

Original Article



Effect of pilates training on hepatic fat content and liver enzymes in men with non-alcoholic fatty liver disease in Qazvin

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Abstract

Background and aims: Non-alcoholic fatty liver disease (NAFLD), which is associated with fat accumulation and deposition in liver cells, is a serious risk factor for other diseases such as cardiovascular disorders and diabetes. The aim of this study was to investigate the effect of Pilates training on hepatic fat content and liver enzymes in men with NAFLD in 2019.

Methods: In this semi-experimental study, 20 men with NAFLD were randomly divided into Pilates training (n=10) and control (n=10) groups. The Pilates group participated in the Pilates training program for eight weeks (three 60-minute sessions per week), whereas the control group engaged in no regular physical activity. The body composition, anthropometric indices, liver fat content, serum levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) were measured before and after the training period. Eventually, data were analyzed using paired and independent *t* tests at a significance level of 0.05 by SPSS 18.

Results: After eight weeks of Pilates training, liver fat content in the Pilates group was significantly lower than that in the control group ($P=0.001$). Further, the serum levels of ALT, AST, and ALP significantly decreased in the Pilates group compared to the control group ($P=0.04$, $P=0.05$, and $P=0.02$, respectively). In addition, eight weeks of Pilates training significantly reduced body weight, body mass index (BMI), fat percentage, and the waist-to-hip ratio of patients, while no significant changes were observed in the control group.

Conclusion: The results of the present study indicated that Pilates training could be effective in improving liver fat content and reducing the serum levels of ALT, AST, and ALP in men with NAFLD. Furthermore, Pilates training helps to improve body composition and anthropometric indices in patients afflicted with NAFLD and can have a role in the management of this condition.

Keywords: Pilates, Liver fat, Liver enzymes, Non-alcoholic fatty liver disease

Received: 25 June 2019, Accepted: 6 August 2019, ePublished: 28 February 2020

Introduction

Non-alcoholic fatty liver disease (NAFLD) is a growing health concern around the world (1, 2), with an estimated prevalence of 25%-35% in Western countries and 19%-32% in Asian communities (3). NAFLD comprises a wide spectrum of liver damages, ranging from simple steatosis to cirrhosis and hepatocellular carcinoma (4). It is also significantly associated with other comorbidities such as cardiovascular diseases, type II diabetes, and metabolic syndrome (5). Due to the lack of successful and specific treatments for NAFLD, the burden of this disease and its complications is relatively high.

In addition, NAFLD is characterized by the increased level of liver enzymes including alanine aminotransferase

(ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP), as well as the increased fat content of liver cells (6). Although the pathogenesis of NAFLD and the determinants of its severity have not been fully elucidated, evidence shows that a sedentary lifestyle, obesity, and insulin resistance are among the most important NAFLD risk factors (7). So far, few drug treatments have been proposed for NAFLD, including drugs increasing insulin sensitivity, those reducing fat content, and antioxidant drugs for a fatty liver. Nevertheless, their continuous use is not recommended because of their high cost and side effects (8). Currently, lifestyle modifications, including dietary modifications and physical activity, are the most important treatment suggestions for patients with NAFLD

(7,9). In this regard, exercise training is an important component of NAFLD treatment, which was approved by the American Gastroenterological Association (10). Evidence demonstrates that exercise training, especially when associated with weight loss, can improve liver function and insulin resistance (11).

Pilates training is an effective training method in the use of muscles, which has been highlighted in recent years. Pilates, as a holistic exercise involving muscle stretching and enhancement (12), emphasizes the person's breathing rhythm and mental state and strengthens the deep muscles of the body with the least possible damage (13). Despite some contradictory reports (14), most recent studies have confirmed the important role of Pilates training in improving physical fitness (15), body composition (16,17), and insulin resistance (18). However, limited research is available on the effects of these exercises on liver enzymes and liver fat content. According to our review, only Hagner-Derengowska et al evaluated the effects of Pilates training on ALT and AST enzymes in obese postmenopausal women and found that ALT and AST enzymes did not significantly change after 10 weeks of Pilates training in these women despite a significant reduction in body weight and body mass index (BMI) (11). Therefore, it is still unclear whether these exercises have any effects on the liver fat content and enzyme levels of ALT, AST, and ALP in middle-aged men with NAFLD. Considering the increasing prevalence of NAFLD, the widespread acceptance of Pilates training, and limited information about the effects of this type of exercise on the characteristics of NAFLD, the present study aimed at investigating the effects of eight weeks of Pilates exercise on the liver fat content and liver enzymes of the men who suffered from NAFLD.

