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Physical training programs that affect muscle mass in adult women. Systematic review

Programas de entrenamiento físico que afectan la masa muscular en mujeres adultas. Revisión sistemática

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Abstract

Loss of muscle mass and strength is the main factor limiting functionality in activities of daily living. There are transition periods in which women reduce the practice of activities focused on maintaining muscle mass and strength, which affects their functionality. Interventions that promote the development or maintenance of adequate muscle mass and strength in adult women are effective strategies to prevent motor deficits that lead to physical disability. Objectives: to examine the characteristics of physical activity or exercise interventions that have evaluated changes in muscle mass in adult women under 60 years of age. Methodology: A literature search was carried out in the digital databases: PubMed, Cochrane and Redalyc. Experimental studies of physical training programs published between 2016 and 2021 were included, which included women under 60 years of age, who counted the impact on muscle mass among their results. Contribution: it is necessary to know the characteristics of training programs with influence on muscle mass in adult women, in order to support evidence-based practice for the promotion of physical-functional health.

Exercise, Training, Women

Resumen

La pérdida de masa muscular y fuerza es el principal factor que limita la funcionalidad en las actividades de la vida diaria. Existen períodos de transición en los cuáles las mujeres disminuyen la práctica de actividades enfocadas al mantenimiento de la masa muscular y la fuerza, lo cual repercute en su funcionalidad. Las intervenciones que favorecen el desarrollo o mantenimiento de una adecuada masa muscular y fuerza en mujeres adultas son estrategias eficaces para prevenir las deficiencias motrices que conducen a la discapacidad física. Objetivo: examinar las características de las intervenciones de actividad física o ejercicio que han evaluado los cambios en la masa muscular en mujeres adultas menores de 60 años. Métodos: Se realizó una búsqueda de literatura en las bases de datos digitales: PubMed, Cochrane y Redalyc. Se incluyeron estudios experimentales de programas de entrenamiento físico publicados entre 2016 y 2021, que incluyeron a mujeres menores de 60 años, que contaran dentro de sus resultados el impacto sobre la masa muscular. Contribución: es necesario conocer las características de los programas de entrenamiento con influencia sobre la masa muscular en las mujeres adultas, con la finalidad de apoyar la práctica basada en evidencias para la promoción de la salud físico-funcional.

Ejercicio, Entrenamiento, Mujeres

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Introduction

The optimal functioning of the musculoskeletal system is vital for the performance of the activities of daily life and an adequate metabolism. Loss of muscle mass and strength is the main factor that limits functionality in activities of daily living (Pano-Rodríguez et al., 2020; Skelton & Mavroeidi, 2018). During the fourth decade of life, women experience various changes in metabolism, body composition, and the functioning of the musculoskeletal system. Abdulnour et al. (2016) point out that the loss of muscle mass and strength in this period is greater in women compared to men of similar ages. A consequence of the loss of muscle strength in the lower limbs is a decrease in balance, which increases the risk of falls in middle-aged women (Anek & Kanungsukasem, 2015).

Reduced functional capacity is known to be one of the main causes of disability, mortality, and other negative health outcomes (Pano-Rodríguez et al., 2020). Lifestyle-related factors such as a protein-deficient diet and physical inactivity affect the quantity and quality of muscle mass (Aretson-Lanz et al., 2019).

Regarding physical inactivity, Barranco-Ruiz et al. (2019) point out that its prevalence is higher in the female population, both in developed and developing countries. In Mexico, according to the National Health and Nutrition Survey (ENSANUT) 2018-2019 (Shamah-Levy et al., 2020) and the Women and Men Survey 2020 of the National Institute of Statistics and Geography [INEGI] (2020) , the constant of physical inactivity is observed throughout all the stages of development of this population group, especially from adolescence. Thus, 53.5% of adolescents between 15 and 19 years old are physically inactive, while 65.6% of women older than 18 years do not exercise or practice sports (INEGI, 2019; Shamah-Levy et al., 2020).

Skelton and Mavroedi (2018) report that there are transition periods, such as the beginning of university life, marriage, pregnancy and menopause in which women reduce the practice of activities focused on maintaining muscle mass and strength, which affects its functionality.

Interventions that favor the development or maintenance of adequate muscle mass and strength in adult women are effective strategies to prevent motor deficiencies that lead to physical disability; in sum, women who maintain an adequate level of muscular strength in the lower limbs from early adulthood experience a lesser decline in said conditional ability and have fewer disturbances in balance during middle adulthood (Wu et al., 2017). The quantity of the muscular mass and the quality of this evaluated with respect to the resulting physical condition, are indicators associated with the physical functionality and quality of life.

