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Effects of High-Intensity Aerobic Exercise and Resistance Training on Cardiometabolic Risk in Early-Postmenopausal Women

Einfluss von hochintensivem Ausdauer- und Krafttraining auf kardiometabolische Risikofaktoren bei Frauen in der frühen Postmenopause

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Summary

- ▶ **Purpose:** The menopausal transition is a critical period in women's lives. The central aim of the present study was to evaluate the effect of a multimodal exercise protocol on the cardiometabolic risk factor potentially related to menopausal transition in early postmenopausal women.
- ▶ **Methods:** Fifty-four (54) early-postmenopausal women (54.0±1.8 years) were randomly assigned to two groups: (1) exercise group (EG: n=27) which conducted a high intensity aerobic and resistance training three times/week and (2) active control group (CG: n=27) exercising once a week with low exercise intensity. Besides bone density, the main variable of this project, the outcome variable in this thesis was also cardiometabolic risk, as summarized by the Metabolic Syndrome (MetS) Z-Score. We applied Intention-to-Treat (ITT) and Per Protocol Analyses (PPA) with multiple imputation and used standardized mean differences to illustrate the effects.
- ▶ **Results:** After 16 weeks of exercise two participants (EG: n=1; CG: n=1) were lost to follow-up. Effects for the MetS Z-Score were moderate (EG: -0.36±1.36 vs. CG: 0.51±2.28; SMD: 0.47, 95% CI: -0.08 to 1.03), albeit borderline non-significant (ITT: p=.089; PPA: p=.060).
- ▶ **Conclusion:** The present multimodal exercise protocol just failed to affect the MetS Z-Score and its underlying cardiometabolic risk factors. Whether this result can be generalized to the entire cohort of early-postmenopausal women or whether it has to be attributed to the only moderately high exercise intensity during the early weeks of the intervention along with a relatively short intervention period remains to be evaluated.

Zusammenfassung

- ▶ **Problemstellung:** Die Wechseljahre sind eine kritische Phase im Leben der Frau, die mit vielen negativen Veränderungen vergesellschaftet ist. Neben muskuloskelettalen Größen werden dabei auch kardiometabolische Risikofaktoren überwiegend negativ beeinflusst. Das Ziel der vorliegenden Untersuchung war es daher, die Wirkung eines multimodalen Trainingsprotokolls u. a. auf kardiometabolische Risikofaktoren (sekundärer Studienendpunkt) von früh-postmenopausalen Frauen mit niedrigem Knochenmineralgehalt zu evaluieren.
- ▶ **Methoden:** Vierundfünfzig (54) Frauen in der frühen Postmenopause (54,0±1,8 Jahre) wurden nach dem Zufallsprinzip zwei Gruppen zugeordnet: (1) eine Trainingsgruppe (EG: n=27), die dreimal pro Woche ein hochintensives Aerobic- und Krafttraining durchführte, und (2) eine aktive Kontrollgruppe (CG: n=27), die einmal pro Woche mit geringer Intensität trainierte. (Sekundärer) Endpunkt war das Metabolische Syndrom (MetS), ein kardiometabolischer Risikocluster, der über einen Z-Score zusammengefasst wurde. Wir verwendeten das Intention-to-Treat (ITT) Prinzip mit multipler Imputation sowie Per-Protokoll-Analyse (PPA) und berechneten neben Signifikanzwerten auch Effektgrößen (SMD).
- ▶ **Ergebnisse:** Nach 16 Wochen Intervention konnten zwei Teilnehmerinnen (EG: n=1; CG: n=1) nicht an der Kontrollmessung teilnehmen. Die Effekte auf den Endpunkt MetS Z-Score waren moderat hoch (EG: -0,36±1,36 vs. CG: 0,51±2,28; SMD: 0,47), aber grenzwertig nicht signifikant (ITT: p=.089; PPA: p=.060).
- ▶ **Diskussion:** Das vorliegende multimodale Übungsprotokoll zeigte weder signifikante Effekte auf den MetS Z-Score noch dessen zugrundeliegenden kardiometabolischen Größen. Inwieweit dieses Ergebnis einschlägig für dieses Frauenkollektiv ist oder auf die zu Studienbeginn lediglich moderat hohe Belastungsintensität bei vergleichsweise kurzer Interventionsdauer zurückzuführen werden kann, ist noch zu evaluieren.

