Exercise Effects on Menopausal Risk Factors of Early Postmenopausal Women: 3-yr Erlangen Fitness Osteoporosis Prevention Study Results

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ABSTRACT

KEMMLER, W., S. VON STENGEL, J. WEINECK, D. LAUBER, W. KALENDER, and K. ENGELKE. Exercise Effects on Menopausal Risk Factors of Early Postmenopausal Women: 3-yr EFOPS Results. *Med. Sci. Sports Exerc.*, Vol. 37, No. 2, pp. 194–203, 2005. **Purpose:** To determine the impact of multipurpose exercise training on bone, body composition, blood lipids, physical fitness, and menopausal symptoms in early postmenopausal women with osteopenia. **Methods:** Forty-eight fully compliant (more than two sessions per week for 38 months) women (55.1 ± 3.3 yr) without any medication or illness affecting bone metabolism took part in the exercise training (EG); 30 women (55.5 ± 3.0 yr) served as the nontraining control group (CG). Both groups were individually supplemented with calcium and vitamin D. Bone mineral density (BMD) at various sites (lumbar spine, hip, forearm, calcaneus) was measured by dual x-ray absorptiometry (DXA) and quantitative ultrasound (QUS). Maximal isometric and dynamic strength, maximal oxygen consumption ($\dot{V}O_{2max}$), CHD risk factors (blood lipids, body composition), and menopausal symptoms were determined. **Results:** After 38 months, significant differences between EG and CG were observed for the BMD at the lumbar spine (0.7% vs −3.0%) and the femoral neck (−0.7% vs −2.6%), body composition (waist circumference, waist-to-hip ratio), blood lipids (total cholesterol, triglycerides), and menopausal symptoms (insomnia, migraines, mood changes). Maximal isometric strength increased significantly by 10–36% in the EG, whereas, with one exception, changes in the CG were all negative. One-repetition maximum increased significantly at all sites measured (15–43%, $P < 0.001$). $\dot{V}O_{2max}$ of the EG increased throughout the study with a significant 13.9 ± 15.6% net increase after 3 yr. No significant changes after 3 yr could be observed in the CG. **Conclusions**: Our mixed high-intensity exercise program effectively compensates for most negative changes related to the menopausal transition. **Key Words:** EARLY MENOPAUSAL WOMEN, EXERCISE, BONE, CHD RISK FACTORS, PHYSICAL FITNESS

The effects of estrogen decline during the early postmenopausal years are complex. Because estrogen receptors are abundant throughout the body, estrogen depletion affects most organ systems (19). Accelerated bone loss is one classic symptom of the early postmenopausal years (22). Blood lipids are also affected negatively during the menopausal transition (21), and, in many studies, negative changes of body weight, body fat, and fat distribution are also observed (2). Furthermore, some authors (9) showed an accelerated decrease in muscle strength during that period; however, there is ongoing discussion of the effects of estrogen depletion on muscle mass and tissue distribution.

Physical activity or, even better, exercise may be one strategy to offset some these negative consequences. During the past decade, it has been shown that exercise favorably modifies muscle strength (23), bone mineral density (BMD) (29), body composition (18), and blood lipids (30) in the elderly population. However, exercise studies in early postmenopausal women are rare and seldom exceed a period of 12 months (13,29).

In this article, we report the 3-yr results of the Erlangen Fitness Osteoporosis Prevention Study (EFOPS), an ongoing 5-yr exercise trial in early postmenopausal women. Details of the study design and recruitment strategies have been extensively described in this and other journals along with the 1- and 2-yr results (15,16). In short, EFOPS is a multipurpose exercise program with an emphasis on maintenance of BMD and reduction of risk factors and complaints of early postmenopausal women.

MATERIALS AND METHODS

Subjects

Of 7500 women, ages 48–60, contacted by mail in the Erlangen area, 137 subjects were included in the study.

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Inclusion criteria were early menopausal status (1–8 yr) and osteopenia at the spine or total hip as defined by the WHO (−1 SD > DXA-T score > −2.5 SD). Exclusion criteria were known osteoporotic fractures, secondary osteoporosis, use of medication and diseases affecting bone metabolism during the past 2 yr before study start, inflammable diseases, cardiovascular diseases, low physical capacity (<75 W) at cycle ergometry, and athletic activity history during the past 2 decades before study start.

There were 86 subjects in the exercise group (EG) and 51 in the control group (CG). Participants in the CG were requested to continue their usual lifestyle, whereas participants in the EG underwent the training outlined below. According to nutritional intake, vitamin D and calcium were individually supplemented in both groups.

The EFOPS study was approved by the Ethics Committee of the University of Erlangen (Ethik Antrag 905), the Bundesamt für Strahlenschutz (S9108-202/97/1, S21-22112-81-00), and the Bayerisches Landesamt für Arbeitsschutz (13B/3443-4/5/98). All study participants gave written informed consent.

Exercise Design

The exercise program consisted of four sessions per week. Two supervised group sessions were performed on nonconsecutive days in groups of approximately 12–15 subjects. In addition, an unsupervised home training program was to be carried out twice weekly. Individual training logs kept by the participants and attendance protocols were analyzed every 6–8 wk to monitor attendance and compliance. In the following, we briefly summarize the exercise program. For further details, the reader is referred to related publications (14,15).

Group Exercise Session

The joint exercise session lasted approximately 65–70 min and was subdivided into four sequences: 1) warm-up and endurance, 2) jumping, 3) strength training, and 4) stretching.

Warm-up/endurance sequence. The group training session started with 10 min of running and gaming to promote unusual strain distributions under weight-bearing conditions. Then 10 min of aerobic exercises with a progressively increasing amount of high impact concluded this sequence. Heart rate (HR_{max}) ranged from 70 to 85% during the sequence.