It is necessary to know the characteristics of training programs with influence on muscle mass in adult women, in order to implement them appropriately in the professional practice of the multidisciplinary health team. The objective of the present systematic review is to examine the characteristics of physical activity or exercise interventions that have evaluated changes in muscle mass in adult women under 60 years of age.

This study presents the sections of methods, results, discussion and conclusions. The methods section describes the literature search process, the inclusion and exclusion criteria of articles, as well as the evaluation of the quality of the literature found. The results section describes the characteristics of the studies included in the systematic review in consideration of the research objectives. In the discussion section, the contrast between the methodologies of the training programs is exposed. In the conclusions, the limitations found in the analyzed studies are identified and areas of opportunity for research are identified.

Methods

A literature search was carried out in the digital databases: PubMed, Cochrane and Redalyc. The keywords used in English were exercise AND muscle mass AND women NOT elderly or older and exercise AND muscle mass AND adult women NOT elderly or older.

The search was carried out from September to December 2021.

Experimental studies of physical training programs were included, which were evaluated as high-quality evidence, published in the period from 2016 to 2021, which included women under 60 years of age, who counted the impact on muscle mass among their results. Articles that could not be found in extensive, exercise programs with a duration of less than six weeks, that did not have the description of the training, in participants with an average age of over 60 years, studies that included physically active men or women were excluded. Fourteen documents were removed, and it was not possible to find the full text.

The quality level evaluation was obtained according to the criteria of the Grading of Recommendation Assessment, Development and Evaluation -GRADE- (Manterola, Asenjo-Lobos & Otzen, T., 2014). Three investigators conducted the electronic database search, title and abstract analysis, and cross-checked the report. The data analysis was carried out in descriptive tables of the training programs considering the indicators of the impact on women.

Results

The systematic literature search yielded a total of 328 articles in the three databases considered: PubMed, Cochrane and Redalyc. Once the selection criteria were reviewed, 14 articles were analyzed in this literature review (Figure 1).

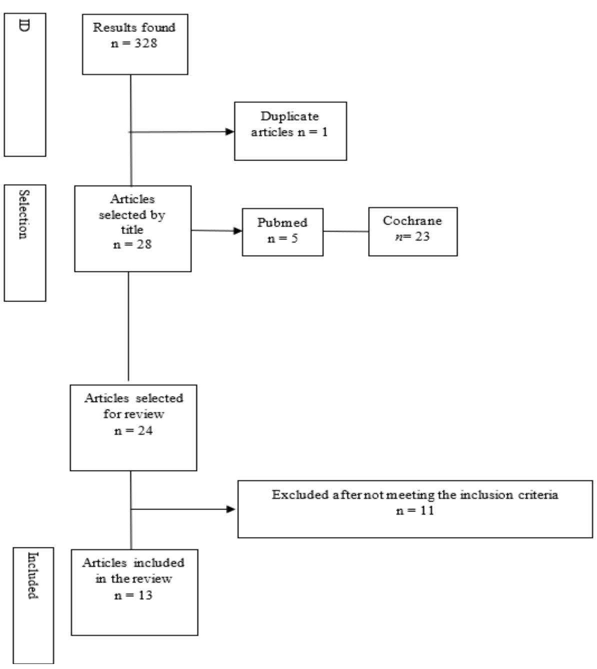

Figure 1 Flowchart for selecting articles for review

Table 1 shows the descriptive characteristics of the articles considered in the review. The characteristics of the experimental groups are distinguished, the design and classification according to the type of program evaluated.