KEY WORDS:

Metabolic Syndrome, MetS Z-Score, Menopausal Transition

SCHLÜSSELWÖRTER:

Metabolisches Syndrom, MetS Z-Score, Wechseljahre

Introduction

The menopausal transition with its very pronounced decline of estradiol levels cause predominately negative effects on all tissue with estrogen receptors (25) included the negative influence on risk factors that promote cardiovascular disease (1). Women between 55 and 69 years of age are particularly at risk (36). Cardiometabolic and cardiovascular diseases, in addition to muscular and skeletal disorders, also

contribute to high morbidity in this age group (26, 33). For these reasons, an exercise program should be developed that counteracts precisely these problems. Unfortunately there is a lack of studies that focus on this issue, particularly with respect to cardiometabolic risk factors related to menopausal Estradiol decline (27, 34). There is considerable evidence that tailored exercise interventions can reduce cardio-



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metabolic risk (8, 14). According to the determination of the International Diabetes Federation (IDF), the metabolic syndrome (MetS) can be considered as a cluster of cardiometabolic risk factors and diseases (2). However, so far no randomized controlled exercise study (RCT) on early-postmenopausal women has verified the positive effect of multicomponent exercise on the MetS.

Thus, in the present ACTLIFE-ER study, we aimed to determine the effect of a multipurpose exercise program on the MetS in early-postmenopausal women.

Our hypothesis was that the exercise group (EG) of early postmenopausal women demonstrated significantly higher effects on the MetS Z-Score (16) compared with a corresponding control group (CG).

Materials and Methods

Study Design

The ACTLIFE-ER study is an 18-month randomized controlled exercise study embedded in a European study designed by the Institute of Medical Physics (IMP), Friedrich-Alexander-University of Erlangen-Nürnberg (FAU), Germany. The University Ethics Committee of the FAU (Ethikantrag 118_18b) and the Federal Bureau of Radiation Protection (BFS, number Z5-22462/2-2018-055) approved ACTLIFE-ER. After receiving detailed information, all study participants gave their written consent. The project was fully registered under ClinicalTrials.gov: NCT03959995. The present publication focuses on the secondary study endpoint "cardiometabolic risk" during the first phase (16 weeks; (February 2019-June 2019)) of the intended 18-month intervention. Less relevant for the present publication, however, the study had to be terminated due to the COVID-19 related lockdown after 13 months (March 2020).

Participants

Participant recruitment was conducted from November 2018 to January 2019. Using citizen registers 2500 women 48-60 years old were contacted by personal letter. Interested women were provided with more detailed information, and checked for eligibility by telephone. Women eligible and willing to participate in the study were invited to information meetings. As the main focus of the study is on the effects of physical exercise in postmenopausal women with reduced bone density, we included women 1-5 years postmenopausal with osteopenia or osteoporosis according to WHO (>1 SD T-Score). Participants were excluded if they had any of the following: (a) secondary osteoporosis (osteoporosis arising from disease or treatment), (b) a history of clinical low trauma fractures, (c) (osteo)anabolic and anti-resorptive pharmaceutical therapy, (d) Glucocorticoid therapy >7.5 mg/d during the previous 2 years, (e) diseases/health prohibited intensive exercise, (f) resistance exercise >60 min/week during the last 5 years, (g) alcohol consumption >60 g/d ethanol, (h) absence >3 weeks in a row during the intervention period. Figure 1 shows participant flow through the study and details of the recruitment process.