Jumping sequence. A jumping program was introduced after study participants had been accustomed to higher strain rates (5 months). After initial rope skipping, four sets of different jumps with 15 repetitions were performed. The intensity was gradually increased by choosing jump types with higher impact. Peak ground reaction forces of the different jump types as measured by force plates (Erbe-Medizintechnik, Tübingen, Germany) ranged from 1791 ± 344 N to 2363 ± 462 N.

Strength-training sequence. A major emphasis was placed on strength training. One of the two group training sessions was carried out using resistance machines (Techno Gym, Gambettola, Italy). On the machines, all main muscle groups were trained (13 exercises). In the other supervised group session, a strength-training sequence with calisthenic/isometric and dumbbell exercises was also integrated.

At the start of the study, high-volume resistance training with gradually increasing intensity (beginning at 50% one-repetition maximum (1RM) and 20 repetitions) was performed. After 6–7 months and exercising at 70% 1RM, this protocol was changed; 12 wk of high-intensity training were interleaved with 4–6 wk of regenerational training. Exercise intensity during the high-intensity period ranged from 70 to 90% 1RM. The number of repetitions was not maximized until complete exhaustion of the participants. Ten different exercises with a total of 24–27 sets per session and 90–120 s of rest were performed. During the heavy-loading periods, participants worked with individual logs based on 1RM tests. These were carried out before and after each high-intensity period. Based on these tests, the loads for the following period were adjusted accordingly. During the regeneration periods, the average intensity was around 50% 1RM. Thirteen different exercises with two sets and 15–20 repetitions were performed per session.

During the initial 6 months, the second strength-training session consisted of isometric maximal strength and elastic belts (Thera-Band) exercises. Twelve to fifteen exercises with 2–4 sets for all main muscle groups were performed with a 6- to 10-s maximal intensity and a 20-s rest period. Three exercises with 2–4 sets and 15–20 reps were additionally carried out for the upper body using elastic belts. Intensity of the belt exercises was increased using different belts and belt shortening.

After 7 months, the exercise protocol changed in parallel with the machine session. Exercises with dumbbells and weighted vests replaced the elastic belt training during the heavy-loading periods. Exercise regulation during the dumbbell/weighted vest session was comparable with the high-intensity regimen described above. Different from the machine training exercise, the protocol was based on a 10RM test.

A standardized stretching program (8–10 exercises with 1–2 sets and 30 s of passive stretching) was performed before the strength complex and during the rest periods of the strength-training sessions.

Home training session. Home training consisted of three different sets of rope skipping, 2–3 sets of 6–8 isometric exercises each, 2 sets of 2–3 belt exercises each, and 4–6 stretching exercises. To ensure proper technique, home training exercises were first discussed and performed in the group training sessions. The home training exercises were replaced every 12 wk by different and more intense ones.

Baseline and 3-yr Measurements

Anthropometric data. We measured height, weight, and circumferences at different sites, and body composition.

Body composition was determined by the bioimpedance technique (Tanita BF 305, Tanita, Japan).

BMD. BMD was measured by dual x-ray absorptiometry (DXA) at the lumbar spine (L1-4), the proximal femur, and the forearm using standard protocols (QDR 4500A; Hologic, Bedford, MA). Quantitative ultrasound (QUS) was measured at the calcaneus (Sahara; Hologic) also using the standard protocol.

Blood lipids. Blood was sampled from an antecubital vein in the morning after an overnight fast. Serum samples were frozen at −70°C after being centrifuged at 3000 rpm for 20 min. Total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, glucose, and uric acid (Olympus Diagnostica GmbH, Hamburg, Germany) and apolipoproteins A1 and B (Dade-Behring, Marburg, Germany) were determined.

Exercise-Specific Tests

Isometric muscle strength. Isometric muscle strength of the trunk extensors and flexors, hip flexors, and leg adductors and abductors was measured with a Schnell M-3 isometric tester (Schnell, Peutenhausen, Germany) following the protocol recommended by Tusker. In addition, maximal isometric strength of the arm flexors and extensors was determined by a Schnell-Trainer-dynamometer (Schnell, Peutenhausen, Germany) also using Tusker's protocol. Grip strength of the dominant hand was determined using a Jamar dynamometer (Jamar, Bolingbrook, IL). All tests were supervised by research assistants. The exact positioning protocols of the isometric strength measurements have been described elsewhere (14).

Dynamic muscle strength. Horizontal leg press, horizontal bench press, rowing, and leg adduction were selected for 1RM tests according to Kraemer. Initial 1RM tests were performed after 6 wk. All tests were supervised by research assistants. The dynamic measurements were not carried out in the CG.

Treadmill ergometry. A stepwise treadmill (Techno Gym) test up to the voluntary maximum was carried out to determine aerobic capacity. Running velocity was increased in steps of 1 $km \cdot h^{-1}$ every 3 min starting with 6 $km \cdot h^{-1}$ at a 0° slope. Aerobic capacity was measured breath by breath using a Zan 600 open spirometric system (ZAN, Oberthulba, Germany). Subjects with a maximal heart rate below 155 $beats \cdot min^{-1}$ were excluded from the analysis because of poor test compliance.

Questionnaires. A detailed baseline questionnaire completed by the participants in both the EG and CG combined several parts: 1) overall life satisfaction with emphasis on health, 2) frequency and intensity of pain at various skeletal sites, 3) prestudy physical activity and exercise levels, and 4) osteoporotic risk factors including falls. Changes that had occurred during the intervention period were controlled by an additional questionnaire completed annually after study start by the participants.