Reference	GE(n)	GC(n)	GE Age (years ± SD)	GC Age (years ± SD)	Design	Type
Barranco-Ruiz et al., 2019	31/GE2: 23	22	38 ±6.4*	NE	Randomized clinical trial	RA
Cholewa et al., 2018	11	12	20.7±1.4	21.2±1.3	Randomized clinical trial	BC
Daly et al., 2020	122	121	45- 65	45- 65	Randomized, double-blind, placebo-controlled trial	BC
de Oliveira Júnior et al., 2020	13/GE2: 13	14	58.53 ± 8.03 /GE 2= 59.31 ± 8.37	59.80 ± 9.43	Randomized clinical trial by control group	RM
Dutra et al., 2018	15 /GP: 12	15	23.7±1.6	23.6±3.6	Randomized, double-blind, placebo-controlled trial	BC
Franco et al., 2019	14	18	24.3 ± 6 4.8	24.3 ± 6 4.8	Randomized controlled trial	RM
Hernández-Reyes et al., 2019	24/ GE2: 27	29	42.97± 10.84	46.10 ±10.57	Randomized trial	RA
Hettchen et al., 2021	27	27	53.6 ± 2.0	54.5 ± 1.6	Randomized trial	BC
Jendricke et al., 2019	45	45	38.3±8.7	41.6±6.9	Randomized, double-blind, placebo-controlled trial	BC
Miller et al., 2020	30	30	37.9±7.69	35.9±10.3	Randomized clinical trial	BC
Orsatti et al., 2017	16	16	58.8 (8.9)	56.8 (6.6)	Randomized placebo-controlled trial	BC
Said et al., 2017	16	16	30.58 ± 3.8	29.66 ± 4.2	Randomized controlled intervention trial	RA
Zeng et al., 2021	18/ GE3: 18	18	21.13 ±1.64	22.13 ±1.96	Randomized clinical trial	RA

Note: GE = experimental group; GC = Control group; GP = placebo group; RA = Aerobic endurance; BC = Multicomponent; RM = Muscle endurance. * NE: They do not specify by group

Table 1 Characteristics of high-quality experimental studies evaluating muscle mass in adult women
Source: check full data in references

Table 2 describes the characteristics of the evaluated programs, the indicators to evaluate muscle mass and the results related to this indicator. For the description of the programs, the explanation of frequency, intensity, time, type, volume and progression was considered in accordance with the recommendations for physical training programs. Table 2 presents the aerobic resistance training programs; the muscular resistance training programs are presented in Table 3 and finally, the bicomponent programs are described in Table 4.

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Reference	Experimental group 1 program	Description	Control or experimental group program 2	Description	Muscle mass	Results
Barranco-Ruiz et al., 2019	Zumba classes	F: 3 s / s I: EB (0-10 T: 60 min	Zumba Fitness ® classes + GE2 muscle resistance exercises: 10,000 steps daily walk + Bodybump muscle resistance training	F: 3 s / s I: EB (0-10) T: 80 min (60 min of Zumba and 20 min of strength exercises)	Anthropometry ISAK + ec. de Lee (Lee et al., 2000)	In both groups, MG decreased (p <.01) and MM increased (G1 p = .05 and G2 p <.01)
Hernández-Reyes et al., 2019	10,000 steps daily walking program (GE1)	F: daily I: 60% VO2max T: 60 min V: 10,000 steps METS: 5-8	CG: 5000 steps daily walk + hypocaloric diet Low impact aerobic exercise program + muscular resistance exercises (LIAS)	GE2 F: 4 s / s I: 70% VO2max T: 60 min V: 10,000 steps F. Bodybump: 3 s / s METS:> 8	Electrical bioimpedance (Tanita BWB 800-A)	There was a greater increase in MM in GE2 compared to GE1 (βs. = 0.182 vs. βs. = 0.008)
Said et al., 2017	High Impact Aerobic Exercise Program (HIA)	F: 4 s / s I: 60% of HR max. (week 1-4); 75% of HR max. (week 5-14); 86% of HR max. (week 15-24) T: 50-60 min	GE2: high intensity interval aerobic exercise (HIIT) program	GC F: daily T: 30 min V: 5000 steps METS: 1-4	Anthropometry + ec. Womersley & Durnin (Womersley & Durnin, 1977)	Significant increase in fat-free mass in the LIAS group compared to the HIA group (p <.05)
Zeng et al., 2021	Continuous aerobic exercise program for maximum fat oxidation (FAT max)	F: 3 s / s T: 45 min V: 5 min warming + 40 min exercise	GE3: muscular endurance training program	LIAS F: 4 s / s I EA: 50-55% of HR max. (week 4-14); 60-65% of HR max. (week 15-24) I ER: 60-80% of 1 RM T: 50 min EA of exercise and 20 min of ER V ER: 2 sets with 15 s rest between exercises. 3 min rest between sets.	Electrical bioimpedance (INBODY 7.0, model ef-265B, South Korea).	Muscle mass increased in the 3 groups, being higher in the GE3 group (p <0.05).