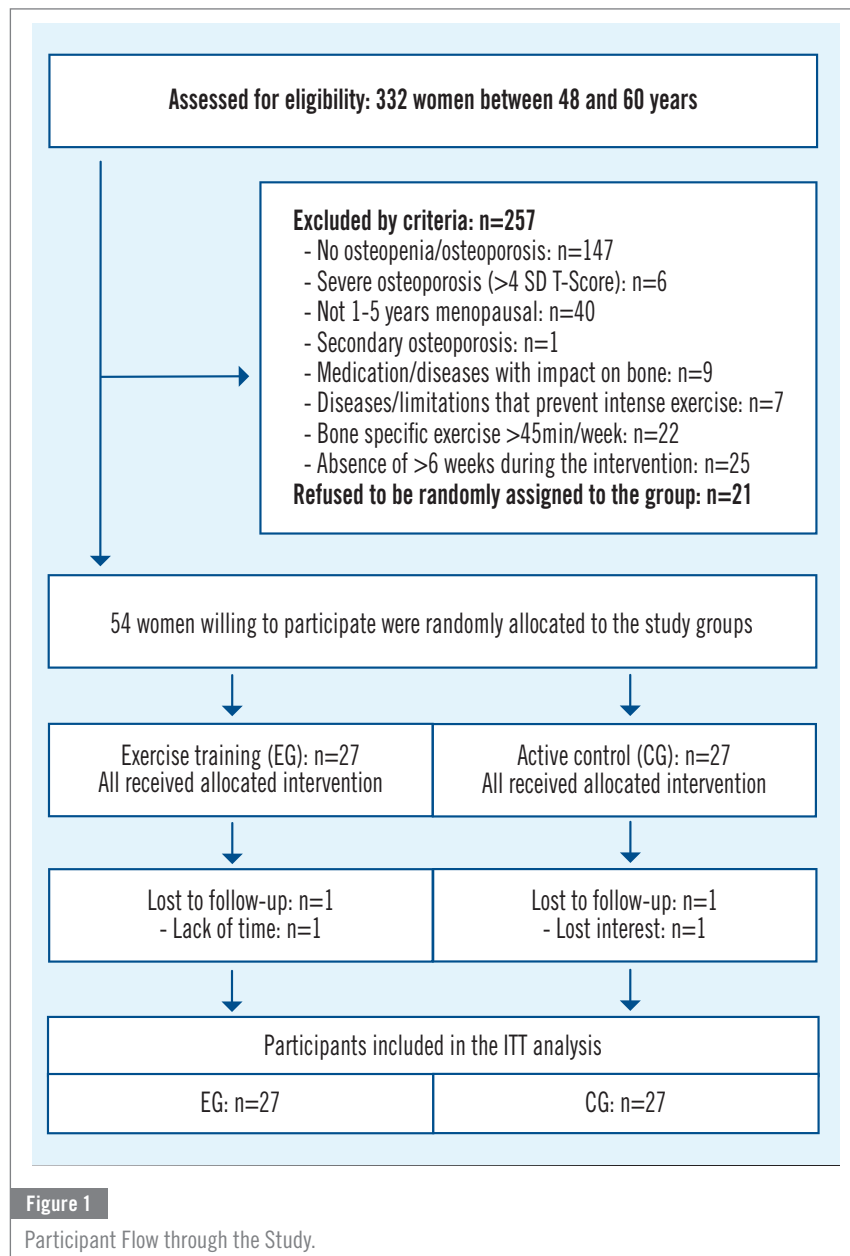


Figure 1
Participant Flow through the Study.

Randomization Procedures

Stratified for lumbar spine bone mineral density (LS-BMD), the 54 participants were randomly assigned to an exercise (EG, $n=27$) or control group (CG, $n=27$) by drawing lots. Lots were placed in opaque plastic shells and drawn by participants from a bowl. Neither participants nor researchers knew the allocation beforehand.

Blinding

Outcome assessors were unaware of and not permitted to ask about the participant's group status (EG or CG).

Intervention

The interventions were conducted in our lab and (EG only) in a women's gym (Ladies First Erlangen, Germany). All participants were asked to maintain their lifestyle and particularly their physical habits outside the study intervention. Attendance and compliance with the exercise protocol was checked by instructors who supervised and monitored all exercise sessions and by analyzing the training logs completed by the participants of the EG and CG.

Table 1

Baseline characteristics of the ACTLIFE-ER study. ¹ n=51 (EG: n=26, CG: n=25); ² at age 47 years; ³ verified osteoporosis in close relatives (parents, aunts, uncles, grandparents).