Materials and Methods

Subjects

In this semi-experimental study with a pretest-posttest control-group design, the statistical population consisted of men with NAFLD from Qazvin, Iran. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the human research committee of the institution. The sample was recruited by advertising in medical and administrative centers and the study sample included 20 men with NAFLD (31-49 years). The main inclusion criterion was the diagnosis of steatosis grade 1 or higher (>5% triglyceride), which was confirmed via ultrasonography with an acceptable diagnostic accuracy. On the other hand, the exclusion criteria included being afflicted with genetic, metabolic, and endocrine diseases, consuming alcohol, having cardiovascular and respiratory diseases, as well as using lipid-lowering drugs or dietary supplements and the lack of regular exercise in the past six months.

Further, the sample size was determined based on previous studies, using the infinite population formula at

a 95% confidence level and the margin of the error of 5% (19). A total of 20 eligible candidates were selected through a purposive sampling method. Before the study, a full description was presented to the subjects about the study implementation and Pilates protocols. Next, the consent form, health questionnaire, and 24-hour dietary recall were completed by the participants. The participants were randomly divided into two homogeneous Pilates (n=10) and control (n=10) groups based on pre-test results.

Pilates training protocol

The Pilates protocol included 60 minutes of exercise (i.e., 10, 40, and 10 minutes of warm-up, Pilates training, and cool down, three times a week for eight weeks, respectively). The intensity of Pilates training gradually increased from basic levels to advanced stretching, muscular endurance, balance, flexibility, and musculoskeletal coordination training. Additionally, the exercises were focused on the upper and lower muscles of the upper trunk and performed in standing, sitting, and lying-down positions without any need for advanced equipment. The applied exercises included the fundamentals, as well as basic and intermediate Pilates exercises (Table 1).

To comply with the overload principle, the speed and repetition of movements in each session increased compared to the previous session, starting from 10 repetitions in the first week and reaching 20-25 repetitions in the eighth week. Similarly, the maximum heart rate formula (peak heart rate = 220 minus age) and a polar heart rate sensor were used to control exercise intensity. The exercises began in the first week at 50%-55% of the maximum heart rate and reached 75-80% of maximum heart rate in the eighth week (an increase of approximately 5% in exercise intensity per week). All training sessions were conducted under the supervision of an official trainer holding a certificate from the Pilates society of Iran. It should be noted that the control group did not engage in any sports activities or exercises during the study.

Anthropometric indices and body composition

One week before the study, the participants visited the Sport Sciences Laboratory of Imam Khomeini International University in Qazvin in order to be familiarized with the study tools and methods. Some anthropometric and body composition indices were measured before the training period and 48 hours after the final Pilates training session. Each participant's height was also measured using a Seca scale (Germany) with 0.01 accuracy. Moreover, waist and hip circumferences were measured using a tape measure and the waist-to-hip ratio was calculated as well. The weight and body fat percentage were also calculated based on bioelectrical impedance analysis using a body composition analyzer (ZEUS 9.9, Korea) according to the manufacturer's guidelines.

Table 1. Fundamentals, basic, and intermediate of Pilates exercises

Fundamentals	Basic	Intermediate
Breathing	Hundred	Hundred
Imprinting	Roll up	Roll up
Leg slides	Roll down	Langes
Spinal bridging	Single leg circles	Reverse crunch
Knee sway	Rolling like a ball	Teaser
Pelvic bowl	Basic squat	Single Leg Shoulder Bridge
Knee folds/stirs	Langes	Toe touches
Leg slides	Single leg stretch	RT-LT side crunch
Prone hip extension	Double leg stretch	Side plank
Cervical nod	Swimming	Plank
Head float	Leg pull front	Seal
Ribcage/angel arms	Saw	Corkscrew
Rotating arms	Legs up and down	Single leg stretch
Torso twist	Spine stretch forward	Single leg stretch
Flight		Single leg stretch
Cat		Single leg stretch
Bowing		

Hepatic fat content and liver enzymes

The hepatic fat content and serum levels of liver enzymes were measured before the training period and 72 hours after the final Pilates training session, followed by examining the liver fat content using an ultrasound system (Medison SonoAce X8, Korea). In addition, ultrasonography was performed by an expert at the Advanced Medical Imaging Center after at least five hours of fasting. Likewise, hepatic steatosis was graded from one to three representing a mild, moderate, and severe increase in echogenicity, respectively (20).

