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Effects of Nordic Walking and Pilates training programs on aminotransferase activity in overweight and obese elderly women

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ABSTRACT

Background & Aims: Elevation of alanine (ALT) and aspartate aminotransferase (AST) activities may appear as liver injury due to fat storage and other enzyme sources, such as rhabdomyolysis. Elevated ALT is associated with all-cause and cardiovascular mortality in an elderly population. The aims of this study was to determine the effect of a 10-weeks training program on the serum activity of these enzymes in postmenopausal women with overweight and obesity.

Methods: The study comprised 81 postmenopausal women with overweight and obesity: 34 (42%) of whom completed a 10-weeks Nordic Walking (NW) rehabilitation program, 27 (33%) of whom completed a Pilates rehabilitation program, and 20 (25%) of whom were the control group. Blood for testing for ALT, AST, and other parameters of metabolic syndrome was collected before the program commenced and after it finished.

Results: Elevated (> 34 U/l) ALT and AST activities presented in 9 (11%) and 7 (9%) of the patients, respectively. A reduction in ALT and AST activities was observed in 43 (53%) of the subjects, and in 61%, 59% and 40%, and 47%, 63% and 50% of the individuals who completed the NW and Pilates programs and were in the control group, respectively.

Conclusions: The outcome of the training programs on aminotransferase serum activities in postmenopausal women with overweight and obesity was individually different and not related to exercise type.

Keywords: alanine aminotransferase, aspartate aminotransferase, obesity, Nordic Walking, Pilates.

BACKGROUND

Alanine (ALT) and aspartate aminotransferase (AST) are enzymes that take part in many metabolic processes. An elevation in their blood activities is frequently recognized as a liver injury marker, but they may also be found in the heart, brain, kidney, or muscles. In study by Villegas et al. [1], 11.13% and 5.85% of the participants had elevated serum ALT and AST levels, respectively. Viral hepatitis, metabolic syndrome, hyperlipidemia and physical inactivity and a fatty liver are the major risk factors in an elevated serum ALT level [1-7]. The relation between aminotransferase activity and carbohydrate diet composition has also been reported. It shows a J-shaped curve with the lowest point (the J point) located at the 50-60% carbohydrate proportion of total energy intake [8].

Elevated ALT or other "liver enzymes" is associated with all-cause and cardiovascular mortality in an elderly population [9,10]. Such elevated levels had opposite associations with death from diabetes and ischemic heart disease (IHD) in a National Health and Nutrition Examination Survey (NHANES III) [11], where ALT level was positively associated with death from diabetes, but negatively linked with IHD unrelated to diabetes. Elevated serum gamma-glutamyl transferase (GGT) level has been proposed as a risk factor for IHD and associated with poor clinical outcome in acute coronary syndrome (ACS), probably due to the absence of coronary collateral vessels [12]. Serum GGT and ALT activities have been used to predict endothelial dysfunction in patients with non-alcoholic steatohepatitis (NASH) [13,14]. Moreover, "liver enzymes" have also been considered as a predictor of a new onset of depression in employees undergoing health screening examinations [15], markers of future development of metabolic syndrome [16], and insulin resistance in overweight and obese non-diabetic adults [17].

Obesity, overweight, physical inactivity, and metabolic syndrome are the most prevalent disorders in contemporary populations of developed countries. They are associated with non-alcoholic fatty liver disease (NAFLD), which is the most prevalent cause of hepatic injury and aminotransferase elevation and affects up to 27-30% of the population worldwide [18-22]. One of the most important therapeutic strategies for this disease is modulating insulin resistance and oxidative stress [10,18,19]. Although the future of NAFLD and NASH treatment has many promising agents, clinicians are currently faced with limited options, with an emphasis on lifestyle modification [23]. Weight reduction and/or exercise (aerobic or resistance) has improved hepatic dysfunction, liver function test level and insulin resistance in type 2 diabetic patients with NAFLD through reduction of inflammation, macrophage infiltration and oxidative stress, as well as via restoration of pancreatic beta-cell function and autonomic nervous system activity [10,19,22,24-30]. Such effects were also observed in postmenopausal women [31]. On the other hand, it should also be taken into consideration that excessive muscular activity during strenuous exercise is the leading, but frequently overlooked, cause of rhabdomyolysis in healthy people. This disorder may lead to elevation of the serum activity of aminotransferases and to the suspicion of hepatitis [32].