Note: F = frequency; s / s = weekly sessions; I = intensity; EB = Borg scale; T = time; min = minutes; V = volume; P = progression; ISAK = International Society for the Advancement of Kineanthropometry; VO2 max = maximum oxygen consumption; GE2 = experimental group 2; CG = control group; HR max = maximum heart rate; EA = aerobic exercise; ER = resistance exercise; RM = maximum resistance; GE3 = experimental group 3.

Table 2 Description of changes in muscle mass evaluated in aerobic resistance training programs for adult women
Source: check full data in references

Reference	Experimental group 1 program	Description	Control or experimental group program 2	Description	Instrument to evaluate muscle mass	Results
De Oliveira et al., 2020	High Volume Muscle Endurance Training (HRVT) Program	F: 3 s / s I: 30-90% of 1 RM per exercise series V: 6 s from 8-12 r	Low Volume Resistance Program (LRVT)	F: 3 s / s I: 30-90% of 1 RM per exercise series V: 3 s of 8-12 r	DEXA (Lunar iDXA; GE, Madison, WI, USA).	Increased FFM in the thigh in the HVRT group (p <.01) compared to the LVRT group
Franco et al., 2019	Low Load Muscle Endurance Training Program (LL)	F: 2 s / s I: 20-90% RM V: 3 s from 30-35 r	High Load Muscle Endurance Training Program (HL)	F: 2 s / s I: 20-90% RM V: 3 s of 8-10 r	DEXA (GE / Lunar iDXA Corp, Madison, WI, USA)	In both groups there was a gain in MM in the legs (p <.05), being greater in the LL group [95% CI: 0.4 kg; 0.2 kg] HL group [95% C: 0.2 kg; 0.0 kg]. The GF was similar, no differences were observed between groups

Note: F = Frequency; s / s = weekly sessions; I = intensity; RM = repetition maximum; V = volume; s = series; r = repetitions; MLG = fat free mass; MM = muscle mass; GF = strength gain

Table 3 Description of changes in muscle mass evaluated in muscular resistance training programs for adult women.
Source: check full data in references

