Menopause: The Journal of The North American Menopause Society
Vol. 22, No. 11, pp. 1215-1223
DOI: 10.1097/GME.0000000000000446

Effects of Nordic Walking and Pilates exercise programs on blood glucose and lipid profile in overweight and obese postmenopausal women in an experimental, nonrandomized, open-label, prospective controlled trial

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Abstract

Objective: Cardiometabolic effects of physical exercise depend on its intensity, duration, and type. The aim of this study was to compare the effects of two exercise models, Nordic Walking (NW) and Pilates, on postmenopausal women.

Methods: The study comprised 196 overweight or obese women: 20 were advised to maintain their previous level of physical activity (control group) whereas the others started either an NW exercise program (n = 88) or a Pilates exercise program (n = 88). Blood was collected twice for testing: before the program commenced and after it had ended.

Results: Of the 196 women who enrolled in the study, 147 (75%) completed the study; among those women, 69 (47%) completed a 10-week NW exercise program, 58 (39%) completed a 10-week Pilates exercise program, and 20 (14%) were in the control group. After 10 weeks, women in the NW group showed a significant reduction in body weight (6.4%), body mass index (6.4%), blood glucose (3.8%), total cholesterol (10.4%), non-high-density lipoprotein (HDL) cholesterol (16.7%), low-density lipoprotein cholesterol (12.8%), and triglycerides (10.6%), as well as an increase in HDL cholesterol (9.6%). Significantly smaller—although still favorable—changes, except for glucose and HDL cholesterol levels, were observed in the Pilates group (decreases of 1.7%, 1.7%, 1.6%, 5.3%, 8.3%, 7.5%, and 6% and an increase of 3.1%, respectively). Nevertheless, at the end of the study, the percentage of women with target concentrations of the lipid fractions had significantly increased in both exercise groups. No significant changes in the studied parameters were found in the control group. On multiple regression analysis, type of exercise program was an independent predictor of amplitude changes in most of the studied parameters.

Conclusions: Exercise training in accordance with the NW model causes statistically and clinically more significant changes in glucose and basic blood lipid levels than do Pilates and dietary intervention alone.

Key Words: Nordic Walking – Pilates – Lipids – Glucose concentration – Cardiovascular risk factors.

During menopause, defined as the cessation of menstrual bleeding, numerous metabolic changes take place. The postmenopausal period is characterized by, for instance, a drop in the levels of estradiol and high-density lipoprotein (HDL) cholesterol and an increase in body weight (often with fat accumulating in the stomach area) and an increase in the concentrations of low-density lipoprotein (LDL) cholesterol or very-low-density lipoprotein and triglycerides (TG). The postmenopausal period is also diabetogenic, manifesting as decreased glucose tolerance. Each of these elements contributes to atherosclerotic processes and is a component of a potentially life-threatening or health-threatening disorder called the metabolic syndrome. Thus, intervention is necessary to decrease the harmful cardiometabolic effects of menopause, which include increasing body weight, dyslipidemia, and glucose intolerance. Both nonpharmacological (eg, dietary intervention and increased physical activity) and pharmacological recommendations are useful for treating these disorders.

Regular physical activity has many advantages.[1,2] It reduces not only the risk of cardiovascular events (including sudden cardiac death; by 20%-30%)[3] but also the degree of being overweight and obesity; diminishes the risk of

Received July 29, 2014; revised and accepted January 14, 2015.

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Funding/support: This study was supported by a grant from The Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University, for the statutory research activity of the Chair and Clinic of Rehabilitation.

Financial disclosure/conflicts of interest: None reported.

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hypertension, diabetes mellitus, and thromboembolic complications; improves exercise tolerance, blood lipid profile, and functions of the endothelium and microcirculation; exerts a positive influence on the hemostasis system; reduces the risk of muscle and bone disease; boosts immunity, sleep, and sexual function; and reduces the risk of cancer. In general, physical activity prolongs life. However, whether comparatively low-intensity physical activity (eg, Pilates) has a favorable prognostic effect on individuals who cannot meet the recommended criteria of moderate physical activity[3] because the dose-response relationship between fitness and cardiovascular and/or cardiometabolic risk is still undergoing debate.[3]