To determine the serum levels of liver enzymes (i.e., ALT, AST, and ALP), blood samples were collected from the antecubital vein after 8-12 hours of fasting and then poured into a test tube containing an anticoagulant. Next, the blood sample was centrifuged and the separated serum was stored at -70°C until further analysis. The levels of ALT and AST enzymes were also evaluated using quantitative detection kits (Pars Azmoon, Iran), based on the kinetic VV method in an Advia 1200 system (USA) according to the International Federation of Clinical Chemistry and Laboratory Medicine standards. Finally, the level of the ALP enzyme was determined using a quantitative diagnostic kit (Bionic), based on the photometric method according to

the German Society for Biochemistry standards in an Advia 1200 system (USA).

Statistical Analysis

After data collection, the normal distribution of data was evaluated by the Shapiro-Wilk test and means and standard deviations were measured for descriptive statistics. Further, paired and independent t-tests were used to examine intra- and inter-group differences, respectively. The significance level was set at 0.05 and all statistical analyses were performed in SPSS software, version 18.0 (SPSS, Inc. Chicago, Illinois, USA).

Results

The Shapiro-Wilk test was used to examine the normal distribution of data in different groups. The results indicated that the collected data had a normal distribution and the curve of the sample was assumed to be normal ($P > 0.05$). The anthropometric characteristics and body composition of the participants before and after Pilates training are presented in Table 2. Furthermore, the findings showed that eight weeks of Pilates training caused a significant reduction in the body weight, BMI, fat percentage, and the waist-to-hip ratio of middle-aged men with NAFLD,

Table 2. Characteristics of subjects before and after eight weeks Pilates training in two groups

Variables	Control (n=10)				Pilates (n=10)			
	Pretest	Posttest	Δ	P-value	Pretest	Posttest	Δ	P value
Age (y)	39.30 \pm 4.64	-	-	-	41.67 \pm 5.62	-	-	-
Height (cm)	173.40 \pm 4.81	-	-	-	174.11 \pm 6.33	-	-	-
Weight (kg)	82.10 \pm 7.44	82.50 \pm 7.47	0.4 \pm 0.84	0.16	83.21 \pm 6.16	80.33 \pm 6.28	-3.66 \pm 0.86*	<0.001
BMI (kg/m ²)	27.39 \pm 3.40	27.52 \pm 3.41	0.13 \pm 0.28	0.18	27.57 \pm 2.54	26.56 \pm 2.52	-1.21 \pm 0.30*	<0.001
Body fat (%)	23.68 \pm 2.32	23.74 \pm 2.31	0.06 \pm 0.18	0.34	24.45 \pm 2.50	22.74 \pm 2.09	-1.71 \pm 0.61*	<0.001
WHR (ratio)	0.91 \pm 0.01	0.91 \pm 0.01	0.003 \pm 0.006	0.39	0.93 \pm 0.02	0.91 \pm 0.01	-0.03 \pm 0.01*	<0.001

Note. Values are presented as mean \pm SD.

SD: Standard deviation; BMI: body mass index; WHR: Waist-to-hip ratio.

* $P < 0.01$ indicates the significant difference between control and Pilates Training.

while no significant changes were observed in the control group (Table 2).

Based on the results, the liver fat content, which was evaluated via ultrasonography, significantly decreased in the Pilates group after eight weeks of training, whereas no significant change was found in the control group in this regard (Figure 1). Therefore, the results revealed a significant difference between Pilates and control groups with respect to the posttest liver fat content ($P=0.001$) and the range of changes ($P=0.019$).

Regarding the level of liver enzymes, the results demonstrated that all three enzymes (i.e., AST, ALT, and ALP) significantly reduced in the Pilates group after eight weeks of training ($P=0.04$, $P=0.05$, $P=0.02$, respectively), while no significant changes were observed in the control group. Accordingly, there was a significant difference between the Pilates and control groups regarding the posttest serum levels of AST, ALT, and ALP and the range of enzyme changes (Table 3).

Discussion

Considering the importance of sports activities in the treatment of patients with NAFLD, it is essential to identify the most effective exercises for these patients. The present study was conducted to investigate the effect of eight weeks of Pilates training on the liver fat content and liver enzymes of middle-aged men with NAFLD.

The results indicated that eight weeks of Pilates training significantly reduced the liver fat content (decreased liver steatosis grade) in middle-aged men with NAFLD ($P=0.001$). The grade of liver steatosis decreased in 31% of subjects in the Pilates group. Additionally, the reduction of liver fat content was associated with a significant decrease in the serum levels of ALT, AST, and ALP following eight weeks of training ($P=0.04$, $P=0.05$, and $P=0.02$, respectively). More precisely, the serum levels of ALT, AST, and ALP enzymes in the Pilates group showed 17%, 14%, and 7% reductions, respectively. In the present study, the Pilates exercises often involved flexibility, balance, and muscular endurance activities, with 10-25 repetitions at a relative intensity of 55%-75% of the maximum heart rate.