Reference	Experimental group 1 program	Description	Control or experimental group program 2	Description	Muscle mass	Results
Cholewa et al., 2018	ERM program + betaine supplement	F: 3 s / s I: 65% of 1RM V: 3 s of 10 r of 6-7 exercises for the MsSs and MsIs His p: 2 betaine capsules 2 times a day (625 gr per capsule)	ERM + placebo program	Same GE program.	Air displacement plethysmography (Bod Pod®, Cosmed, Concord, CA, USA). Quadriceps muscle thickness: B-mode ultrasound (ECO3; Chison Medical Imaging, Jiang Su, China)	Significant effects were found for changes in MM (2.4 ± 1.8 kg) and muscle thickness (0.13 ± 0.08 cm); no significant interactions.
Daly et al., 2020	ERM and balance program + fortified dairy supplement	*ERM F: 3 s / s I: effort from 3 to 8 in the BE T: 60 min V: 3 s of 10 r of ≥7 exercises for the MsSs and MsIS P: week 1-4: execution of exercises in a slow and controlled manner; week 5-8: increase in the speed of execution of the exercises Balance F: 3 s / s I: effort from 6 to 10 in the BS T: 30-60 seconds for each exercise V: 4 s of 10-20 r of ≥2 exercises for balance and mobility. His p: 30 g of supplement dissolved in 150 ml of water. I consume 2 times a day.*	ERM program and balance + placebo	Same GE program.	DEXA (Lunar iDXA, GE Medical Systems; Encore version 16). Muscle cross-sectional area: peripheral computed tomography (XCT 3000, Stratec Medizintechnik GmbH).	The supplement improved total MM (p = .02) and muscular cross-sectional area (thigh p = .03 and leg p = .05) but there were no differences in terms of strength, gait speed and dynamic balance.
Dutra et al., 2018	ERM program + antioxidant supplement	F: 2 s / s I: 1 RM P: week 1-2: 2 s of 12 r; week 3-4: 3 s of 12 r; week 5-6: 3 s of 10 r; week 7-8: 3 s of 8 r; week 9-10: 4 s of 10 r. His p: 3 antioxidant pills / day for 70 days.	ERM + placebo program	Same GE program.	Electrical bioimpedance (OMRON HBF-514C; OMRON Healthcare Inc., Lake Forest, IL, USA) Quadriceps muscle thickness: B-mode ultrasound (Philips-VMI).	In both groups, the muscle thickness of the quadriceps improved (p <.05).
Hettchen et al., 2021	GE: high intensity ERM program and EA + calcium and cholecalciferol supplement	*EA F: 4 s / s I: 80-85% of HR max. T: 15 min ERM F: 2 s / s I: 60-80% of 1RM V: 8-10 r His p: 2 capsules cholecalciferol (5000 IU / week)*	CG: low intensity ERM program and EA + calcium and cholecalciferol supplement	*ERM F: 1 s / s I: 3 in EB T: 20 min V: 2 s of 6-8 r EA F: 1 s / s T: 15 min Supplementation 2 capsules of colecalciferol (5000 IU / week)*	Direct segment and multi-frequency bioimpedance (DSM-BIA; InBody 770, Seoul, Korea	The GLM improved in the EG and decreased in the CG (0.39 ± 1.08 vs −0.37 ± 1.34 kg, p = 0.026).
Jendricke et al., 2019	ERM program + supplementation of specific collagen peptides (SCP)	F: 3 s / s T: 60 min V: 3 s of 5 exercises for the MsSs and MsIs P: week 1-2: 15 r; 3-4: 12 r; 5-8: 10 r; 8-12: 8 r. His p: 60 gr of supplement dissolved in 250 ml of water. I consume once a day.	ERM + placebo program	Same program as the experimental group	Electrical bioimpedance (SECA © mBCA 515, Hamburg, Germany).	Increase in FFM in both groups (p <.01). In EG the increase was greater (p <.05) after the RMANOVA analysis
Miller et al., 2020	Energy restricted diet + ERM and EA program	*ERM F: week 1-6: 3 s / s; 7-12: 2 s / s; 13-24: 1 s / s; 25-48: 1 biweekly session T: 60 min V: 1-3 s of 08-10 r of 8 exercises for the MsSs and MsIs EA F: week 1-6: 3 s / s; 7-12: 2 s / s; 13-24: 1 s / s; 25-48: 1 biweekly session I: 60-85% HR max. T: 20-30 min The supervised sessions were complemented with self-administered sessions for a total of 200 min a week of exercise His p: Diet with energy restriction: consumption of between 450-680 kcal per day in the intensive phase and 1200 kcal per day in the stabilization phase*	Energy restricted diet	*Diet with energy restriction: consumption of between 450-680 kcal per day in the intensive phase and 1200 kcal per day in the stabilization phase*	DEXA (GE Lunar Prodigy Pro, Madison, WI, USA 53718)	There were no significant changes in MM between the groups after 12 months of intervention (p = .352). Muscle strength gain was greater in EG (p <.05)
Orsatti et al., 2017	ERM program + soy supplement	F: 3 s / s I: 70% of 1RM V: 3 s of 8-12 r of 8 exercises for the MsSs and MsIs P: week 1: 1 s of 15 r with 40-50% of 1 RM; week 4: 3 s of 8-12 r with 60-80% of 1 RM. His p: 25 gr of supplement dissolved in 200 ml of milk. I consume once a day	ERM + placebo program	Same GE program.	Electrical bioimpedance (Biodynamics, model 450, USA). Anthropometry + ec. de Janssen et al. (2000).	Increase in MM (bioimpedance) in both groups, showing no differences between them (GE = 1.1 kg; CG = 1.5 kg). The strength gain was greater in the EG (p <.05).

Note: ERM = muscular endurance training; F = frequency; s / s = weekly sessions; Intensity = intensity; RM = repetition maximum; HR max = maximum heart rate; T = time; min = minutes; V = volume; P = progression; s = series; r = repetitions; Sup = supplementation; MsSs = upper limbs; MsIs = lower limbs; MM = lean mass; EA = aerobic exercise; EB = Borg scale; gr = grams; ml = milliliters; MLG = fat free mass; EG = experimental group; CG = control group

Table 4 Description of bicomponent programs - supplement / diet and muscular resistance training- for adult women included in the review
Source: check full data in references

Discussion

Research on the characteristics of training programs that include the evaluation of changes in muscle mass in adult women is relevant, given the high levels of physical inactivity reported in this population group. Physical inactivity is known to be one of the main contributing factors to muscle wasting.