AIMS

The aim of this study was to compare the effect of 10-week Nordic Walking and Pilates training programs on aminotransferase serum levels in healthy postmenopausal women with overweight or obesity.

METHODS

Participants

The study was designed as an experimental, non-randomized prospective controlled trial. Eighty-one postmenopausal women with overweight or obesity with a mean age of 60.9 (95% confidence interval [CI]: 59.1-62.6 y; range: 50-70 y) were included into the investigation. The inclusion criteria for the study were: female gender, age 50-75 y, natural cessation of menstruation, and overweight or obesity. The exclusion criteria were: known liver disease, abnormalities in liver ultrasonography, diabetes mellitus, mental illness, cancer, age under 50 y, body mass index (BMI) below 25 kg/m^2, and irregular participation in the training program.

Patients were recruited by open access through notices placed in outpatient clinics and published in newspapers, as well as during health promotion classes at Bydgoszcz University entitled ‘An active senior citizen’. None of the patients suffered from serious somatic (including diabetes mellitus) or mental diseases. In addition, patients who participated in the study did not take any medication other than metabolically neutral hypotensive drugs, diet supplements containing electrolytes or those affecting the gas-base balance, and did not change their medication during the study period.

Equipment and protocol

The primary intervention of the experiment was one of two rehabilitation programs: Nordic Walking (NW) and Pilates [33-40]. Rehabilitation was carried out under a trainer's supervision (three times a week) and at home without the trainer's guidance. Meetings took place three times a week for 10 weeks (in total: 30 sessions, 60 minutes each, and the same amount of exercise at home). Prior to commencing the program, training in the chosen rehabilitation technique was carried out and participants were tested on their mastery. All the participants mastered the exercise rules. A warm-up was organized before each training session. For the NW group, the average daily distance amounted to 3.6 km initially. As progress in rehabilitation was made and exercise tolerance improved, the average daily distance increased to 4.8 km. The average estimated energy expenditure for each NW session amounted to 428 kcal, and to 402 kcal for each Pilates session. All the patients completed the full rehabilitation program.

During the entire period of the study, each woman was on the same diet (meals consumed in catering establishments). The participants' daily diet consisted of five meals with a total caloric value of 1,500 kcal. Energy sources were allocated as follows: complex carbohydrates = 50%, fat = 30%, and protein = 20%. During rehabilitation, the participants did not change their medicine, as this could otherwise have influenced the studied parameters. The patients did not take any dietary supplements.

All the participants underwent a medical examination at the beginning and at the end of the study. During these examinations, anthropometric parameters (weight, height, BMI) were evaluated and blood was collected for biochemical investigation. Serum ALT and AST activities, their ratio (AST/ALT, known as the De Ritis ratio), as well as markers of metabolic syndrome, such as serum glucose, high-density lipoprotein (HDL) cholesterol, triglycerides, and uric acid, were determined before and after finishing the rehabilitation program. The measurement of biochemical parameters was performed based on blood serum collected in the morning, before training, from the cubital fossa vein, with minimum tourniquet pressure, 14 hours after the last meal and after 15 minutes of rest. All biochemical investigations were carried out at the same laboratory.

Measured outcomes (end points)

The primary end point was a change in serum aminotransferase levels after the rehabilitation program. Secondary outcomes were the relationships between changes in the respective analyzed parameters. Absolute and relative (percentile, proportional) changes and their absolute magnitude for each parameter's value were also calculated.

Bioethical Commission

The study was carried out after the Bioethical Commission of the Nicolaus Copernicus University in Toruń, Ludwik Rydygier Collegium Medicum in Bydgoszcz, granted its consent (No. KB/340/2007) in June 2007 and continued its approval (No. KB/602/2011) in September 2011. Each patient expressed her consent regarding participation in the study in writing. The study was carried out in conformity with the Declaration of Helsinki.