Some common ways of increasing physical activity include walking, jogging, swimming, cycling, and dancing. Increasingly, Nordic Walking (NW) is included in this group of activities.[4] NW is a combination of walking and cross-country skiing (ie, pushing oneself over the ground using poles).[4] The most important elements of this form of exercise include the following: thrusting the walking pole forward and placing the end of it on the ground, pushing oneself off with the arm holding the pole, and lifting one leg off the ground. These movements, combined with a fluent technique, influence the speed of walking and its effectiveness. NW uses 90% of all muscles in the body (including those of the lower and upper extremities), strengthens the muscles of the upper body and shoulders, and increases the mobility of the upper segment of the spine. Walking poles relieve stress from joints, straighten and relieve stress from the spine, and correct faulty posture by strengthening stabilizing muscles.[5,6] It expends approximately 400 kcal/hour (a normal walk burns approximately 280 kcal/h).[7,8] To date, 16 randomized studies (1,062 participants) and 11 observational studies (831 participants) of the clinical effects of NW have been performed. These studies have confirmed the positive effects of NW on resting cardiac heart rate, arterial blood pressure, exercise tolerance, exercise oxygen consumption, and quality of life in the course of various diseases in young,[9] middle-aged,[10] and older persons.[4,11-13] This model of exercise training, particularly when supervised,[14] improves claudication distance in women with atherosclerosis in the lower extremities[15]; fitness of women with Parkinson's disease[16,17]; low back pain[14,18]; symptoms of depression[19] and fibromyalgia[20,21]; and quality of sleep, body weight reduction, and exercise tolerance. However, whether NW reduces cardiometabolic risk, especially in relation to its effects on glucose tolerance and lipid profile, is still undergoing debate.[12,22-26]

On the other hand, Pilates is a system of physical exercise whose purpose is to stretch all muscles and make them flexible.[27] Pilates is a combination of yoga, ballet, and isometric exercises.[28] According to assumptions regarding this method, it is suggested to strengthen muscles without excessive muscle building, relieve the spine, improve posture, make the body more flexible, lower the level of stress, and, generally, improve the health of people who practice it. The breathing exercises that are part of the Pilates program also reduce stress. Moreover, this model of exercise training has beneficial effects on backache,[29-33] blood pressure,[34] cognitive impairment,[35] quality of life,[36] sleep quality,[37,38] and the fitness of women with heart failure,[39] multiple sclerosis,[40,41] Parkinson's disease,[42] ankylosing spondylitis,[43] and fibromyalgia.[44] However, no effects of exercises on body weight, carbohydrate metabolism, and lipid metabolism have been demonstrated.[45]

The main hypothesis of this study was that both types of exercise, dynamic (NW) and resistance (Pilates), influence cardiometabolic risk in postmenopausal women. The aim of this study was to assess the influence of physical training alone and to compare the effects of two exercise training models (NW and Pilates) on body weight and on the values of the basic parameters of carbohydrate and lipid metabolism in the blood of overweight and obese postmenopausal women.

METHODS

The study was designed as an experimental, nonrandomized, open-label, prospective controlled trial. The research program ran from 2007 to 2012, and data were collected during that time. Data analysis was conducted in 2013.

Initially, 196 participants joined the program. The inclusion criteria for the study were as follows: female sex, age 50 to 75 years, and overweight (body mass index [BMI] between 25 and 29.9 kg/m^2) or obesity (BMI $\geq$30 kg/m^2). The exclusion criteria were absence of menopause (still menstruating) and a history of diabetes mellitus, mental illness, or cancer.

Women were recruited by open access (through notices placed in outpatient clinics and published in newspapers) and during health promotion classes (titled "An active senior citizen") at Bydgoszcz University. Women who participated in the study did not take any medication other than metabolically neutral hypotensive drugs and did not change their medications during the study period.

Of the 196 participants, 88 (45%) were nonrandomly selected to be part of the NW group, 88 (45%) were chosen to be part of the Pilates group, and 20 (10%) were chosen to be part of the control group and advised to maintain their previous level of physical activity (Fig. 1). Of these women, 147 completed the study: the NW exercise program was completed by 69 women (47% of those who finished; mean [SD] age, 58.4 [5.8] y; range, 50-71 y), the Pilates program was completed by 58 women (39%; mean [SD] age, 58.6 [5.5] y; range, 50-69 y), and the control intervention (no exercise) was finished by all 20 members (14%; mean [SD] age, 59.0 [6.0] y; range, 51-69 y; Fig. 1). Age differences among the groups were not statistically significant. Forty-nine (25%) of the original participants were not included in the data analysis because they either did not finish the training program or did not take part in the control examination.

Intervention

The primary intervention of the experiment was one of two exercise training programs, NW or Pilates—the results of which were compared with each other and with the control