VARIABLE	EG (N=27) MV ± SD	CG (N=27) MV ± SD	P
Age [years]	53.6 ± 2.0	54.5 ± 1.6	.441
Body Mass Index [kg/m ²]	23.7 ± 3.4	24.9 ± 4.8	.306
Body mass [kg]	64.0 ± 9.6	67.4 ± 14.6	.320
Age at menarche [years]	13.6 ± 1.6	13.7 ± 1.7	.838
Age at menopause [years]	49.8 ± 3.8	51.0 ± 3.0	.189
Exercise volume [min/week]	63.7 ± 47.5	45.6 ± 38.4	.128
Waist circumference [cm]	87.8 ± 8.6	91.1 ± 9.9	.191
Energy intake ¹ [kcal/d]	2009 ± 444	2067 ± 355	.613
Protein intake ¹ [g/d]	75.8 ± 14.4	78.0 ± 14.7	.597
Carbohydrate intake ¹ [g/d]	223 ± 69	227 ± 57	.841
Fat intake ¹ [g/d]	84.1 ± 20.6	85.7 ± 23.8	.806
Alcohol intake ¹ [g/d]	2.63 ± 4.06	5.53 ± 6.39	.066
Vit-D level (25-OHD) [nmol/l]	69.5 ± 29.3	54.0 ± 27.0	.051
Calcium intake [mg/d]	645 ± 252	642 ± 265	.972
Ovariectomy <50 years [n]	1 ²	0	.313
Family disposition ³ [n]	7	9	.551

Exercise Group

The training protocol consistently scheduled three supervised sessions a week. On Mondays and Wednesdays, the participants completed 20 minutes of high intensity aerobic dance interval training (HIIT) followed by single set resistance training, also conducted with high intensity and high velocity (HIT). After four weeks of familiarization and learning of proper lifting technique, we started the first 12-week phase. Each session in our lab started with 5 min of aerobic dance with low exercise intensity (65% HR_{max}). On Mondays, intervals consisted of 60s at ≈ 80-85% HR_{max} intermitted by 60s at ≈ 65-70% HR_{max} intervals; on Wednesdays, intervals were shorter but more intense (30s/30s). Maximum heart rate was determined by a stepwise treadmill test to failure. HR during the session was monitored by the instructor checking the participants' HR watches. The aerobic dance sequence included 80-120 movements/jumps with moderately intense ground reaction forces (GRF: 2.5-3x body weight). During the dynamic resistance training (DRT), a single set circuit approach consisted of 10-12 exercises/session (calf rises, lunges, leg-press, half squat, (half) squats; back extension (roman chair), deadlifts; single side lateral rows, trapezius, latissimus pulldowns, bench dips, incline dumbbell bench press). Loading phases versus rest periods varied between 40/30s, 60/30s and 80/30s, while time under tension (TUT) was prescribed at 2s (concentric) – 1s (isometric) – 2s (eccentric). Thus, the number of repetitions (reps) varied between 8 and 16 reps.

On Fridays or Saturdays, the participants performed a single set of resistance training (RT) in a commercial gym using conventional resistance devices. Starting with 10-15 minutes warm up on a cross-trainer (65-70% HR_{max}), DRT addressed 15 exercises (leg press, -extension, -curls, -adduction, -abduction, latissimus front pulleys, rowing, roman chair, trunk-extension, -flexion, inverse fly, bench press, military press, lateral raises, shoulder/triceps press). We applied a periodized protocol that ranged between 5-20 reps. Movement velocity was similar to the circuit training in our lab (2s-1s-2s).

After 8 weeks of exercising, exercise intensity was defined by the repetition in reserve (RIR) approach (39). During phase one, we prescribed work to incomplete failure (nRM; repetition maximum minus 1-2 reps), for both the circuit training in our lab and training on resistance devices.

Control Group

The low intensity intervention in the CG started 4 weeks after the EG. One supervised training session of 45 min per week was scheduled for 12 weeks. The training session consisted of 15 minutes low impact warm up (marching variations), 20 minutes of muscle training and 10 minutes of cool down. The muscle training sequence included stretching exercises, mobilization, easy floor and bodyweight exercises (calisthenics). Eight lower extremity and trunk muscle groups were each stretched for 30 seconds. Mobilization and strength training mainly addressed abdominal, lower and upper back muscle groups. Dynamic and isometric exercises were performed once with 10-12 repetitions (2s-1s-2s) or 30 seconds each. Emphasis was placed on low exercise intensity. Cool down focus on general relaxation.

Vit-D / Calcium Supplementation

Based on baseline blood concentrations of 25 OH Vitamin-D3 (25-OHD3), participants with levels below 40 mg/ml were provided with 5,000 IE/week Vit-D supplements (MYVITAMINS, Manchester, UK).

We used the questionnaire (Rheumaliga Suisse) to calculate the amount of individual daily dietary calcium intake. In order to reach the recommended dose of 1000 mg/d (11), we provided participants with calcium capsules (Sankt Bernhard, Bad Dientzenbach, Germany).