Statistical analysis

The results were presented as a mean value and 95% confidence interval (95% CI), as well as the number of patients (n) or percentage of patients depending on the variable (quantitative or qualitative). Absolute magnitudes of absolute and proportional changes in ALT, AST, and the AST/ALT ratios were also calculated to verify the maximal differences in the studied liver function tests independently from their direction. A comparison of the significance of the values of the studied parameters was carried out with the ANOVA method with a post-hoc test of Fisher's least significant difference (for parametric variables) and a Kruskal-Wallis ANOVA by Ranks and with Median Test. In addition, the percentage of patients with abnormal ALT and AST values was calculated. A comparison of the significance of differences within the scope of the size of the groups was carried out using a non-parametric Chi^2 test. Spearman's rank correlations were calculated. The logistic regression method was also used. A licensed version of STATISTICA 10.0 for Windows was utilized.

RESULTS

Of the 81 study participants, 34 (42%) completed a 10-week NW rehabilitation program, 27 (33%) followed a Pilates program, and 20 (25%) formed the control group. There were only a few statistically significant differences between the groups as far as the initial and final values of the studied parameters were concerned (Table 1). For the whole of the group studied, the initial ranges of ALT and AST were 12-70 U/l and 15-58 U/l, respectively, and, after finishing the training programs, amounted to 5-60 U/l and 15-49 U/l, respectively. At the start of the study, ALT and AST activities were elevated above the laboratory norm (> 34 U/l) and presented in 9 (11%) and 7 (9%) of the patients, respectively. At the end of the study, increased ALT and AST were found in 6 (7%) of the patients. For this reason, the medians of every liver test calculated for all 81 persons were taken as discriminative values. Initially, and at the end of this study, patients from the NW and Pilates groups were found to have a greater prevalence of AST/ALT ratios elevated above the median and a less frequent increase in ALT in comparison to the control group. Changes in the percentages of patients with abnormal ALT, AST and AST/ALT values after finishing the training program were not significant (Table 1). Moreover, after finishing the training program, 19% of patients from the NW group with initial ALT serum activity below the median value presented a greater value of this enzyme, and in 39% of subjects with ALT values above the median its reduction had been achieved (p = 0.011). After finishing the NW training program, 33% of the patients moved from the group with AST activity above the median to the group with a lower AST value, and in 31% of subjects with a lower AST value an increase above the cut-off value (the median for the whole group) was found. In the postmenopausal women completing the Pilates training program and in the control group, the above-mentioned shifts concerned 20% and 10% of the groups, respectively.

After finishing the 10-week training program, the serum levels in the studied liver function tests did not change significantly, in spite of a simultaneous and significant decrease in body weight, BMI, glucose and triglycerides observed in the NW group and in the Pilates (with the exception of glucose) group (Table 1). The values of the determined parameters did not change in the control group. At the end of the study, the patients who had completed the NW training program had a significantly greater De Ritis ratio and HDL serum concentration and lower triglyceride concentration than the control group. In the patients finishing the Pilates rehabilitation program, greater values were found for the De Ritis ratios, glucose, HDL cholesterol and uric acid than in the control group (Table 1).

Table 1. Values for the examined parameters before and after finishing a training program for the respective patient groups.

Parameter	**Nordic Walking (n = 34)**			**Pilates (n = 27)**			**Control group (n = 20)**		
	At the beginning of the study	**At the end of the study**	***P***	**At the beginning of the study**	**At the end of the study**	***P***	**At the beginning of the study**	**At the end of the study**	***P***
ALT (U/l)	24.6; (22.1, 27.1)	22.1; (19.8, 24.4)	*0.039*	25.5; (22.2, 28.7)	23.3; (20.2, 26.3)	*0.24*	25.0; (21.9-28.1)	25.2; (22.8, 27.6)	*0.73*