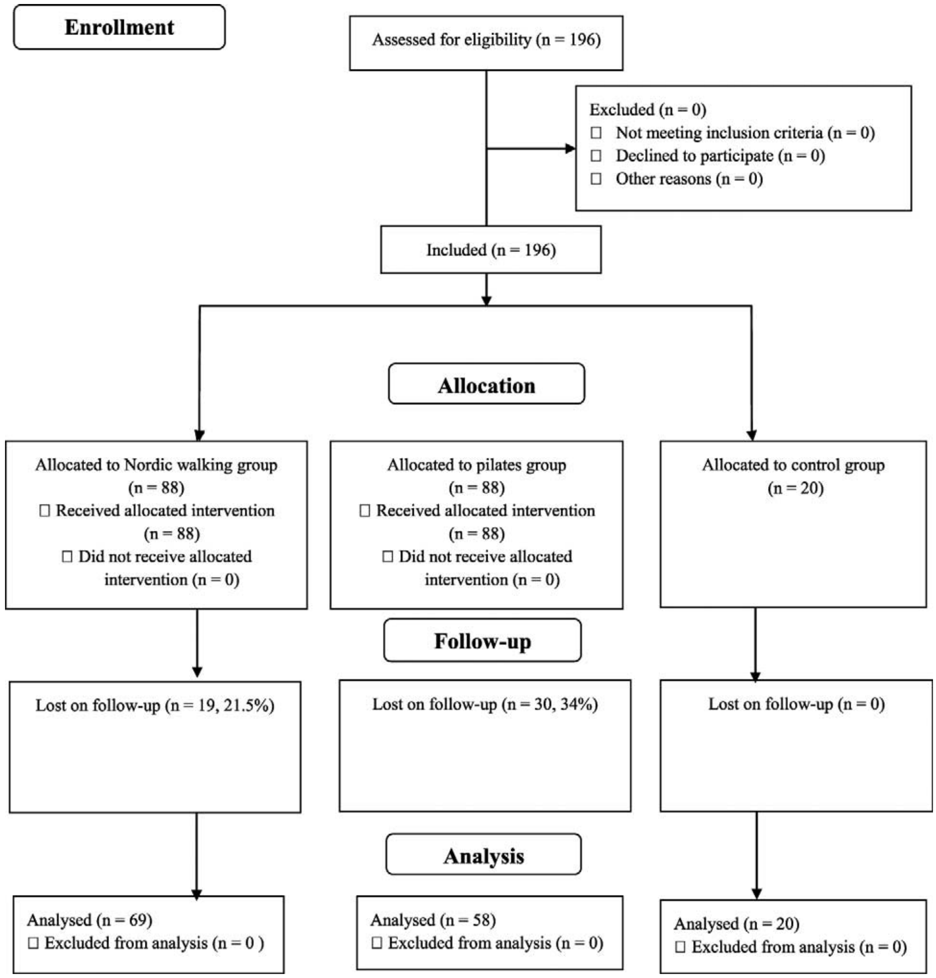

FIG. 1. Flow of women through the trial.

group, whose members did not undergo any active exercise training. Exercise training for both programs (NW and Pilates) was performed under a trainer's supervision three times a week and without the trainer's supervision at home. Meetings took place three times per week for 10 weeks (total: 30 sessions, 60 min each, and "homework" of the same amount). Before commencing the program, participants trained for the stated exercise technique and were tested on their mastery. All participants mastered the exercise rules.

Warm-up was organized before each training session. Cool-down was performed at the end of each session and was an integral part of the training. The average daily distance for participants in the NW exercise training model amounted to 3.6 km. Progress in exercise training was made, and exercise tolerance improved; by the end of the study, the average daily distance had increased to 4.8 km. Pilates exercise training was performed with the same frequency and duration as the NW model. The average energy expenditure of each session based on reference data was estimated to be 65 to 88 kcal (1.46 kcal/min for "going up front," 1.08 kcal/min for "arm springs," and 1.3 kcal/min for "footwork"). Exercise intensity was measured with POLAR M51.[4,7,8,27,33] The participants self-reported that they completed the exercise sessions outside the structured training programs. After each homework session, participants sent a text message to the instructor responsible for group training.

Members of the control group did not undergo exercise training and were advised to maintain their previous level of physical activity.

The second intervention, which was identical for all study participants, was a change in their previous diet. During the entire study period, each woman, including those from the control group, 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 established) and was determined by a dietician. Energy sources were allocated as follows: complex carbohydrates, 60%; fat, 20%; protein, 20%. Before commencement of the study, no participant took statins or other medicines that would influence lipid metabolism. During the exercise training program, the participants did not change any of the medicines they were taking that could have influenced the studied parameters. The women did not take any dietary supplements.

Measured outcomes (endpoints)

All of the participants' anthropometric parameters (weight, height, and BMI) and biochemical examinations were evaluated twice: once at the beginning of the study and once at the end of the study. The following biochemical parameters were examined: serum concentrations of glucose, total cholesterol (TC), LDL cholesterol, HDL cholesterol, and TG. Moreover, non-HDL (nHDL) cholesterol concentration (TC − HDL cholesterol concentration) was calculated. The biochemical parameters were measured based on blood serum collected (in the morning before training) from the cubital fossa vein, with minimal tourniquet pressure, and at least 14 hours after the last meal and after 15 minutes of rest. All biochemical investigations were performed at the same laboratory.