Compliance with Vitamin-D and Calcium supplementation was monitored by bimonthly personal routine interviews and by questionnaires at follow-up assessments.

Outcome

Study Outcome: Changes of the MetS Z-Score, based on the NCEP (National Cholesterol Education Program) Adult Treatment Panel (ATP) III Definition (13) from baseline to 16-week follow-up assessment. Explanatory Outcomes: Variables constituting the MetS Z-Score according to NCEP ATP III. Changes of Trial Outcomes after Trial Commencement: No changes of trial outcomes were made after trial commencement.

Testing

Baseline and follow up assessments were performed using identical calibrated devices, in precisely the same setting and at the same time of the day (±90 min). The same research assistants guided and supervised the tests at baseline and 16-week follow-up (FU). All participants were asked to refrain from intense physical activity and exercise 48 hours prior to the test sessions.

Anthropometry

Body height was measured using a calibrated Stadiometer, body mass and composition were determined via direct-segmental, multi-frequency Bio-Impedance-Analysis (DSM-BIA; InBody 770, Seoul, Korea).

Blood Parameters

Blood was sampled in the morning (7:00 to 9:00) after an overnight fast from an antecubital vein in a sitting position. Serum

Table 2

Baseline data and changes of MetS Z-Score in the exercise and control group; Differences between the groups; MV=Mean Value; CI=Confidence Interval. MetS Z-Score: Negative score values indicate lower risk of metabolic syndrome. Negative changes in the score show a more favorable progression.

METS Z-SCORE	CG MV ± SD	EG MV ± SD	DIFFERENCE MV (95%-CI)	P-VALUE
Baseline	-3.76 ± 4.06	-5.02 ± 2.43	-	.183
Changes	0.51 ± 2.28	-0.36 ± 1.36	0.89 (-1.87 to 0.14)	.089

samples were centrifuged at 3000 RPM for 20 minutes and were immediately analyzed. Inter alia, serum glucose, total cholesterol, HDL-, LDL-cholesterol and triglycerides (all Olympus Diagnostica GmbH, Hamburg, Germany) were evaluated.

Blood Pressure

Blood pressure (RR) was determined twice in a row on different arms with a rest of 30 s between the samples after 15 min of relaxation in a sitting position with an automatic sphygmomanometer (Bosco, Bosch, Jungingen, Germany). Subjects were asked to avoid relevant physical activity and to refrain from coffee or tea for at least 2 hours prior to testing. Mean Arterial Pressure (MAP) was calculated (diastolic RR + diastolic RR + systolic RR)/3.

Metabolic Syndrome Z-Score

In order to classify the risk for a metabolic syndrome in one single value, we calculated the Metabolic Syndrome (MetS) Z-Score according to Johnson et al. (16), which is based on the NCEP-ATP III Criteria of the MetS. Using the individual data of the participants, the ATP-III cut off point for a female population and the corresponding baseline standard deviation (SD) of the entire cohort MetS Z-Score was calculated as: $[(50 - \text{HDL-Cholesterol}) / \text{SD HDL-C}] + [(\text{Triglycerides} - 180) / \text{SD TriGly}] + [(\text{Glucose} - 100) / \text{SD Glucose}] + [(\text{waist circumference} - 88) / \text{SD WC}] + [(\text{mean arterial pressure} - 100) / \text{SD MAP}]$.

Questionnaires and Protocols

General characteristics, medication, diseases and lifestyle including physical activity and exercise, were determined using standardized questionnaires (7, 19, 20). These were checked by the principal investigator in cooperation with the participants during the assessments in our lab. The sixteen-week FU questionnaire predominately focused on changes of confounding variables concerning lifestyle including physical activity and exercise, diseases, medication, and supplementations.

After careful instruction, four-day diet records (Freiburger Nutrition Record, nutri-science, Hausach, Germany) were completed by all participants at baseline and after 16 weeks. In cases of dubious results (e.g., energy intake <1,000 kcal/d or >3,500 kcal/d), we asked the participant to complete another diet record based on more representative days.

Sample Size

The sample size calculation was based on the primary study outcome of the ACTLIFE-ER project BMD changes at the LS after 18 months. Assuming an effect (Δ -EG vs Δ -CG) on BMD-LS of $2.0 \pm 2.5\%$ determined in comparable studies (7, 18) and applying a t-test based sample size calculation, the required sample size to generate a 80% power (1-beta) and $\alpha = .05$ is 25 participants per group. To adjust for drop-out (per-protocol analysis) we included slightly more participants. Based on the included 27 participants per group we were able to detect a group difference for the MetS Z-Score between EG and CG of $10 \pm 12.5\%$ (22, 37) with a power of 84% ($\alpha = .05$).