ALT > 34 U/l (n; %)	3 (9%)	4 (12%)	*0.59*	4 (15%)	2 (7%)	*0.35*	2 (10%)	0 (0%)	*0.14*
ALT > median (U/l)	13 (38%) +	12 (35%) +	*0.79*	16 (59%)	14 (52%)	*0.60*	13 (65%)	15 (75%)	*0.49*
AST (U/l)	25.5; (23.6, 27.4)	24.3; (22.6, 25.1)	*0.11*	25.7; (23.1, 28.3)	24.6; (21.8, 27.5)	*0.33*	22.8; (20.8, 24.9)	22.5; (20.4, 24.6)	*0.77*
AST > 34 U/L	2 (6%)	2 (6%)	*1.0*	5 (19%) *	4 (15%)	*0.69*	0 (0%)	0 (0%)	*1.0*
AST > median (U/l)	18 (53%)	13 (48%)	*0.68*	13 (48%)	13 (48%)	*1.0*	10 (50%)	11 (58%)	*0.61*
AST/ALT	1.13; (1.02, 1.25) *	0.7; (0.5, 0.9) +	*0.26*	1.1; (0.9, 1.2) *	0.48; (0.2, 0.7) *	*0.38*	0.9; (0.8, 1.1)	0.2; (0.0, 0.4)	*0.40*
AST/ALT > median	21 (62%)*	24 (71%) +	*0.43*	13 (48%)	13 (48%) *	*1.0*	7 (35%)	4 (20%)	*0.28*
Weight (kg)	81.5; (76.5, 86.6)	76.1; (71.0-81.2)	*0.0001*	80.5; (76.4, 84.5)	79.2; (75.3, 83.2)	*0.0001*	77.9; (74.2, 81.7)	78.3; (74.5, 82.0)	*0.22*
BMI (kg/m^2)	30.5; (28.7, 32.2)	29.4; (28.2-30.6)	*0.0001*	31.2; (29.8, 32.7)	30.4; (29.4, 31.4)	*0.001*	28.9; (27.8, 29.9)	28.9; (27.9, 30.0)	*0.28*
Glucose (mg/dl)	98.8; (94.6, 103) #	96.3; (92.2, 100.3) #	*0.001*	106.3; (99.9, 112.6) #	103.5; (98.1, 108.8) # *	*0.056*	100.5; (91.9, 109.1)	100.2; (93.4, 107.0)	*0.87*

HDL (mg/dl)	55.3; (52.3, 58.2) *	59.4; (54.0, 64.6)*	*0.25*	57.5; (54.7, 60.2) *	58.5; (52.8, 64.1) +	*0.78*	47.2; (43.6, 50.9)	46.5; (42.7, 50.3)	*0.34*
TG (mg/dl)	132.0; (103.5, 161)	107.4; (92.6, 122.1)*	*0.019*	135.1; (114.5,155.6)	118.2; (102.2, 134.1)	*0.016*	127.3; (116.2, 138.4)	129.1; (119.0, 139.2)	*0.51*
Uric acid (mg/dl)	5.1; (4.7, 5.5)	5.0; (4.6, 5.5)	*0.47*	5.3; (4.8, 5.8) *	5.3; (4.9, 5.7) +	*0.94*	4.6; (4.1, 4.9)	4.6; (4.3, 4.9)	*0.47*

Annotation: data were presented as a mean value; (95% confidence interval, 95% CI); ANOVA post-hoc test: least significant difference; * = $p < 0.05$: the difference in values in relation to the control group; + = $p < 0.001$: the difference in values in relation to the control group; # = $p < 0.05$: the difference in values between the NORDIC WALKING and the PILATES groups; ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; HDL = high-density lipoprotein cholesterol; TG = triglycerides; the median for ALT, AST, and AST/ALT ratios at the beginning of the study amounted to 22.8 U/l, 24.3 U/l, and 1.02, respectively, and the median for ALT, AST and AST/ALT ratios after finishing the investigation amounted to 22.4 U/l, 22.8 U/l, and 1.07, respectively.

The differences in the levels at the end in comparison with those at the beginning of the study (delta) and proportional changes in ALT, AST and AST/ALT ratios as well as their absolute magnitudes during the rehabilitation program were individually diversified (Table 2). During the time of the study, both decreases and increases in ALT (range: -31.8-14.7 U/l; -83.7-83.5%) and AST (range: -20.5-12.6 U/l; -50.1-65.0%) were observed. The statistical significance of the deltas for the studied parameters were found only for absolute magnitudes of De Ritis ratio changes (between the NW and Pilates groups) as well as for absolute magnitudes of ALT differences between the study beginning and finishing between patients who completed either of the two training programs and the control group (Table 2). The absolute magnitude of the proportional change in ALT activity was significantly greater only in the NW in comparison to the control group (Table 2). Reduction in ALT activity was observed in 43 (53%) of all subjects, and in 19 (61%), 16 (59%) and 8 (40%) of the individuals in the groups who completed the NW and Pilates training programs and in the control group, respectively (p = 0.38). Similarly, a decrease in AST activity after the study finished was observed in 42 (53%) of all the subjects, and in 16 (47%), 17 (63%) and 10 (50%) of the patients from the respective study groups (p = 0.44). The De Ritis ratio increased in 42 of all the subjects (52%), and in 20 (59%), 13 (48%), and 9 (45%) of the subjects in the other groups, respectively (p = 0.55). Patients with an increase or reduction in liver function test during the study did not differ in accordance with the values of the analyzed clinical, anthropometric and biochemical parameters (detailed data not presented).