The effects of the exercise training programs were measured through changes in the above described values of anthropometric and biochemical parameters. The absolute and relative (percentile) changes in each parameter's values were calculated. We also checked whether women had achieved the target concentrations of plasma lipids as per the 2012 recommendations of the European Society of Cardiology, which indicated that lipid fractions in the blood of women with a moderate or low risk of cardiovascular event should have the following threshold values: TC lower than 190 mg/dL, LDL cholesterol lower than 115 mg/dL, nHDL cholesterol lower than 130 mg/dL, HDL cholesterol of 46 mg/dL or higher, and TG lower than 150 mg/dL.[3,46] In addition, percentile change in relevant BMI ranges was determined (underweight, $<18.5\,kg/m^2$; normal, $18.5\text{-}24.9\,kg/m^2$; overweight, $25\text{-}29.9\,kg/m^2$; obese, $\geq 30\,kg/m^2$).[3]

Bioethical Commission

The study was performed after the Bioethical Commission of Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University, granted consent (no. KB/340/2007) in June 2007 and gave permission to continue (no. KB/602/2011) in September 2011. Each woman expressed in writing her consent for participation in the study. The study was performed in conformity with the Declaration of Helsinki.

Statistical analysis

Sample size was not determined before the start of the study, and the number of participants in the groups resulted from the number of women who responded to the invitation to participate and went on to finish one of the exercise training programs. Women who began the study but did not finish the entire training program were excluded from the analysis, which was therefore performed as a "per-protocol" analysis. Results are presented as mean (SD) or as number (percentage) of women, depending on the type of variable (quantitative or qualitative). The normal distribution of all variables was evaluated using Shapiro-Wilk test. Statistical analysis was performed with a power of 0.9 and a P value less than 0.05. The significance of the values of the studied parameters was compared using analysis of variance and Fisher's least significant difference post hoc test. In addition, the percentage of women who achieved the recommended BMI and lipid levels was calculated. A comparison of the significance of the differences in parameters according to the size of the groups, in contrast, was performed with Fisher's exact test. A stepwise progressive method (forward selection) of multiple regression was used to determine the factors that affected proportional changes in the studied biochemical parameters (eg, TC% and LDL%) in the entire study group ($n = 147$). They were calculated with the following formula: 100% × [(value obtained at the end of the investigation − value obtained at the beginning of the investigation)/value obtained at the beginning of the investigation]. Dependent variables included proportional changes in blood TC, HDL cholesterol, nHDL cholesterol, LDL cholesterol, TG, and glucose (termed TC%, HDL%, nHDL%, LDL%, TG%, and glucose%, respectively). Independent variables included type of exercise (NW, Pilates, or control group); age; initial body weight, BMI, asparagine aminotransferase, alanine aminotransferase, glucose, TC, LDL cholesterol, HDL cholesterol, nHDL cholesterol, and TG; and proportional change in body weight and proportional change in BMI between values obtained at the end and at the start of the study. The order in which the independent variables were placed into each model was determined automatically by the statistical software. In every obtained regression equation, the determination coefficient (R^2) was calculated as a parameter to show the percentage of variance in the dependent variables explained by the model. A licensed version of Statistica 10.0 for Windows was used.

RESULTS

Of the 196 women who enrolled in the study, 49 (25%) dropped out mainly because of exercise program intolerance, and 127 (72%) of 176 women finished the entire training program (Fig. 1). Among women who completed the program, 69 (78%) of 88 completed a 10-week NW exercise training program, 58 (67%) of 88 followed a 10-week Pilates program, and 20 (14%) of 196 formed the control group. There were no significant between-group differences in the initial values of most of the studied parameters (Table 1). Participants of the NW and Pilates exercise programs had higher BMI and HDL cholesterol at the beginning of the study than women from the control group.

After completing the exercise program, women in the NW group showed a significant loss of weight (mean [SD], 6.4% [4.3%]) and decreases in BMI (6.4% [4.4%]), glucose (3.8% [10.6%]), TC (10.4% [13.1%]), nHDL cholesterol (16.7% [17.8%]), LDL cholesterol (12.8% [22.5%]), and TG (10.6% [23.4%]; Table 1). The increase in HDL cholesterol level (mean [SD], 9.6% [20.0%]) was not significant. Significantly smaller ($P < 0.05$)—although still favorable—changes (except for glucose and HDL cholesterol levels) were observed in the Pilates group: mean (SD) decreases in body weight, 1.7% (2.0%); BMI, 1.7% (2.0%); TC, 5.3% (11.9%); nHDL cholesterol, 8.3% (16.0%); LDL cholesterol, 7.5% (15.8%); and TG, 6% (27.2%); and an increase in HDL

TABLE 1. *Values of examined parameters and percentages of women meeting their target levels*