As described before (14), individual 5-d dietary records were used at baseline and follow-up visits to determine the nutritional intake. Based on the calcium and vitamin D results, study participants were individually supplemented to ensure a total daily intake of 1500 mg calcium and 500 IE vitamin D.

Statistical Analysis

All measured values are reported as means and SD. Three-year results are reported as percent changes compared with baseline. The Kolgomorov–Smirnov test was used to check for normal distribution. Homogeneity of variance was investigated using Levine's *F*-test. For normally distributed variables, differences within and between groups were assessed with paired and unpaired *t*-tests; otherwise, the Wilcoxon or the Mann–Whitney *U*-tests were used. All tests were two tailed; a 5% probability level was considered significant (*). We used SPSS 12.5 (SPSS Inc., Chicago, IL) for statistical analysis.

RESULTS

After 3 yr, the dropout rate was 21% in the EG and 29% in the CG. Of the 33 dropouts, 11 women quit EFOPS due to occupation changes. Nine women developed serious diseases (e.g., tumor (four women) or asthma (two women)). One subject left the study due to a hairline fracture of the os

TABLE 1. Baseline data of anthropometric parameters and osteoporotic risk factors in exercise group (EG) and control group (CG).

Variable	EG (*N* = 48)	CG (*N* = 30)	*P*
Age (yr)	55.2 ± 3.3	55.5 ± 3.0	NS
Height (cm)	163.9 ± 6.6	162.7 ± 6.9	NS
Weight (kg)	68.1 ± 9.6	67.3 ± 11.9	NS
Age at menarche (yr)	13.4 ± 1.4	13.3 ± 1.5	NS
Age at menopause (yr)	50.4 ± 3.3	50.5 ± 3.4	NS
No. of pregnancies	2.0 ± 1.2	2.0 ± 1.3	NS
Physical activity[a]	4.2 ± 1.3	4.1 ± 1.3	NS
Energy intake ($kJ \cdot d^{-1}$)[b]	8164 ± 1255	7751 ± 1730	NS
Calcium intake ($mg \cdot d^{-1}$)	1055 ± 379	971 ± 287	NS
Phosphorus intake ($mg \cdot d^{-1}$)	1311 ± 324	1220 ± 338	NS
Vitamin D intake ($\mu g \cdot d^{-1}$)	5.7 ± 4.5	5.5 ± 5.1	NS
Osteoporosis of parents or siblings (% per group)	17%	20%	NS
Corticosteroids (>5 $mg \cdot d^{-1}$) or thyroxin (≥75 $mg \cdot d^{-1}$) for >6 month during lifetime (% per group)	10%	13%	NS
Coffee intake ($mL \cdot d^{-1}$)	753 ± 329	787 ± 312	NS
Smokers (% per group)	10%	13%	NS

[a] Based on a scale from 1 (very low) to 7 (very high) according to a subjective assessment of professional, household, and recreational activities.
[b] Five-day dietary analysis.

TABLE 2. Baseline data of BMD at different sites in exercise group (EG) and control group (CG).

Variable	EG (*N* = 48)	CG (*N* = 30)	*P*
DXA PA L1–4 (g·cm^{-2})	0.876 ± 0.087	0.878 ± 0.098	NS
DXA total hip (g·cm^{-2})	0.852 ± 0.078	0.857 ± 0.071	NS
DXA ultradistal radius (g·cm^{-2})	0.419 ± 0.049	0.414 ± 0.047	NS

pubis after a fall during the aerobic sequence. A total of eight dropouts cited study-related reasons, related either to the exercise protocol (four women) or the calcium/vitamin D supplementation (four women). Three women quit the study for unknown reasons. Thus, 68 subjects in the EG and 36 women in the CG participated in the 3-yr follow-up visit.

After analyzing follow-up questionnaires and attendance rates, another 26 women were not included in the statistical analysis. Subjects were excluded because of diseases or medication affecting bone metabolism (ten women), significant change in lifestyle (one woman), or inadequate training compliance (15 women), which was defined as a training frequency of fewer than two sessions (17) per week averaged over the total follow-up time of 3 yr. Thus, the results shown here represent 48 subjects in the EG and 30 subjects in the CG.

The overall attendance rate of the EG (*N* = 63, subjects with attendance rates of fewer than two sessions per week included) was 2.4 ± 0.5 (range 1.5–3.4) sessions per week. Although attendance rates significantly decreased during the first 14 months (from 2.6 to 2.4 sessions on average), no further decrease took place during the second and third study years.

Tables 1 and 2 show the baseline values of relevant parameters. As can been seen, there were no significant differences between the EG and CG for anthropometric parameters, for osteoporotic risk factors (Table 1), for variables describing BMD (Table 2), or for physical fitness parameters (Table 3). The exception was grip strength, which was higher in the EG.