Although limited research is available on the effects of Pilates training in patients with NAFLD, the majority of previous studies incorporating aerobic or resistance training have indicated the positive effects of these trainings

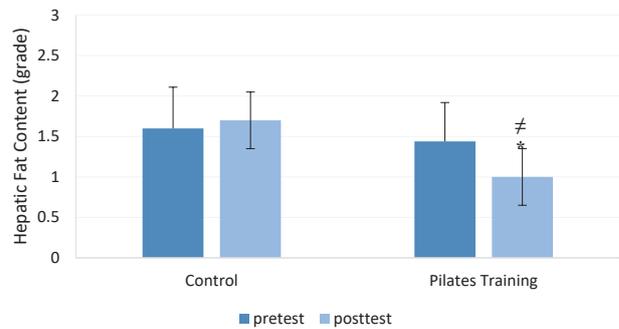


Figure 1. Hepatic fat content in the control and Pilates groups before and after eight weeks of Pilates training.

Note. * $P<0.05$ and * $P<0.01$ indicate significant differences between pre and post training, as well as control and Pilates training.

on reducing the liver fat content and liver enzymes. In this regard, Houghton et al. showed that 12 weeks of combined exercise training reduced the liver fat content, as well as ALT and AST levels in patients with NAFLD (16). Similarly, Hallsworth et al reported that 12 weeks of cycling significantly reduced the fat mass and ALT and AST levels in patients with NAFLD (21). Moreover, Haus et al concluded that even short-term exercises could improve the liver fat content in NAFLD patients and thus reduced the risk of disease progression (22). Although the exact mechanism contributing to the increased liver fat content and liver enzymes after exercise training remains unclear, evidence suggests that aerobic and muscular endurance training can improve NAFLD through the activation of lipolysis, the regulation of UCP-1 and PPAR γ , and the changes in adipocytokines (23). In a review study, Guo et al. argued that aerobic training could be effective in improving NAFLD by stimulating lipid metabolism, along with the inhibition and modulation of oxidative stress, inflammation, and liver apoptosis (24).

Limited studies have examined the effect of Pilates training on the grade of liver steatosis and liver enzymes, although the mechanism of the effect of Pilates exercise on NAFLD remains unclear. However, these exercises may reduce the liver fat content and serum levels of ALT, AST, and ALP in patients with NAFLD by improving insulin resistance, body composition, and physical fitness. In

Table 3. Liver enzyme changes before and after eight weeks of Pilates training in two groups

Variables	Control (n=10)			Pilates (n=10)		
	Pretest	Posttest	Δ	Pretest	Posttest	Δ
ALT (U/L)	31.30 \pm 5.90	31.70 \pm 6.78	0.40 \pm 1.26	28.88 \pm 3.98	24.11 \pm 2.61*	-4.77 \pm 1.78*
AST (U/L)	23.80 \pm 3.01	24.20 \pm 2.89	0.40 \pm 0.84	24.1 \pm 3.87	20.77 \pm 4.11*	-3.21 \pm 2.1*
ALP (U/L)	157.55 \pm 53.41	157.77 \pm 69.60	0.22 \pm 2.27	154.63 \pm 26.82	145.44 \pm 45.30*	-10.33 \pm 6.04*

Note. Values are presented as mean \pm SD.

ALT: alanine amino transferase; AST: aspartate amino transferase; ALP, alkaline phosphatase.

* $P<0.01$ and * $P<0.05$ represent significant differences between pre and post training, as well as control and Pilates training.