The studies analyzed suggest that programs focused on muscle resistance training can generate benefits on the amount of muscle mass. Barranco-Ruiz et al., 2019 and Hernández-Reyes et al., 2019 compared the effects of aerobic exercise programs against muscular resistance programs, obtaining a greater increase in muscle mass in the latter. Other authors (Hettchen et al., 2021; Jendricke et al., 2019; Orsatti et al., 2017) evaluated muscular resistance training programs with the addition of nutritional supplements without achieving significant changes in the indicators considered to measure muscle mass. In addition, Miller et al., 2020 report that the combination of an energy-restricted diet and exercise does not produce changes in muscle mass.

Regarding the characteristics of the training programs, it was found that the methodology used to estimate exercise intensity was based on MRI (Cholewa et al., 2018, De Oliveira et al., 2020, Dutra et al., 2018, Franco et al., 2019, Orsatti et al., 2020 and Zeng et al., 2021), the Borg Scale (Daly et al., 2020), maximum HR and MR (Said et al., 2017). In contrast, Hernández-Reyes et al. (2019) estimated energy expenditure based on the METS unit of measurement. Despite the diversity in the methods used, positive changes in muscle mass were observed in all studies.

Different research indicators are considered for the evaluation of muscle mass. Electrical bioimpedance was the most used method (Dutra et al., 2018, Hernández Reyes et al., 2019, Hettchen et al., 2021, Jendricke et al., 2019, Orsatti et al., 2017 and Zeng et al., 2021); Dual energy X-ray absorptiometry (DEXA) considered the gold standard was the second most frequent method used (Daly et al., 2020, De Oliveira et al., 2020, Franco et al., 2019, Martins et al., 2018 and Miller et al., 2020). Two projects used formulas based on anthropometric measurements to estimate body composition (Barranco-Ruiz et al., 2019; Said et al., 2017) and only one report used air displacement plethymography (Cholewa et al., 2018). Verifying the validity and reliability of the indicators according to the study population is important for the comparative analysis of findings. The heterogeneity of indicators responds to the possibilities of each investigation. The evaluation of the quality of the muscle mass in addition to the quantity persists as an area of opportunity in this type of project.

Conclusions

The objective was to examine the characteristics of physical activity or exercise interventions that have evaluated changes in muscle mass in adult women under 60 years of age. Muscle resistance training programs appear to be effective in improving muscle mass in untrained adult women. This highlights the importance of resistance training for maintaining adequate levels of muscle mass during adulthood. Although the quality of the design of this type of project has many strengths, it is still necessary to promote the unification of the indicators used to evaluate muscle mass, consider the quality of muscle mass and the description of training programs.

References

Abdulnour, J., Doucet, É., Brochu, M., Lavoie, J. M., Strychar, I., Rabasa-Lhoret, R., & Prud'homme, D. (2012). The effect of the menopausal transition on body composition and cardiometabolic risk factors: A Montreal-Ottawa New Emerging Team group study. Menopause, 19(7), 760–767. https://doi.org/10.1097/gme.0b013e318240f6f3

Anek, A., Kanungsukasem, V., & Bunyaratavej, N. (2015). Effects of Aerobic Step Combined with Resistance Training on Biochemical Bone Markers, Health-Related Physical Fitness and Balance in Working Women. Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 98 Suppl 8, S42-51.

Arentson-Lantz, E. J., Galvan, E., Ellison, J., Wacher, A., & Paddon-Jones, D. (2019). Improving Dietary Protein Quality Reduces the Negative Effects of Physical Inactivity on Body Composition and Muscle Function. The Journals of Gerontology. Series A, Biological sciences, and medical sciences, 74(10), 1605–1611. https://doi.org/10.1093/gerona/glz003

Barranco-Ruiz, Y., Ramírez-Vélez, R., Martínez-Amat, A., & Villa-González, E. (2019). Effect of Two Choreographed Fitness Group-Workouts on the Body Composition, Cardiovascular and Metabolic Health of Sedentary Female Workers. International Journal of Environmental Research and Public Health, 16(24), 4986. https://doi.org/10.3390/ijerph16244986

Cholewa, J. M., Hudson, A., Cicholski, T., Cervenka, A., Barreno, K., Broom, K., Barch, M., & Craig, S. (2018). The effects of chronic betaine supplementation on body composition and performance in collegiate females: a double-blind, randomized, placebo-controlled trial. Journal of the International Society of Sports Nutrition, 15(1), 37. https://doi.org/10.1186/s12970-018-0243-x