	Nordic Walking (n = 69)			Pilates (n = 58)			Control (n = 20)		
Parameter	Beginning of study	End of study	*P*	Beginning of study	End of study	*P*	Beginning of study	End of study	*P*
Weight, mean (SD), kg	84.3 (14.2)	78.9 (14.1)	<0.0001	81.1 (10.5)	79.8 (10.2)	<0.0001	77.9 (8.0)	78.3 (8.0)	ns
BMI, mean (SD), kg/m^2	31.4 (5.04)[a]	29.4 (5.1)	<0.0001	30.9 (3.8)[a]	30.4 (3.7)	<0.0001	28.9 (2.2)	29.0 (2.2)	ns
BMI category, n (%)									
Normal	0 (0)	16 (23)	<0.0001	0	0	<0.0001	0	0	0.004
Overweight	31 (45)	23 (33)		25 (43)	29 (50)		15 (75)	13 (65)	
Obese	38 (55)	30 (44)		33 (57)	29 (50)		5 (25)	7 (35)	
Glucose, mean (SD), mg/dL	97.3 (13.7)	93.1 (13.5)[a,b]	0.001	100.9 (16.5)	98.4 (12.3)	ns	100.5 (18.3)	100.2 (14.4)	ns
TC, mean (SD), mg/dL	216.4 (56.6)	190.3 (42.3)[b]	<0.0001	222.5 (41.4)	209.7 (43.0)[b]	0.0005	202.9 (36.6)	207.1 (39.1)	ns
TC <190 mg/dL, n (%)	26 (38)	36 (52)	<0.0001	12 (21)	17 (29)	0.001	6 (30)	5 (25)	0.004
LDL cholesterol, mean (SD), mg/dL	138.3 (48.9)	115.6 (37.3)[a,b]	0.0003	143.7 (38.9)	132.2 (40.3)[b]	0.0002	143.0 (29.0)	145.1 (26.2)	ns
LDL cholesterol <115 mg/dL, n (%)	21 (30)	35 (51)	0.0001	11 (19)	19 (33)	0.0001	5 (25)	2 (10)	0.01
HDL cholesterol, mean (SD), mg/dL	55.3 (12.2)[a]	59.8 (13.4)[a]	<0.0001	57.5 (10.4)[a]	59.1 (12.3)	0.08	47.2 (7.8)	46.5 (8.1)	ns
HDL cholesterol >46 mg/dL, n (%)	49 (71)	60 (87)	0.001	49 (85)	50 (86)	0.01	12 (60)	12 (60)	ns
nHDL cholesterol, mean (SD), mg/dL	161.1 (54.8)	130.5 (41.1)[a]	<0.0001	165.0 (40.4)	150.6 (42.8)	0.002	155.6 (35.5)	160.6 (37.2)	ns
nHDL cholesterol <130 mg/dL, n (%)	20 (29)	35 (51)	<0.0001	9 (15)	20 (35)	0.001	5 (25)	4 (20)	ns
TG, mean (SD), mg/dL	131.3 (76.7)	108.2 (46.9)	0.0003	135.3 (52.3)	121.3 (39.6)	0.006	127.3 (23.7)	129.1 (21.5)	ns
TG <150 mg/dL, n (%)	49 (71)	56 (81)	0.0001	41 (71)	47 (81)	0.004	17 (85)	15 (75)	0.01

Analysis of variance post hoc test: least significant difference.
P values refer to preintervention-to-postintervention changes within a group.
ns, not significant; BMI, body mass index; TC, total cholesterol; LDL, low-density lipoprotein; HDL, high-density lipoprotein; nHDL, non-HDL; TG, triglycerides.
[a] $P < 0.05$, difference from the control group.
[b] $P < 0.05$, difference between the Nordic Walking group and the Pilates group.

cholesterol, 3.1% (12.4%) (Fig. 2). Changes in the studied parameters in the control group were not significant and, in most cases, were in the opposite direction of the exercise groups (mean [SD] increases in body weight, 0.44% [1.7%]; BMI, 0.39% [1.7%]; TC, 2.3% [9.5%]; nHDL cholesterol, 4.0% [14.0%]; LDL cholesterol, 2.4% [12.5%]; and TG 2.2% [9.3%]; and an increase in HDL cholesterol, 1.4% [6.8%]).

As a result of these changes, at the end of the program, women who had undergone NW exercise training had considerably lower concentrations of glucose and TC and a higher concentration of HDL cholesterol compared with members of the control group and women who underwent Pilates exercise training (Table 1). The amplitudes of proportional changes in body weight, BMI, TC, HDL cholesterol, and nHDL cholesterol were also significantly ($P < 0.05$) greater in the NW group than in the Pilates and control groups. Moreover, proportional changes in body weight, BMI, TC, nHDL cholesterol, and LDL cholesterol were also significantly ($P < 0.05$) greater in the Pilates group than in the control group.

