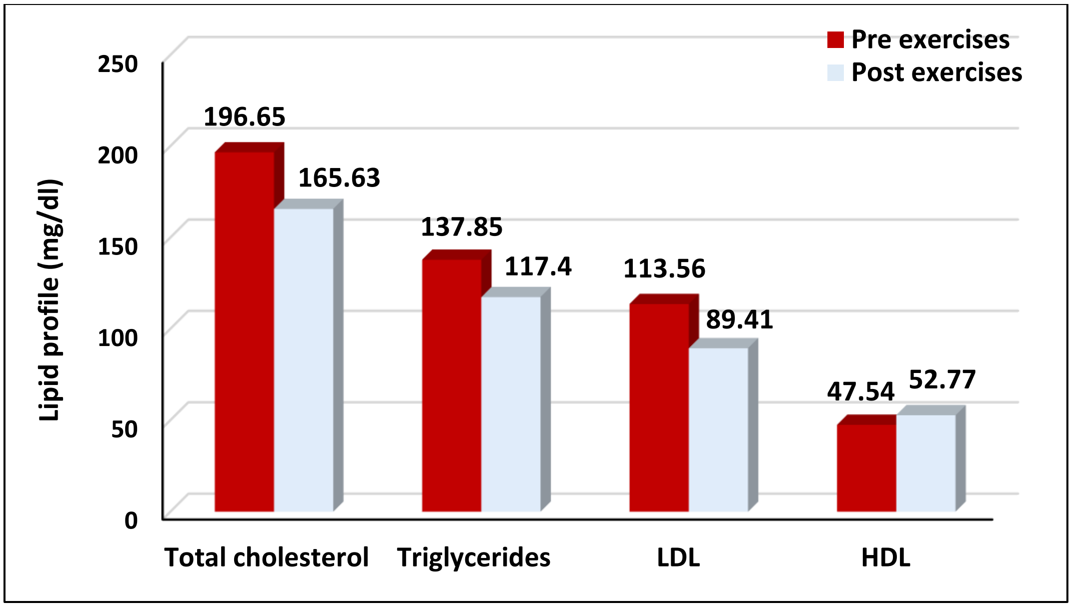

Figure 7. Mean total cholesterol, triglycerides, LDL and HDL pre and post exercises of study group.

Discussion:

The current gold standard for treating patients with end-stage liver disease is liver transplantation. As post–transplant survival improves, health–related quality of life through patient reporting is an essential independent measure to evaluate transplant outcomes (nutritional statues– ability to perform activities of daily livings). Restoring health to a level comparable to pre-transplant levels is the ultimate aim of liver transplantation **(7).**

This study was carried-out to examine the impact of aerobic and strength exercises upon fatigue as well as lipid profile post liver transplantation by assessing functional capacity, fatigue severity, and lipid profile which were measured pre-treatment and 12 week post-treatment using 6MWT, (Fatigue Severity Scale, and Visual Analogue Scale), and blood analysis respectively.

As far as we know, this study is one of the few studies that assesses the impact of a demanding rehabilitation program on individuals who have received liver transplants and experience fatigue or severe fatigue. The study examines how the program affects fatigue levels, physical fitness, daily physical activity, lipid profile levels, and consequently, cardiovascular risk. Unfortunately, this study lacked a control group, thus requiring a cautious interpretation of the results. The findings suggest that a 12-week rehabilitation program, which involves closely monitored physical training and counselling on physical activity, is well received by participants and shows promise in alleviating fatigue. Moreover, following the rehabilitation program, there was an increase in aerobic capacity and an improvement in body lipid profile compared to the initial measurements. The level of adherence demonstrated by the participants was deemed satisfactory, indicating a high degree of compliance. Moreover, the participants expressed a high level of satisfaction with the study. Importantly, no adverse events were reported during of the study.