Body Composition and Muscle Circumference

After 38 months, the exercise effect on body composition was rather homogeneous (Fig. 1). Body fat decreased nonsignificantly by −2.2 ± 6.3% in the EG and was stable (−0.2% ± 7.2) in the CG. Although hip circumference was not affected in the EG or the CG, waist circumference significantly decreased in the EG (−2.5 ± 5.3%). Thus, the

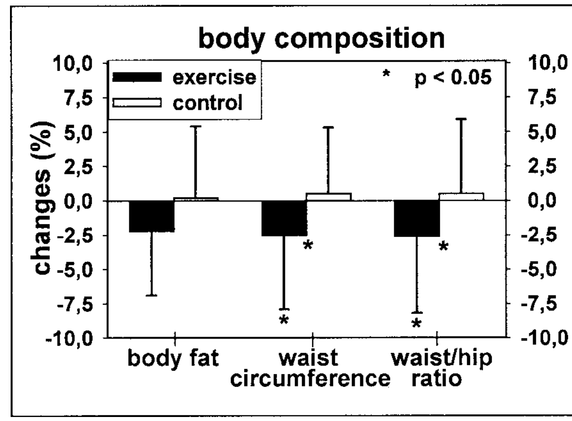

FIGURE 1—Changes in body composition after 3 yr in exercise and control groups.

waist-to-hip ratio also decreased in the EG (−2.6 ± 5.6) and was stable (+0.5 ± 5.5%) in the CG, resulting in a significant difference between both groups. For lean body mass, no significant differences were observed. Furthermore, after 38 months, there were no relevant changes or between-group differences for the calf, thigh, and lower and upper arm circumferences.

BMD

The BMD results are summarized in Figures 2–4. The overall trend in the spine (Fig. 2), neck, and trochanter (Fig. 3) is a stabilization of BMD in the EG and a decrease in the CG (from −1.8 ± 2.7% in the trochanter to −3.0 ± 2.3% in the spine). The projected area of the vertebrae measured by DXA significantly increased in the EG up to +1.6 ± 2.2% after 3 yr (Fig. 2). In the forearm, there were no differences between EG and CG (Fig. 4). In both groups, BMD significantly decreased. Speed of sound (SOS), broadband ultrasound attenuation (BUA), and the combined quantitative ultrasound index (QUI) as measured by QUS were stable in the EG and significantly decreased (from −0.9 ± 1.0% for SOS to −6.6 ± 7.0% for QUI) in the CG (Fig. 4).

Blood Lipids

Year 2 results for blood lipids are included in Table 4 along with the baseline data. Blood was not drawn in year 3.

Exercise-Specific Tests

Isometric muscle strength. After 38 months, isometric muscle strength (Fig. 5) in the EG significantly increased by +9.5% (grip strength) to +36% (hip flexors). With two exceptions (trunk flexors: −6.3% and arm extensors: −5.9%), no significant changes were measured in the CG. Apart from grip strength, differences between EG and CG were significant for all sites.

Dynamic muscle strength. RM results of four exercises are shown in Figure 6. The first 1RM test (baseline test) was carried out 6 wk after the start of the training. As

TABLE 3. Baseline data of isometric strength and aerobic capacity in exercise group (EG) and control group (CG).

Variable	EG (*N* = 48)	CG (*N* = 30)	*P*
Grip strength baseline (kg)	28.1 ± 5.3	20.7 ± 6.2	***
Trunk extensors baseline (NM)	100.2 ± 31.6	103.5 ± 39.9	NS
Trunk flexors baseline (NM)	56.6 ± 18.6	50.5 ± 15.4	NS
Hip flexors baseline (NM)	36.3 ± 11.1	36.9 ± 13.9	NS
Leg adductors baseline (NM)	98.7 ± 23.1	102.0 ± 23.1	NS
Leg abductors baseline (NM)	76.7 ± 21.4	75.0 ± 22.9	NS
Arm extensors baseline (NM)	58.6 ± 14.5	53.5 ± 15.3	NS
Arm flexors baseline (NM)	64.6 ± 13.5	60.7 ± 16.2	NS
$\dot{V}O_{2max}$ baseline (L·min^{-1})	1.78 ± 0.45	1.73 ± 0.35	NS
VE baseline (L·min^{-1})	63.6 ± 15.5	63.3 ± 13.4	NS

*** $P < 0.001$.

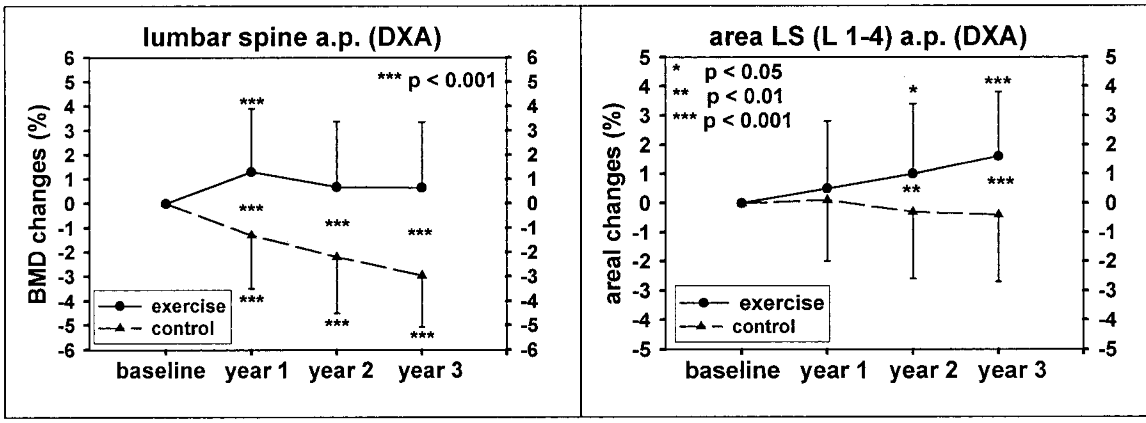

FIGURE 2—Changes in BMD (*left panel*) and area (*right panel*) at the lumbar spine during 3 yr in exercise and control groups.

mentioned above, dynamic tests were performed in the EG only. After 38 months of exercise, 1RM for all exercises increased significantly by 43% for leg press, 41% for chest press, 15% for rowing, and 25% for leg adduction.