Statistical Analysis

We applied the Intention to Treat (ITT) principle that included all participants regardless of their loss to follow-up measurement or compliance. Missing values were imputed by multiple imputation (15, 29). The full dataset was used for imputation, while imputation being repeated 100 times. In addition to the ITT analysis, we conducted a per protocol (PP) analysis, that included all participants with follow-up assessments. Statistical and graphical procedures for determining normal distribution showed high agreement for MetS Z-Score. Thus, within-group differences were determined with dependent t-tests. Group differences were calculated with pairwise t-test comparisons (EG vs CG) with pooled SD. We consistently applied 2-tailed tests and accepted significance at $p < 0.05$. In order to determine effect sizes we calculated standardized mean difference (SMD) according to Cohen (9).

Results

Baseline characteristics displayed in Table 1 indicated no statistical differences between EG and CG at study start. However, 25 OHD3 concentration, waist circumference and exercise volume per week, differed considerably between the groups. Two women of the CG and one of the EG were underweight ($\text{BMI} < 18.5 \text{ kg/m}^2$); four women of the CG and one woman of the EG can be considered obese ($> 30 \text{ kg/m}^2$).

Exercise Characteristics

One participant each of the CG and EG was lost to follow-up. Reasons for dropping out were lack of time (EG) or loss of interest (CG). Exercise attendance averaged $78 \pm 12\%$ in the EG and $75 \pm 20\%$ in the CG. Compliance with the exercise protocol according to the rating of the instructors and the training logs was moderate-high in both groups.

MetS Z-Score

Slight deteriorations ($p = .150$) were observed in the CG while the MetS Z-Score non-significantly improved in the EG ($p = .197$). MetS Z-score showed considerable intra-individual variation. According to both types of analysis, differences between the groups were not significant (ITT, mean difference (MD): 0.89, 95% CI: -1.87 to 0.14, $p = .089$, SMD: 0.47 (Table 2) vs. PP, MD: 0.92, 95%-CI: -0.04 to 1.89, $p = .060$, SMD: 0.52). Thus, we have to revise our hypothesis of significantly higher effects on MetS Z-Score in the EG compared with the CG. Revisiting the underlying variables of the metabolic syndrome Z-Score, we observed no significant exercise effects (ITT) for waist circumference (EG: -3.4 ± 4.6 vs. CG: -1.3 ± 4.2 cm, MD: 2.1 cm, 95%-CI: -0.3 to 4.5 cm, $p = .081$, SMD: 0.48), MAP (EG: -1.4 ± 6.5 vs. CG: -0.4 ± 9.2 mmHG, MD: 1.0 mmHG, 95%-CI: -3.4 to 5.4 mmHG, $p = .652$, SMD: 0.13), glucose (EG: -0.9 ± 6.6 vs. CG: $+1.9 \pm 9.8$ mg/dl, MD: 2.8 mg/dl, 95%-CI: -1.9 to 7.4, $p = .234$, SMD: 0.34), HDL-C (EG: -1.4 ± 6.2 vs. CG: -1.6 ± 6.7 mg/dl, MD: 0.2 mg/dl, 95%-CI: -3.3 to 3.6, $p = .929$, SMD: 0.03) and triglycerides (EG: $+5 \pm 26$ vs. CG: $+16 \pm 48$ mg/dl, MD: 11 mg/dl, 95%-CI: -11 to 37 mg/dl, $p = .291$, SMD: 0.28). ➔

Changes in Confounders

All participants reported full compliance with the recommended Vit-D and Ca supplementation. However, as per the protocol we did not determine the 25 OHD 3 levels after 16 weeks. Based on questionnaires and protocols, we did not detect relevant changes and corresponding between-group differences for physical activity and exercise outside the ACTLIFE project. Correspondingly, none of the women reported changes of nutritional intake habits during the study period. Further, changes of medication, appearance of new diseases or worsening of existing complaints were not reported.