Aerobic exercise alters lipid metabolism within the blood and a number of markers of lipid metabolism, according to research. By decreasing levels of serum triglycerides, total cholesterol (TC), and LDL cholesterol (LDL-C), and raising the amount of HDL cholesterol

(HDL-C), exercise reduces serum lipids in patients having hyperlipidemia **(8).**

There is evidence from prior research that LT patients also have decreased exercise capacity. To assess the participants' exercise capacity and everyday functional abilities, we administered the 6MWT. This test offers a cost-effective, simple, and objective assessment of global physical function.

Following surgery, it is essential to evaluate patients based on their activity capacity. Functional ability, therapy reaction, as well as prognosis following a particular treatment program can all be acquired through 6MWT **(9).**

The findings showed that there was a significant improvement in 6MWT distance after exercise compared to before exercise (p = 0.001), and the percent of change was 24.80%.

This come in the agreements of **van den Berg–Emons et al**. **(2)** who reported that 6MWT physiologically comparable to daily activities also were slightly lesser than the normal level of healthy people with larger improvements in physical fitness and aerobic capacity, and long distance to the training sets after weeks of aerobic exercises programme.

In patients who are awaiting a liver transplant, multiple studies have shown that strength training and aerobic capacity training both reduce mortality and morbidity. Exercise enhances aerobic capacity, according to numerous research conducted on liver transplant patients. 6MWT was a commonly used metric for monitoring aerobic capacity. Prior research has shown that aerobic and resistance strength training under medical supervision for 12–16 weeks increases peak VO2 and 6MWT distance **(10,11).**

Aerobic exercises, as observed by Garcia et al**. (12),** which comprise an overall 24 sessions of thirty minutes of continuous treadmill activity, enhance walking distances of patients by 19% after liver transplantation.

Cycle ergometer is a form of aerobic exercises that also has the same effect as it increased VO2, that will by its favour increase the functional performance then increase the walking distance **(2).**

Our findings contradict those of S**irisunhirun et al. (13)** who failed to detect a statistically significant association between exercise and 6MWT distance, this difference of the result may be due to in the previous study the exercises were a home routine program that the participants were not under a good physical therapist's observation.

After exercising, our subjects' FSS levels were significantly lower than their pre-exercise levels (p = 0.001), with a percentage reduction of 41.72 percent. Additionally, the percentage of improvement was 73.11% and the VAS was significantly lower after exercise than before (p = 0.001).

Patients on the transplant list for liver transplantation often report fatigue as a symptom. **Van den Berg-Emons et al. (14)** reported that this symptom can persist for up to a year following a liver transplant. It should be noted that fatigue is not always easy to quantify, despite the fact that numerous questionnaires have been created and administered to LT patients. The VAS and FSS were used in this study because of their reliability in this particular case **(15).**

The findings were consistent with **van den Berg–Emons et al. (2)** who found that there was a significant improvement in fatigue score of FSS after the rehabilitation program of combinations of aerobic with strength exercises, this improvement may be as a cause of aerobic and strength exercises which increase the functional performance and functional capacity that by its role it decreases the fatigability level and increases the physical performance level.

In the same line, **Yüksel et al (16)** had reported that aerobic exercises (3 days/week) at a moderate– intensity are recommended to enhance physical performance status and FSS score for LT patients, it was found that fatigue after transplantation happened due to decrease physical performance after surgery so there is direct relation between fatigue and physical performance, so aerobic exercises increase functional capacity and so physical performance and then decrease the fatigability sensation.

Also, it come with the agreements of **Lima et al. (17)** who confirmed a negative relationship between 6MWT and FSS in this group of LT patients, suggesting that exercise test scores dropped as fatigue levels rose; hence, fatigue levels dropped as exercise levels dropped.

According to **Van den Berg-Emons et al. (14)** The symptoms of exhaustion that liver transplant recipients may have originated in the physical rather than the psychological. According to Van den Berg-Emons et al. Another study (2006) found that those who had liver transplants reported significantly less physical activity daily, which may explain why they felt so exhausted after the procedure. Fortunately, this problem was alleviated with exercise.

Our study found that TC, triglycerides, and LDL) all decreased significantly after exercise compared to before ($p = 0.001$), with corresponding percentage changes of 15.77%, 14.83%, and 21.27 percent. On the other hand, HDL increased significantly after exercise compared to before ($p = 0.007$), with corresponding percentage changes of 11%.