The above-mentioned differences in liver function tests were accompanied by simultaneous significant improvement in values for body weight and BMI, glucose and triglycerides (Table 2).

Table 2. The relative and proportional differences and their absolute values for the examined liver function tests and the other examined parameters in the three study groups.

Parameter	**Nordic Walking (n = 34)**	**Pilates (n = 27)**	**Control group (n = 20)**
Mean delta of ALT (U/l)	-2.15; (-5.3, 1.0)	-2.21; (-6.0, 1.6)	0.24; (-1.1, 1.6)
Median and range of absolute delta of ALT changes (U/l)	4.6; (0, 31.8) *	3.9; (0.1, 27.6) *	2.0; (0.2, 5.3)
Proportional ALT change (%)	-3.4; (-14.3, 7.6)	-2.5; (-16.8, 11.8)	3.32; (-3.1, 9.7)
Median and range of absolute proportional ALT change (%)	21.0; (0, 83.7) *	18.7; (0.5, 83.5)	6.7; (0.6, 27.6)
Mean delta of AST (U/l)	-1.1; (-3.1, 0.99)	-1.09; (-3.3, 1.2)	-0.23; (-1.8, 1.4)
Median and range of absolute delta of AST changes (U/l)	2.7; (0.1, 20.5)	3.0; (0.2, 17.2)	2.2; (0.1, 8.3)

Proportional AST change (%)	-1.4; (-8.4, 5.6)	-2.6; (-10.9, 5.7)	0.16; (-8.1, 8.5)
Median and range of absolute proportional AST change (%)	11.3; (0.5, 62.7)	13.1; (0.6, 65.0)	9.3 ± (0.5, 57.2)
Delta of AST/ALT ratio	0.1; (-0.08, 0.3)	0.1; (-0.1, 0.3)	-0.04; (-0.1, 0.05)
Median and range of absolute delta AST/ALT	0.11; (0.01, 2.9)	0.08; (0.01, 2.1)	0.12, (0.1, 0.4)
Proportional AST/ALT change (%)	15.9; (-6.4, 38.1)	17.4; (-8.3, 43.0)	-1.7; (-10.8, 7.4)
Median and range of absolute proportional AST/ALT ratio	9.2; (0.1, 343.4) +	17.5; (0.9, 260.8) +	14.0; (1.0, 39.0)
Delta of body weight (kg)	-5.4; (-6.4, -4.4) +*	-1.2; (-1.7, -0.8) +*	0.3; (-0.2, 0.9)
Proportional weight change (%)	-6.8; (-8.1, -5.5) +*	-1.5; (-2.0, -1.0) +*	0.4; (-0.3, 1.2)
Delta of BMI (kg/m^2)	-2.0; (-2.3, -1.7) +*	-0.5; (-0.6, -0.3) +*	0.1; (-0.1, 0.3)
Proportional BMI change (%)	-6.8; (-8.0, -5.5) +*	-1.6; (-2.0, -1.1) +*	0.4; (-0.3, 1.1)
Delta of glucose (mg/dl)	-2.5; (-6.1, 1.0)	-2.8; (-5.2, -0.3)	-0.3; (-3.9, 3.3)
Proportional glucose change (%)	-2.0; (-5.3, 1.3)	-2.2; (-4.3, 0.04)	0.6; (-3.3, 4.4)
Delta of HDL (mg/dl)	1.6; (-1.2, 4.5)	0.3; (-2.0, 2.6)	-0.7; (-2.2, 0.8)
Proportional HDL change (%)	3.9; (-1.5, 9.5)	0.4; (-3.6, 4.4)	-1.3; (-4.5, 1.8)
Delta of TG (mg/dl)	-24.7; (-45.0, -4.3)	-16.9; (-30.4, -3.4) *	1.8; (-3.7, 7.3)
Proportional TG change (%)	-9.6; (-18.2, -1.0) *	-8.9; (-17.8, -0.03) *	2.2; (-2.1, 6.5)