Discussion

The central aim of the ACTLIFE-ER study is to investigate the effect of a multimodal exercise protocol on menopausal risk factors in early-postmenopausal women with osteopenia and osteoporosis. However, due to the lack of corresponding studies we focused on cardiometabolic risk-factors affected by the menopausal transition (31). In summary, whilst observing positive effects, we narrowly failed to determine significant data on our study endpoint "METS Z-Score". So far, the present study confirmed the non-significant finding of our TRACE study that also included early postmenopausal women (21). However, due to our diverging exercise protocol we expected more favorable results in the present study. Unfortunately, only few other studies focus on the MetS in early post-menopause women. Closest to our studies, after 16 weeks of exercise, Conceicao et al. reported a significant reduction of the MetS Z-Score along with favorable changes of body composition in his cohort of sedentary women 45-60 years old. Of note, Conceicao et al. focus exclusively on a RT protocol similar to our RT approach (10). Indeed, there is some evidence that in general, muscle strength is important in the prevention of the MetS (17, 38). Nevertheless, Bateman et al. concluded that aerobic exercise (AE) or mixed AE/RT but not RT protocols alone were effective for improving the MetS Z-Score in overweight, dyslipidemic subjects 18-70 years old (6). However, in view of the different health and age status, it is difficult to compare the studies.

More surprisingly, we did not detect any significant effect on underlying variables of the MetS according to NCEP ATP III namely, fasting glucose, triglycerides, HDL-C, resting blood pressure or waist circumference (13). Of note, only the latter variable improved significantly in the EG, while particular blood parameters did not indicate relevant changes. However, it should be borne in mind that baseline values were on average in the normal range and apart from waist circumference (mean 89 cm), below the cut-off point suggested by the NCEP ATP III criteria. Therefore, the potential for favorable changes was rather limited. Nevertheless, most other exercise studies reported significant effects on cardiometabolic risk factors in similar cohorts of early-postmenopausal women (4). One reason for our results might have been the short length of the intervention along with a low-moderate exercise intensity during the early conditioning period. Indeed, most successful exercise studies were either longer or started with higher exercise intensity (10, 24, 35). However, according to the cross-sectional data of Rennie et al. (32) moderate and vigorous physical activity are both associated with reduced risk of being classified with MetS. Further, soft lean body mass (SLBM) as a variable with a high exercise intensity threshold for adaptation (30) increased significantly in the EG ($2.1 \pm 1.8\%$), indicating that we applied an intensity sufficient to trigger effects on cardiometabolic variables ((e.g. hypertension (4, 28)), 30, 32).

Some aspects of the study might limit the validity and generalization of our results (1). Given the impossibility of blinding participants or implementation of a waiting list control, we introduced an active control group. Although exercising with low exercise frequency and intensity, the protocol of the CG might still have affected cardiometabolic risk factors with low strain thresholds (e.g. MAP (3)). This might have contributed to the lack of significant difference in the effects for MetS Z-Score between groups (2). We calculated a continuous score for the MetS according to NCEP ATP III. We conclude that MetS Z-Score - might be more sensitive than a dichotomous score that simply determines MetS incidence and,
- avoids the multiple test problem present when addressing all underlying risk factors (3, 21).

Although drawing lots might not be the most sophisticated randomization strategy, this approach, along with detailed information about the characteristics of EG and CG, might increase adherence, particularly after self-allocation to the non-favored study arm (4, 23). In order to determine the effect of our exercise protocol on the study endpoint with an adaptive response shorter than bone, we conducted the present interim analysis (12). Our rationale for this approach was
- to evaluate the effect of changes/adaptations of the exercise protocol on selected outcomes (i.e. body composition, cardiometabolic risk factors) in the planned 18-month study period, which had to be terminated early due to Covid 19 however, and
- to provide data that can be compared with the present literature with respect to study duration (i.e. 10-18 weeks) (5).

Although several women had to be excluded for reasons not relevant for the present research issue (Figure 1), we conclude that our data can at least be transferred to early postmenopausal women without diseases /medications/interventions that relevantly impact bone (and muscle). However, it is difficult to estimate the clinical relevance of our result, in particular since we focus on a (MetS-Z) Score that summarizes five cardiometabolic risk factors and might offset high and low changes in risk factors. Although our sample size provided 84% power to detect a group difference for the MetS Z-Score between EG and CG of $10 \pm 12.5\%$ ($\alpha = .05$), we have to be cautious with interpretation and generalization of our finding. ■

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Conflict of Interest

The authors have no conflict of interest.

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