this regard, Church et al. reported that there is a direct relationship between the plasma ALT level of patients with NAFLD and their BMI and abdominal circumference (25). In the present study, Pilates training was associated with a significant reduction in weight, BMI, fat percentage, and the waist-to-hip ratio of the patients. Therefore, a reduction in the liver fat content and enzyme levels in this study can be attributed to the improvement of these indices, which is often related to improved insulin resistance. In the present study, the emphasis on muscular endurance training with frequent repetitions (a 55%-75% of maximum heart rate) also increased the oxidation of fatty acids in the adipose tissues, as well as muscle and liver cells (26). Given that the emphasis of Pilates exercises is to strengthen the deep muscles of the body by improving mental concentration and breathing rhythm, our results indicating the improvement of liver indices in NAFLD patients can be related to the activation of glucose transporter type 4 and AMP-activated protein kinase in the muscles (23). However, Hagner-Derengowska et al found that 10 weeks of Pilates training had no significant effects on the serum levels of ALT and AST enzymes in obese and overweight women, which contradicts the results of the present study. Nevertheless, body weight, BMI, and the serum triglyceride level decreased significantly after 10 weeks of Pilates training (11). Some causes of discrepancies between the present results and the findings of the above-mentioned study may be attributed to age and gender differences, as well as the intensity of Pilates training. The participants in the study conducted by Hagner-Derengowska et al were elderly women with an average age of 60.9 years, who were mostly in the postmenopausal period, while the participants of the present study included middle-aged men with an average age of 40 years. Evidence suggests that the prevalence of unhealthy lifestyle behaviors (e.g., a sedentary lifestyle) is higher at an older age. In fact, the highest prevalence of NAFLD has been reported in the age group of 50-65 years (27). In addition, the prevalence of a fatty liver is somewhat higher among postmenopausal women due to the lower serum levels of estrogen (27). It seems that age and gender influence the effectiveness of Pilates training on liver enzymes and fat content, which is contradictory to the results of the study conducted by Hagner-Derengowska et al. In the present study, the number of exercise activities was high in each Pilates session (with 10-25 repetitions) and training continued for eight weeks. To conform to the overload principle, the intensity of training gradually increased every week. The training intensity in the final week reached about 75%-80% of the maximum heart rate. On the other hand, in the above-mentioned study, the intensity of overload in Pilates training was unknown and the energy expenditure of every Pilates session was reported to be 400 kcal, which is suggestive of mild- to moderate-intensity training. Therefore, the intensity and duration of Pilates training had no significant effects on the levels of

ALT and AST enzymes in elderly women. According to Hagner-Derengowska et al, both ALT and AST enzymes in the Pilates group diminished insignificantly. Of course, this should be taken into account that Keating et al in a meta-analysis showed that exercise training has significant benefits for patients with a fatty liver, without causing any changes in the serum level of the ALT enzyme. The benefits of exercise training were confirmed, while the body weight of patients with NAFLD was unchanged or demonstrated a minimal change (28).

The present study has certain limitations. First, considering the main inclusion criteria of our study, the number of examined patients and the sample size were limited; therefore, further research with a larger sample size is needed to increase the external validity of our findings. Further, ultrasonography was used rather than a liver biopsy, which is the gold standard for measuring a fatty liver (29) according to the guidelines of the American Association for the Study of Liver Disease. It is indicated that although the diagnostic accuracy of ultrasound is about 93% when liver steatosis is greater than 33%, its sensitivity reduces if liver steatosis is below 30% (30,31). It should be noted that liver biopsy is an invasive and costly technique and most patients are reluctant to undergo biopsy due to the possible side effects. Furthermore, the subjects were advised not to change their normal diet (in some cases, it was tried to control their diet using a 24-hour dietary recall), although it was impossible to control and maintain their diet during the study. Therefore, the consumption of some foods such as coffee, tea, soy, as well as vitamins A and E supplements might have affected our results.

Conclusion

Based on the results of the present study, Pilates training can be effective in improving the liver fat content and reducing the serum levels of ALT, AST, and ALP in middle-aged men with NAFLD. Therefore, this type of training can be used as a therapeutic approach for these patients. Furthermore, Pilates training helps to improve body composition and anthropometric indices in patients with NAFLD and can play a role in the management of this condition. Finally, the positive effects of this particular type of exercise program can be interesting for the physicians, patients, and designers of training programs, although further research is necessary to confirm our findings.

Conflict of Interests

The authors declare that there is no conflict of interests.

Acknowledgments

This article was extracted from a Master's thesis in Sports Physiology by Ziba Keymasi in 2019 (No. 98/16526202). The authors would like to thank all the participants of this study.

Ethical Statement

All principles of ethical human research were considered in this study. Furthermore, the subjects were aware of all aspects of the

research and could withdraw from the project at any time. Moreover, all research stages were approved by the Ethics and Research Committee of Allameh Gazvini University (No. 1002/28/P/98/2).

Authors Contribution

Ziba Keymasi, Abbas Sadeghi and Hassan Pourrazi: Study Design; Manuscript Preparation and Literature Search. Ziba Keymasi: Data Collection. Abbas Sadeghi and Hassan Pourrazi: Data Interpretation. Hassan Pourrazi: Statistical Analysis

Informed Consent

All principles of ethical human research were considered in this study. Furthermore, the subjects were aware of all aspects of the research and could withdraw from the project at any time.

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