The results of a meta-analysis of 51 studies showed that, after 12 weeks of treatment with exercises, HDL cholesterol reached 4.6%, triglyceride levels decreased 3.7%, and LDL cholesterol decreased by 5% on average. Although there was no change in TC, there was a significant improvement in the HDL: LDL cholesterol ratio **(18).** These results were agreed to our study, this compatibility may as a result of that aerobics exercises were conducted to 12 weeks.

It was suggested that HDL cholesterol is the component of the lipid profile that is most likely to improve as the result of physical activity. This was supported by evidence relating to aerobic exercise presented by **Banz et al. (19)** who reported a 13% increase in HDL cholesterol (from 29.8 to 33.7 mg/dL, p\0.05) following a relatively short 10–week protocol of training three times weekly at 85 % of the maximal heart rate (HRmax) [from the second week onwards] for 40 min on ski–style exercise equipment.

These increase in HDL lipid and increase of the other components of lipids (LDL, triglycerides) may be due to that aerobics need more energy expenditure and O2 consumption with in role of the body metabolism that will burn harmful fates to get energy and increase good fate by metabolism.

This agrees with the findings of **Nybo et al. (20)** who found that HDL cholesterol was the sole lipid profile component to show improvement. The only aspect of the lipid profile that showed a significant improvement (moving from 3.41 to 2.92, $p<0.05$) in prior untrained participants included the total: HDL cholesterol ratio, which was achieved by exercising for 150 minutes per week at 65% of maximal aerobic capacity (VO2max).

Exercise and other forms of physical activity may help lower cholesterol, according to the above-mentioned statistics. Exercising regularly raises HDL cholesterol while keeping LDL and triglyceride levels stable, and may even neutralize any increase in the latter two. Levels of HDL cholesterol seems to be proportional to the amount of exercise, suggesting a linear dose-response relationship.

Johnson et al. (21) found that aerobic exercise training reduced blood lipid levels. There was a significant decline of 12% in visceral adipose tissue volume ($p < 0.01$), a 21% decrease in hepatic triglycerides concentration ($p < 0.05$), and a 14% decrease in plasma free fatty acids ($p < 0.05$) after a period of four weeks of aerobic cycling activity for patients following LT, in along with the current recommendations for physical activity.

The effects of physical activity on lipid profiles can vary. **Ruschke et al. (22)** showed that physical training improves lipid profiles by increasing messenger RNA levels of PPARc and PGC-1a in both muscle as well as adipose tissue.

Shaw et al. (23) compared the effects of a 16-week moderate-intensity combination aerobic and resistance training program in 28 healthy, young men who had never exercised before with our findings. Aerobic exercise at 60% HRmax and weight training (two sets of fifteen repetitions each) at 60% 1 RM made up the 45-minute program. Despite not being substantially different from the reduction produced by 45 minutes of aerobic exercise only (from 3.64 to 2.87 mmol/L, p\0.05), it was observed that LDL cholesterol decreased substantially after resistance training as well as aerobics (from 4.39 to 3.23 mmol/L, p\0.05). Thus, it can be inferred that incorporating both forms of exercise did not lead to an additional decrease in LDL cholesterol.

Finally, according to the current study results, it is important that Aerobic exercises and strength exercises should be a part of Post–liver transplantation rehabilitation program to avoid any after LT complications.

Limitation

This study was limited by (1) Personal and individual differences between the patients. (2) The daily living activities, which might affect the results of the study. (3) Learning and performance skills (4) Economic, social and cultural level variations. (5) Degree of cooperation of each patient.

Conclusions:

Combinational application of aerobic and strength exercises had a positive effect on fatigue and hyperlipidemia post- liver transplantation. The current study aimed to help physiotherapists in management of fatigability and high blood lipid as post-liver transplant complications through introducing a scientifically rehabilitation program.

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Data Availability Statement: Not applicable

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Conflicts of Interest: There is no conflict of interest.

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