The next part of the analysis sought to verify whether exercise training and its type influenced lipid metabolism by lowering blood lipid levels to levels below those recommended by the European Society of Cardiology.[3] The implementation of the NW program significantly decreased the percentage of overweight and obese women, and 16 women moved into the normal BMI range (Table 1). Women who underwent Pilates exercises showed a slightly less marked but still significant result. At the same time, a significant percentile increase in obese women without significant changes in the remaining parameters was observed in the control group (Table 1). As far as biochemical parameters are concerned, both exercise training methods substantially increased the number of women meeting treatment target lipid values, which was not observed in the control group.

In the last part of the analysis, we used the forward selection method of stepwise multiple regression to determine which of the established independent variables determined the proportional changes in blood lipids and glucose after completion of the exercise program. A significant regression equation was obtained for all of the dependent variables (Table 2). The range of determination coefficients (R^2) amounted to 0.25 for proportional changes in HDL cholesterol concentration and to 0.45 for proportional changes in TG. Type of exercise program (NW, Pilates, or control [maintenance of previous level of physical activity]) was included in all obtained equations and was the significant independent variable that determined variance in the following: proportional change in TC (TC%), proportional change in nHDL cholesterol (nHDL%), proportional change in LDL cholesterol (LDL%), and proportional change in glucose (glucose%) serum concentration (Table 2). Proportions of variance explained by exercise type, which were expressed by β coefficients, were 8.2 to 99 times greater than the other

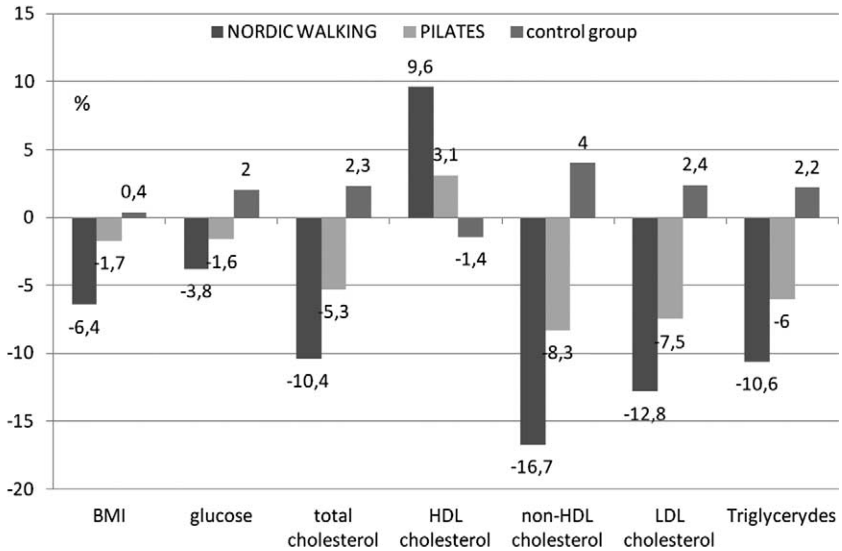

FIG. 2. Average percentage differences in examined parameters after the 10-week exercise training programs. HDL, high-density lipoprotein; LDL, low-density lipoprotein.

variables introduced into the stepwise progressive regression model. Proportional change in body weight had an independent effect on percentage decrease in LDL cholesterol, and proportional change in BMI within the study significantly influenced percentage decrease in TC and percentage decrease nHDL cholesterol (Table 2). The other independent variables that acted as significant independent variables that determined the variance in proportional changes in the studied biochemical parameters were as follows: initial body weight; initial alanine aminotransferase serum activity; and initial blood concentrations of nHDL cholesterol, TG, and glucose. However, their effects were at least eight times smaller than the type of physical activity trained for in the 10-week investigation.

DISCUSSION

This study evaluated the influence of two exercise training methods, NW and Pilates, which each lasted for 10 weeks, on body weight and basic carbohydrate and lipid metabolism parameters in overweight and obese postmenopausal women. The groups that underwent and finished an exercise program showed significant changes in the studied parameters in the desired direction (Table 1, Fig. 2). Greater amplitudes of changes in the studied parameters were observed among women who followed the NW exercise program compared with women who followed the Pilates workout plan or those who followed their usual physical activity (control group; Fig. 2). This difference resulted in women in the NW group showing significantly lower glucose, TC, nHDL cholesterol, and LDL cholesterol levels than women in the Pilates group at the end of the study (Table 1), and in a higher number of women with the desired BMI and lipid concentration compared with the control group (Table 1). The significant independent effect of type of exercise program on serum lipid profile and glucose concentration was confirmed on multiple regression analysis (Table 2). Among the established independent variables, type of training program had the strongest significant effect on proportional changes in TC, nHDL cholesterol, LDL cholesterol, and glucose serum concentrations after completion of the exercise program (in the order NW > Pilates > control). This analysis also showed that the observed decrease in the levels of the mentioned biochemical parameters was independent of accompanying reductions of body weight and BMI, although they also significantly determined the variance in TC, nHDL cholesterol, and LDL cholesterol. In contrast, determination of the values of coefficients in the obtained regression models explained only 25% to 45% of the variance in dependent variables, suggesting the importance of other factors that were not analyzed in the improvement of blood lipids and glucose profile after exercise and dietary intervention. Thus, we suggest that exercise training, in accordance with the NW model, exerts greater lipid reduction and antidiabetogenic effects than the Pilates form of physical exercise as a result of, for instance, greater energy expenditure and increased muscular activation.[4,7,8] However, the large SDs in changes in the studied cardiometabolic parameters showed great individual differences in response to the training program. In another study, these values were not so high.[47]