Endurance and aerobic capacity. Time under load, $\dot{V}O_{2max}$, and $\dot{V}E$ (not shown) significantly increased in the EG by 25.9 ± 16.8%, 13.9 ± 15.6%, and 6.7 ± 13.9%, respectively (Fig. 7), whereas changes in the CG were all negative (−3.7 ± 13.5%, −1.3 ± 13.4%, and −9.6 ± 12.4%) resulting in significant between-group differences. HR_{max} was 168 beats·min^{-1} in the EG and the CG; thus, test compliance was comparable in both groups.

Menopausal symptoms. Changes in menopausal symptoms as assessed by questionnaire (Fig. 8) were more favorable in the EG than the CG. However, significant differences could be observed only for insomnia, migraines, and mood changes.

During the intervention period, no changes for nutritional intake parameters could be observed for either group.

DISCUSSION

To our knowledge, EFOPS is the first long-term exercise study in early postmenopausal women. EFOPS was designed as a multipurpose exercise program to account for the multirisk factor situation caused by declining hormonal production. The central results of the EFOPS study are threefold. First, exercise can stop early postmenopausal bone loss; second, our complex exercise program does not only stabilize BMD but also increases physical fitness, decreases CHD risk factors, and has positive effects on body composition; third, and this is of utmost importance, these exercise effects are not short term but can be maintained (with exercise) in early postmenopausal women over a longer period (3 yr so far).

In this article, we focus on the overall presentation of our results rather than on an extensive discussion of specific topics. The 3-yr results reported here mainly confirm the results of the first 2 yr. Although we used periodized exercise protocols that structured macro- and mesocycles and further provided our subjects with individual protocols over 3 yr, changes in strength and endurance in particular were rather small during year 3. A main reason for this early leveling-off effect may be that we did not increase the number of sessions per week or the duration of the session, which were normally the first two steps in increasing the training load. However, due to the long-term character of our intervention, we prefer a protocol with a reasonable training volume to reduce dropout and increase compliance, accepting the fact that, in our fundamentally sedentary pop-

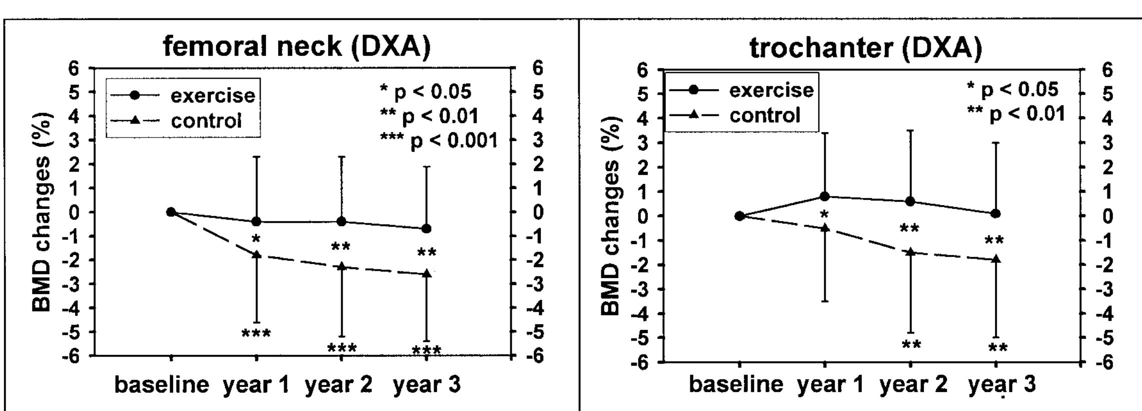

FIGURE 3—Changes in BMD at the femoral neck (*left panel*) and the trochanter site (*right panel*) after 3 yr in exercise and control groups.

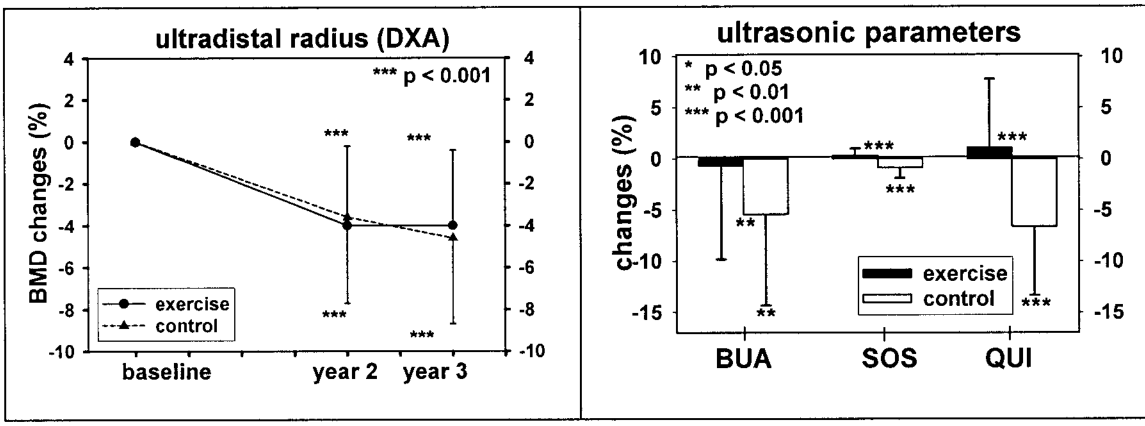

FIGURE 4—Changes in BMD at the ultradistal radius (*left panel*) and ultrasound (*right panel*) parameters after 3 yr in exercise and control groups.

ulation, most people were unwilling to exercise more than 2–3× wk^{-1}.