Delta of uric acid (mg/dl)	-0.1; (-0.3, 0.2)	-0.01; (-0.3, 0.3)	0.1; (-0.1, 0.3)
Proportional uric acid change (%)	-1.2; (-6.3, 3.9)	2.4; (-4.6, 9.4)	3.1; (-2.5, 8.7)

Annotation: data were presented as a mean value; (95% confidence interval, 95% CI); and for absolute values as a median ± range (for liver tests only); + = $p < 0.05$: statistical significance of the difference between the Nordic Walking and the Pilates groups (ANOVA and the least significant difference post-hoc test; * = $p < 0.05$: the difference between the Nordic Walking or the Pilates group and the control group; delta of parameter = absolute difference in the final and initial values of a particular parameter; proportional parameter change = relative difference in the final and initial values of a particular parameter divided by the initial value, expressed as a percentage; absolute delta or absolute proportional changes = absolute values of respective deltas or percentages; BMI = body mass index; HDL = high-density lipoprotein cholesterol; TG = triglycerides.

The relationships between the values and changes in liver function tests and parameters of metabolic syndrome were calculated using Spearman's rank correlations. For the whole of the studied group, the values for ALT and AST and AST/ALT ratios and their absolute and proportional changes correlated as follows:

- initial ALT values correlated with initial body weight (R = 0.23; p < 0.05); BMI (R = 0.27; p < 0.05), initial glucose concentration (R = 0.31; p < 0.05), the following values for the variables after the training program had finished: body weight (R = 0.30; p < 0.05), BMI (R = 0.33; p < 0.05) and glucose (R = 0.23; p < 0.05); HDL cholesterol (R = 0.26; p < 0.05) and triglyceride (R = 0.22; p < 0.05) concentrations; delta of body weight (R = 0.26; p < 0.05); and delta of BMI (R = 0.22; p < 0.05). Values for the aforementioned parameters also correlated with the initial De Ritis ratios, as well as ALT levels and the De Ritis ratios after the training program had finished, with similar values for the R coefficient; however, values for AST, both initially and after the end of the observation period, did not correlate with any of the analyzed variables;
- the difference in ALT activity between the end and the beginning of the study (delta ALT) correlated significantly with the delta for HDL cholesterol (R = -0.22; p < 0.05);

- the delta AST and proportional changes in AST correlated with initial body weight ($R = 0.38$, $p = 0.04$, and $R = 0.23$, $p = 0.048$, respectively);
- the delta AST and proportional changes in AST (delta) correlated with delta HDL cholesterol ($R = -0.22$, $p < 0.05$).

In females who completed the NW training program, we found significant correlations between:

- initial ALT activity and initial BMI ($R = 0.39$; $p < 0.05$); glucose blood concentration ($R = 0.44$; $p < 0.05$); body weight ($R = 0.39$; $p < 0.05$) and HDL cholesterol concentration ($R = 0.35$; $p < 0.05$) after the training program had finished; as well as the delta for body weight ($R = 0.42$; $p < 0.05$) and BMI ($R = 0.40$; $p < 0.05$) during the training program.

DISCUSSION

In our study of postmenopausal women with overweight and obesity but without known liver disease, we tried to verify the effect of two training programs on serum aminotransferase activities as a surrogate marker of liver injury, in comparison with the physically inactive control group. In our investigation, elevated ALT and AST activities before the start of the training programs were found in 9-11% of the subjects, and in 7% after the end of the study. Angsuwathana et al. [41] made a similar observation, when they found abnormal liver function tests in 5.4-6.9% of 366 healthy postmenopausal women among 1,020 patients undergoing a health check-up program. However, in the study by Zhang et al. [7], the prevalence of elevated ALT amounted to 17.53% of 4,072 individuals from the general population in Northeast China. Elevated ALT occurred in males, subjects with a low education level, small businessmen with increased income, and in individuals with increased BMI and triglyceride serum concentrations who had NAFLD and/or metabolic syndrome [7].