No comparisons of the clinical effects of NW and Pilates exercise training on postmenopausal women were found in the literature apart from our own previous research.[48] Consequently, it is impossible to verify the obtained results. In contrast with our results, Marinda et al[34] did not observe a significant influence of an 8-week Pilates exercise training program on blood glucose (15% increase, $P = 0.001$), TC (5.6% increase, $P = 0.073$), and TG (8.5% increase, $P = 0.384$) in 50 women aged 60 years or older in a randomized study. This was also the case for Goodpaster et al,[49] who examined a mixed population consisting of younger men and

TABLE 2. *Relationships between proportional changes in plasma lipids and glucose serum concentrations after the 10-week training program on step-progressive multiple regression (n = 147)*

	TC% ($R^2 = 0.43$; $P < 0.0001$)		HDL% ($R^2 = 0.25$; $P < 0.002$)		nHDL% ($R^2 = 0.37$; $P < 0.0001$)		LDL% ($R^2 = 0.41$; $P < 0.0001$)		TG% ($R^2 = 0.37$; $P < 0.0001$)		Glucose% ($R^2 = 0.45$; $P < 0.0001$)	
Biochemical parameter	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*
Exercise program (NW, Pilates [coded 2], control)	8.8	<0.0001	−5.1	0.056	12.9	0.0002	13.9	0.0008	4.0	0.12	3.11	0.04
Age											−0.24	0.09
Initial weight			0.45	0.047	0.15	0.054					0.17	0.012
Initial BMI	−0.77	<0.02	−1.83	0.011			−1.21	0.024				
Initial AST							−0.75	0.09				
Initial ALT	0.27	<0.06	−0.19	0.22	0.34	0.10	0.72	0.043				
W%			0.38	0.48			−1.68	0.029			−0.50	0.10
BMI%	−0.97	<0.04			−1.38	0.044						
Initial TC			−0.05	0.061			0.26	0.12				
Initial HDL cholesterol									−0.19	0.25	−0.08	0.19
Initial nHDL cholesterol	−0.1	<0.0001			−0.13	0.0003	−0.41	0.019				
Initial LDL cholesterol											0.02	0.19
Initial TG			0.1	0.0002					−0.19	0.0001	−0.05	0.005
Initial glucose											−0.20	0.0002

Dependent variables are presented as proportional changes in serum lipids and glucose concentrations between the end and the beginning of the study, with R^2 coefficients (determination coefficients showing the percentage of explained variance in the dependent variables obtained by regression equation) and *P* values for regression equations obtained for the dependent variables.
Empty cells indicate that the variables were not included in the equation by the statistical method.
NW, coded 1; Pilates, coded 2; control, coded 3.
TC, total cholesterol; TC%, proportional change in serum TC concentration between the end and the beginning of the study (a negative value indicates a decrease); HDL, high-density lipoprotein; HDL%, proportional change in serum HDL concentration between the end and the beginning of the study (a positive value indicates an increase); nHDL, non-HDL; nHDL%, proportional change in serum nHDL cholesterol concentration between the end and the beginning of the study (a negative value indicates a decrease); LDL, low-density lipoprotein; LDL%, proportional change in serum LDL cholesterol concentration between the end and the beginning of the study (a negative value indicates a decrease); TG, triglycerides; TG%, proportional change in serum TG concentration between the end and the beginning of the study (a negative value indicates a decrease); Glucose%, proportional change in serum glucose concentration between the end and the beginning of the study (a negative value indicates a decrease); NW, Nordic Walking (coded 1); BMI, body mass index; BMI%, proportional change in BMI between the end and the beginning of the study (a negative value indicates a decrease); AST, asparagine aminotransferase; ALT, alanine aminotransferase; W%, proportional change in body weight between the end and the beginning of the study (a negative value indicates a decrease).

women but with more advanced obesity. Although a significant reduction in body weight (9%) was observed after 6 months of increased physical activity (although not in the NW model), there was no proof of a significant or characteristic reduction in glucose (3.8%), TC (2%), or TG (3%) levels, and the concentration of HDL cholesterol, paradoxically, significantly dropped by 5%.[48]