Comparing the results of our strength measurements with those of other long-term exercise studies (24 months) in postmenopausal women (12,25), we achieved comparable or somewhat higher increases in isometric strength.

As expected, dynamic strength increases leveled off after 6–7 months of conventional resistance training. At this point, we started the periodized high-intensity exercise regimen, and further 1RM improvements were observed for all four exercises. However, 18–22 months after the first 1RM test, no further significant changes could be observed.

We did not detect a change in lean body mass nor, with the exception of the waist, in the circumferences measured at various locations. This indicates that the increase in muscle strength was not caused by an increase in muscle mass but by other mechanisms, for example, by an improvement of neuromuscular conditions. Our results are consistent with a recent 12-month study of jumping and resistance in early postmenopausal women (26). In contrast, other authors argue that after an initial period of neuromuscular adaptation, strength changes must be associated with muscular hypertrophy (11). In agreement with this statement, two recent studies with early postmenopausal women showed positive effects of resistance exercise on lean body, muscle cross-sectional area, and tissue distribution (3,20).

TABLE 4. Changes in blood lipids after 3 yr in exercise group (EG) and control group (CG).

Variable	EG (*N* = 34)	CG (*N* = 24)	*P*
Total cholesterol baseline ($mg \cdot dL^{-1}$)	233.9 ± 38.9	241.9 ± 42.8	NS
Total cholesterol yr 2 ($mg \cdot dL^{-1}$)	222.3 ± 46.4	251.8 ± 51.9	*
Changes (%)	−5.0 ± 14.6*	+4.1 ± 13.7	*
HDL-C baseline ($mg \cdot dL^{-1}$)	57.7 ± 11.3	62.5 ± 15.1	NS
HDL-C yr 2 ($mg \cdot dL^{-1}$)	58.2 ± 13.8	60.8 ± 16.7	NS
Changes (%)	0.9 ± 15.1	−2.7 ± 16.5	NS
LDL-C baseline ($mg \cdot dL^{-1}$)	141.2 ± 31.7	153.6 ± 32.1	NS
LDL-C year 2 ($mg \cdot dL^{-1}$)	139.6 ± 31.9	155.7 ± 40.3	NS
Changes (%)	−1.1 ± 15.9	1.4 ± 16.4	NS
Triglycerides baseline ($mg \cdot dL^{-1}$)	86.5 ± 32.1	88.3 ± 33.0	NS
Triglycerides yr 2 ($mg \cdot dL^{-1}$)	74.2 ± 28.2	108.8 ± 44.7	NS
Changes (%)	−14.2 ± 33.4*	23.2 ± 31.7*	**
Apolipoprotein A1 baseline ($mg \cdot dL^{-1}$)	1.90 ± 0.33	2.07 ± 0.37	NS
Apolipoprotein A1 yr 2 ($mg \cdot dL^{-1}$)	1.92 ± 0.35	2.12 ± 0.38	*
Changes (%)	1.0 ± 8.6	2.4 ± 11.7	NS
Apolipoprotein B baseline ($mg \cdot dL^{-1}$)	1.04 ± 0.20	1.16 ± 0.24	NS
Apolipoprotein B yr 2 ($mg \cdot dL^{-1}$)	1.05 ± 0.22	1.22 ± 0.28	*
Changes (%)	1.0 ± 14.0	5.2 ± 14.8	NS

* $P < 0.05$; $P < 0.01$.

Furthermore, our results do not agree with authors who postulate an accelerated loss of muscle mass and strength during the early phase of the menopause (9). In the CG, muscular strength and mass remained more or less stable. The differences between the EG and the CG are caused by an increase in the training group.

It is difficult to interpret these diverging results, but it must be remembered that the methods to measure lean body mass, muscle mass, and muscle size vary largely from circumference measurements to bioimpedance, DXA, computed tomography, magnetic resonance imaging, and ultrasound-based methods. This heterogeneity, along with the small and different study populations, may largely account for the discrepancies.

Endurance and aerobic capacity are not central end points of the EFOPS study (two sessions each with 20–25 min at 70–85% HR_{max}). Nevertheless, the improvements in aerobic capacity in the EG are comparable with results of studies focusing on aerobic training in comparable cohorts (4,5).

After 3 yr of exercise, BMD at the lumbar spine and hip and ultrasonic parameters at the calcaneus were not significantly affected in the EG. However, all these parameters significantly decreased in the CG. Thus, at least during early menopause, maintenance of muscular capacity is insufficient to maintain BMD even if the calcium and vitamin D supply is adequate. This is in accordance with the set point theory postulated by Turner (27).

We also observed a continuous increase in lumbar spine area as measured by DXA of up to 1.6 ± 2.2% ($P < 0.001$) after 3 yr in the EG (Fig. 2), which was caused by an increase of projected vertebral width rather than height. From a biomechanical point of view, this alteration increases bone strength even if BMD stays constant (8). However, we must caution that the increase in area may at least partly be caused by an increase in degenerative changes (i.e., osteophytosis) that are difficult to identify on DXA