In our study, the ALT, AST and AST/ALT ratios did not change significantly after the end of the rehabilitation program, whether in the whole group, in patients undergoing either of the rehabilitation programs (NW or Pilates), or in each of the respective study groups (Table 1). However, a decrease in ALT activity was observed in 61%, 59%, and 40% ($p > 0.05$) and a reduction in AST in 47%, 63%, and 50% of the patients from the NW, Pilates and control groups ($p > 0.05$), respectively. The average changes in ALT and AST were relatively small due to the individually diversified direction of liver test response in the observational period and the summarization of positive and negative deltas. However, the ranges of absolute magnitudes of difference between the initial and final values for aminotransferases were very wide and amounted to 167% and 115% for ALT and AST, respectively (Table 2). In other studies, changes in magnitudes for liver function tests after completing a rehabilitation program were apparently lower, but were performed with individuals who were ill. In work conducted by Al-Jiffri et al. [19] with 100 type 2 diabetic male patients with NAFLD, 26.99%, 40.8%, 33.81%, 32.73%, and 37.8% reductions in mean values of alkaline phosphatase (ALP), ALT, AST, and GGT after aerobic exercise training in addition to diet regimen were reported [19]. Straznicky et al. [42] reported that after 12 weeks of caloric restriction, ALT serum activity had significantly decreased by 20%, and then by 24% after caloric restriction was recommended in addition to moderate -intensity aerobic exercise training. The corresponding values for GGT reduction were 28% and 33%, respectively. The differences in liver enzyme values between these two regimens were not statistically significant. In this study, reduction in abdominal fat mass (measured by dual-energy X-ray absorptiometry [DXA]) independently predicted a negative delta for ALT and GGT, whereas a change in dietary saturated fat intake was independently positively associated with the delta for ALT (an increase in enzyme activity) [42]. In a study by Slentz et al., [43] aerobic training (such as NW) led to significant reductions in liver fat, visceral fat, ALT, homeostatic model assessment (HOMA), and total and subcutaneous abdominal fat. Whereas, resistance training (such as Pilates) resulted in a decrease in subcutaneous abdominal fat but did not significantly improve the other variables. Similar favorable effects of regular aerobic training programs with or without additional diet intervention on liver function were also reported by other authors [26,18,44]. However, a meta-analysis by Keating et al. [29] showed clear evidence of a benefit of exercise therapy on liver fat but not ALT levels. This benefit was achieved with minimal or no weight loss and at exercise levels below current exercise recommendations for obesity management [29].

In our study, we found an individually different response in ALT, AST and AST/ALT ratios for the 10-week observation period, both in patients undergoing a training program and in the control group (Table 2). More than half of the subjects in the respective study groups showed a reduction in liver function test values, but the others presented the opposite reaction. Moreover, we did not find any parameter, including body weight, BMI, HDL, triglycerides, glucose or uric acid [21], which would predict the type of reaction, either using simple or advanced (ANOVA, logistic regression) statistical tests. As a group effect (NW, Pilates, control) was not found, it is impossible to say if the observed changes in liver function tests were an effect of a rehabilitation program. It should also be emphasized that the observed changes in ALT, AST and AST/ALT ratio values might have resulted not only from potential liver improvement or injury (due to overtraining leading potentially to oxidative stress), but also from extra-liver sources of these enzymes, e.g., from skeletal muscle [32].

Such a possibility is suggested by the greater magnitudes of deltas and proportional changes in ALT values observed, as well as by only finding a weak correlation between ALT, AST and AST/ALT ratios and their derivatives and the values of metabolic syndrome parameters, in spite of the known relationships between liver function and insulin resistance and visceral adiposity. However, it is impossible to discuss our results along with those from other investigations due to the lack of a control group that did not undergo any intervention in the previously mentioned studies.

The main limitations of our study were a small number of subjects and a lack of objective liver morphology and function estimation at the beginning and end of the study.

CONCLUSION

The absolute magnitudes of the deltas and proportional changes in ALT values were significantly greater in patients undergoing rehabilitation programs than in the control group, but the desirable direction of the liver function test changes examined was similar in the three study groups. The response of serum ALT and AST activities to each of the two training programs was individually variable and no predictive factor of an improvement in their levels was found. Therefore, the outcome of training on aminotransferase serum activities in postmenopausal women with overweight and obesity should be further investigated.

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