The favorable effect of exercise on cardiometabolic risk factors has also been observed with other aerobic forms of exercise. In a randomized placebo-controlled trial, Zhang et al[50] found that, in postmenopausal women, walking with sticks three times a week or more for 4, 6, and 12 weeks led to a reduction in body weight, TC concentration, and TG concentration in comparison with the control group, who continued only their normal activity (as in our study). Improvement in body weight, BMI, waist circumference, hip circumference, glucose, TG, TC, LDL cholesterol, and HDL cholesterol after a 10-week aerobic exercise program (Tae-bo) was also observed in a study by Mathunjwa et al.[51] In another recent study, the exercise program also decreased the LDL cholesterol TC−to−HDL cholesterol ratio and fasting glucose, and increased HDL cholesterol, in employees of a nursing agency.[47] Moreover, Kim and Kim[52] found that 16 weeks of aerobic exercise decreased the blood concentrations of TC and glucose in postmenopausal women.

Among available studies, we found only one article in which the multiple regression method was used to explain the effects of weight loss after a dietary program and an exercise program on cardiometabolic parameters.[53] Dow et al[53] observed 417 overweight or obese women (average age, 44 y) to whom a weight reduction program was introduced. It promoted adherence to a low-fat (20%-30% of total energy), reduced-energy (1,200-2,000 kcal), high-fruit, high-vegetable eating plan with recommendations for increased physical activity (30 min of planned exercise for ≥5 d/wk). They observed a significant reduction in body weight and blood concentrations of TC, HDL cholesterol, and nHDL cholesterol after 24 months of intervention. In this work, the obtained R^2 coefficients of predictive equations for changes in TC (0.46), TG (0.66), and glucose (0.26) were similar to our study only for TC (Table 2).[53]

The obtained results show how important the method of physical exercise—in combination with a dietary intervention comprising a daily energy intake of 1,500 kcal—is in the treatment of overweight, obesity, and coexisting metabolic disorders. Its intensification in the NW model helped us achieve better results in our study, although only 78% (69 of 88) of women completed the exercise training program. These results can be of great importance to the cost-effectiveness of particular methods aimed at improving the health of a population. The 10% to 12% reduction in lipid fractions achieved by women who underwent NW exercise training (Fig. 2) corresponds to the effectiveness of phytosterols or small doses of statins and fibrates[3] and may reduce cardiovascular risk. The metabolic result of Pilates exercise training is also good and can be recommended for persons with motor dysfunction or *cardiovascular/respiratory system* failure.[39-44]

As with most authors, we could not avoid some methodological shortcomings that could influence the strength of our conclusions. The main limitations of this study are as follows: the lack of a random allocation of women to particular models of physical activity (potential selection bias); the 28% of participants who dropped out of the exercise programs; and the per-protocol analysis conducted only on women who completed their allocated exercise training program, without analysis of intervention effect in less adherent women. Although such an analysis might offer the possibility of exercise dose-response estimation (eg, the hypolipemic effect of a 6-wk or 8-wk training program), the blood samplings and biochemical examinations in our study were performed only in women who completed the 10-week training program. Therefore, it is impossible to estimate the effects of a training program on women who did not complete it (per-protocol analysis; Fig. 1). Moreover, the strength of the conclusions is also weakened by a lack of control over the food consumed by women between the meals served by the recommended catering establishments and a lack of individualization in dietary portion intervention. However, only a significant intake of phytosterols or fish oil in the form of dietary supplements (leading to a greater reduction in lipid levels) or snacking on foods that reduce the hypolipidemic effect of exercise could have influenced the observed metabolic changes.[3,46] Moreover, one should take into consideration the fact that the women could have been taking dietary supplements advertised as supplements that would accelerate weight loss. However, the effectiveness of these supplements has not been confirmed, and each woman declared that she did not change any medicine taken during the course of the program. The final study limitation to consider is that energy expenditure during workouts was not individually monitored and was estimated indirectly only based on the duration of the session and reference data concerning average energy consumption during the training programs. However, more detailed monitoring of effort intensity (eg, by checking the percentage of maximal heart rate) might help to explain the large SDs in changes in the analyzed cardiometabolic parameters within the study. In addition, Gerstel et al[47] also obtained favorable cardiometabolic effects only by encouraging women to participate in physical activity and healthy nutrition and by equipping them with bicycles (free of charge) without energy expenditure monitoring.

CONCLUSIONS

1. Both exercise programs, NW and Pilates, have beneficial effects on the BMI, glucose levels, and lipid levels of overweight and obese postmenopausal women.
2. In comparison with the Pilates exercise training group, the NW group shows greater reductions in body weight, BMI, and glucose (on an empty stomach), TC, nHDL cholesterol, and LDL cholesterol concentrations in unifactorial and multifactorial analyses.
3. In response to NW and Pilates, a significantly larger number of women have achieved their therapeutic goals in relation to cardiometabolic risk factors of atherosclerosis, although only 72% of the studied population has completed the exercise training programs.

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