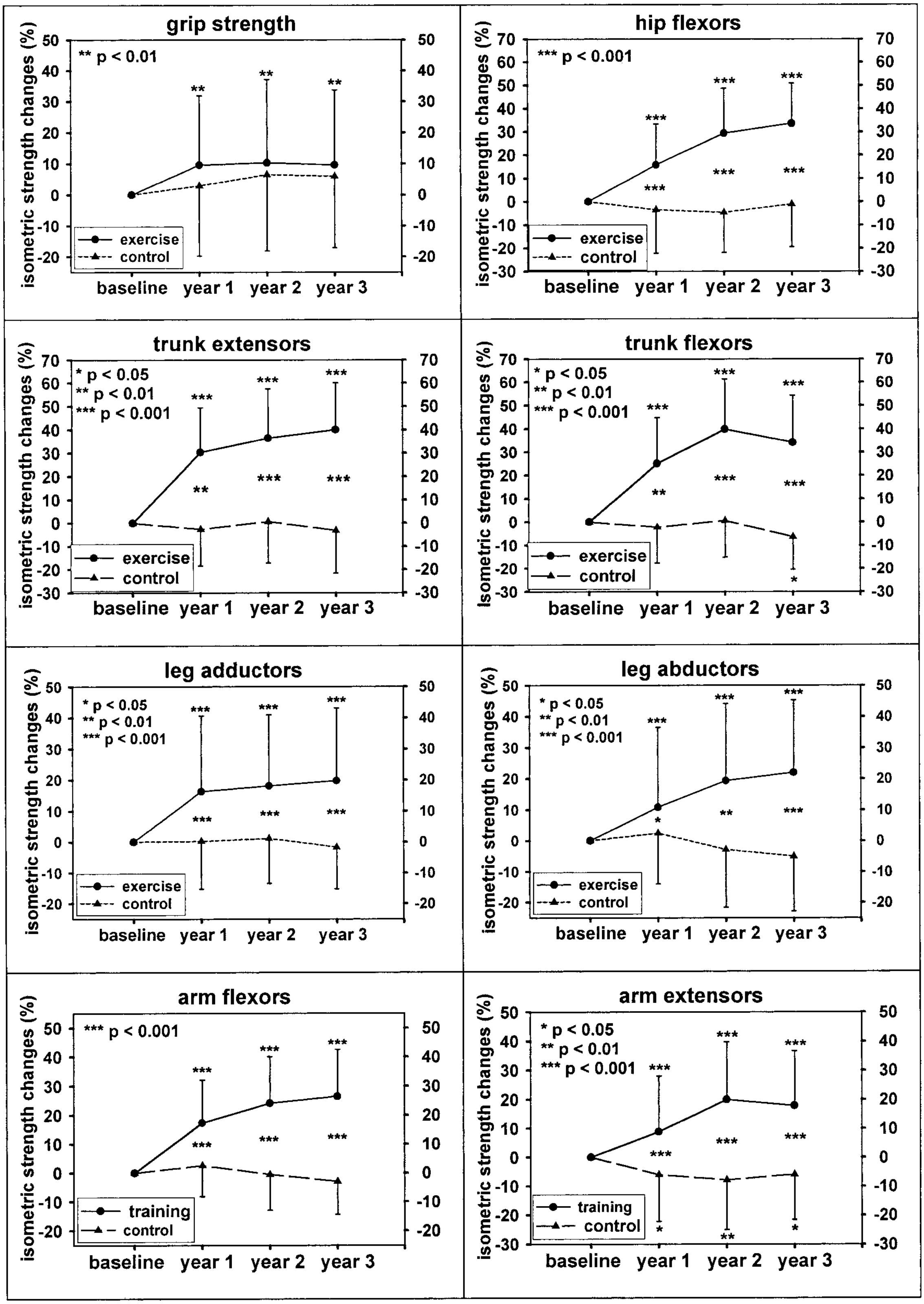

FIGURE 5—Changes in isometric strength at different sites after 3 yr in exercise and control groups.

images. Nevertheless, osteophytes may also increase bone strength.

Contrary to the spine, hip, and calcaneus, BMD at the forearm decreased roughly by 4% in both groups. What can be the reason for this discrepancy between the forearm and the other skeletal sites? A detailed analysis of the effects of different types of exercises used in the EFOPS program is beyond the scope of this article. However, when retrospectively reviewing the program, it became obvious that axial compression with high strain rates was largely applied to the

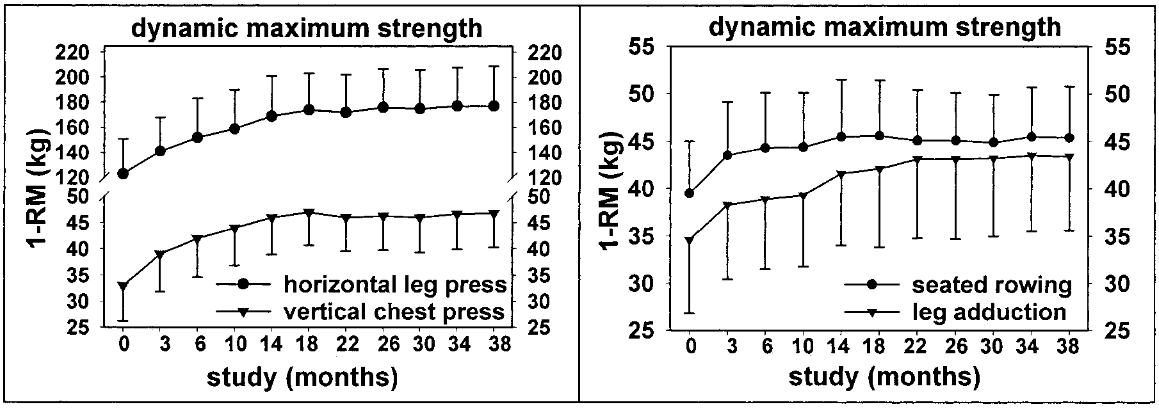

FIGURE 6—Changes in 1RM of four exercises in the exercise group after 3 yr.

spine and the femur, in particular, through the jumping sequences. In the forearm, there was only a single exercise for axial compression (chest press) with a low strain rate due to the relatively low exercise velocity (2-1-2) of the resistance training, whereas other exercises affecting the forearm such as lateral pull either resulted in axial extension or bending of the bone. However, reviewing the literature, there is no consensus on which type of exercise most favorably affects BMD at the forearm.

We also showed that total cholesterol and triglycerides significantly decreased in the EG compared with an increase in the CG. Because nutritional intake remained unchanged during the 3 yr, we attribute the improvement to our training program. This observation is not trivial; actually, most studies failed to demonstrate positive effects on blood lipids in early postmenopausal women (10). However, for HDL-cholesterol, LDL-cholesterol, and apolipoproteins A and B, we did not detect significant changes or differences between the EG and CG.

From the perspective of the individual woman, the relief of climacteric symptoms has a high priority. Here our results are rather modest. There was a trend toward improvement in both groups that was more dominant in the EG, resulting in significant intergroup differences for insomnia, migraines, and mood changes but not for hot flashes and depression.

In the literature, there is some evidence that exercise can compensate for unfavorable alterations with respect to body weight, body fat, and body composition that some authors associate with the menopausal transition (2,7). However, studies in which exercise-induced weight loss occurred also reported negative effects on bone despite the fact that the changes in body weight were small to moderate (<5% over 18 and 48 months, respectively) (24,28). Thus, weight loss and maintenance of BMD are probably contradictory exercise aims.

If we look more specifically at changes in body fat during early menopause without adjuvant diet, only two exercise studies report significant though small results. After 9 months (6) and 24 months (1) of aerobic exercise training, body fat decreased by 2–3% as measured by skinfold measurements or hydrostatic weighting.

Overall, our study design possesses several strengths: 1) The duration of the study was longer and the number of participants was larger than in other exercise studies (29). 2) Exercise attendance and compliance during the study was high. Based on the results of a preceding study (17), we excluded subjects who attended fewer than two exercise sessions per week from the analysis presented here. 3) The exercise program was attractive, which can be derived from the fact that dropout rate was lower in the EG compared

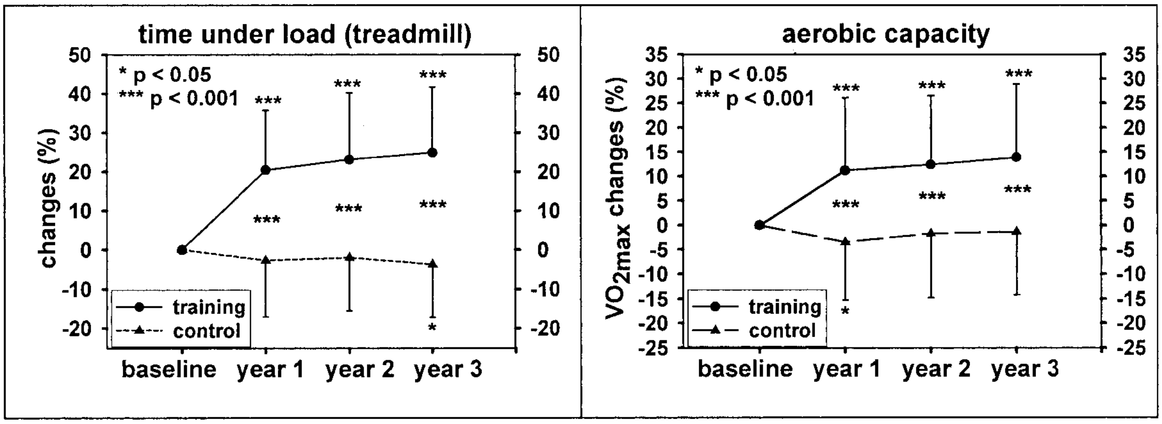

FIGURE 7—Changes in time under load and $\dot{V}O_{2max}$ after 3 yr in exercise and control groups.

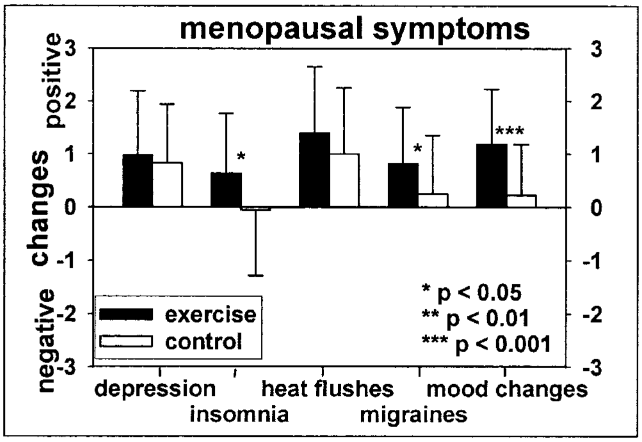

FIGURE 8—Changes in menopausal symptoms after 3 yr in exercise and control groups.

with the CG. 4) The study was well controlled. At baseline, no differences between EG and CG were observed for relevant parameters. Covariates potentially affecting our end points (e.g., diseases, medication, nutrition, lifestyle) were strictly controlled. 5) The gender, age, menopausal status, and bone density of our cohort were very homogenous. 6) The exercise protocol was constantly adjusted during the interventional period. Also the calcium and vitamin D supplementation was adjusted annually according to individual nutritional analysis.

A limitation of our study may be the nonrandomized design. However, as discussed extensively elsewhere (14,15), we think that the effect of randomization in nonblindable studies is rather limited. Furthermore, because one end point of our study was to assess dropout and compliance over a long time, randomization would falsify the results.

In this article, we showed the effectiveness of a mixed training program to compensate for negative changes of age and/or menopausal transition on BMD, physical fitness, body composition, and blood lipids.

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