Daly, R. M., Gianoudis, J., De Ross, B., O'Connell, S. L., Kruger, M., Schollum, L., & Gunn, C. (2020). Effects of a multinutrient-fortified milk drink combined with exercise on functional performance, muscle strength, body composition, inflammation, and oxidative stress in middle-aged women: a 4-month, double-blind, placebo-controlled, randomized trial. The American Journal of Clinical Nutrition, 112(2), 427–446. https://doi.org/10.1093/ajcn/nqaa126

De Oliveira Júnior, G. N., de Sousa, J., Carneiro, M., Martins, F. M., Santagnello, S. B., & Orsatti, F. L. (2021). Resistance training-induced improvement in exercise tolerance is not dependent on muscle mass gain in post-menopausal women. European Journal of Sport Science, 21(7), 958–966. https://doi.org/10.1080/17461391.2020.1798511

Dutra, M. T., Alex, S., Mota, M. R., Sales, N. B., Brown, L. E., & Bottaro, M. (2018). Effect of strength training combined with antioxidant supplementation on muscular performance. Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee, Nutrition et Metabolisme, 43(8), 775–781. https://doi.org/10.1139/apnm-2017-0866

Franco, C., Carneiro, M., Alves, L., Júnior, G., de Sousa, J., & Orsatti, F. L. (2019). Lower-Load is More Effective Than Higher-Load Resistance Training in Increasing Muscle Mass in Young Women. Journal of Strength and Conditioning Research, 33Suppl 1, S152–S158. https://doi.org/10.1519/JSC.0000000000002970

Estarli, M., Aguilar Barrera, E. S., Martínez-Rodríguez, R., Baladia, E., Duran Agüero, S., Camacho, S., Buhring, K., Herrero-López, A., & Gil-González, D. M. (2016). Ítems de referencia para publicar Protocolos de Revisiones Sistemáticas y Metaanálisis: Declaración PRISMA-P 2015. Revista Española de Nutrición Humana y Dietética, 20(2), 148–160. https://doi.org/10.14306/renhyd.20.2.223

Hernández-Reyes, A., Cámara-Martos, F., Molina-Luque, R., Romero-Saldaña, M., Molina-Recio, G., & Moreno-Rojas, R. (2019). Changes in body composition with a hypocaloric diet combined with sedentary, moderate and high-intense physical activity: a randomized controlled trial. BMC Women's Health, 19(1), 167. https://doi.org/10.1186/s12905-019-0864-5

Hettchen, M., von Stengel, S., Kohl, M., Murphy, M. H., Shojaa, M., Ghasemikaram, M., Bragonzoni, L., Benvenuti, F., Ripamonti, C., Benedetti, M. G., Julin, M., Risto, T., & Kemmler, W. (2021). Changes in Menopausal Risk Factors in Early Postmenopausal Osteopenic Women After 13 Months of High-Intensity Exercise: The Randomized Controlled ACTLIFE-RCT. Clinical interventions in aging, 16, 83–96. https://doi.org/10.2147/CIA.S283177

Instituto Nacional de Estadística y Geografía. (2020). Mujeres y hombres en México 2020. Centro de Documentación del Instituto Nacional de las Mujeres sitio web: https://www.inegi.org.mx/contenido/productos/prod_serv/contenidos/espanol/bvinegi/productos/nueva_estruc/702825189990.pdf

Janssen, I., Heymsfield, S. B., Wang, Z. M., & Ross, R. (2000). Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. Journal of Applied Physiology, 89(1), 81–88. https://doi.org/10.1152/jappl.2000.89.1.81

Jendricke, P., Centner, C., Zdzieblik, D., Gollhofer, A., & König, D. (2019). Specific Collagen Peptides in Combination with Resistance Training Improve Body Composition and Regional Muscle Strength in Premenopausal Women: A Randomized Controlled Trial. Nutrients, 11(4), 892. https://doi.org/10.3390/nu11040892

Lee, R. C., Wang, Z., Heo, M., Ross, R., Janssen, I., & Heymsfield, S. B. (2000). Total-body skeletal muscle mass: development and cross-validation of anthropometric prediction models. The American Journal of Clinical Nutrition, 72(3), 796–803. https://doi.org/10.1093/ajcn/72.3.796

Manterola, C., Asenjo-Lobos, C., & Otzen, T. (2014). Jerarquización de la evidencia: Niveles de evidencia y grados de recomendación de uso actual. Revista Chilena de Infectología, 31(6), 705-718. https://dx.doi.org/10.4067/S0716-10182014000600011

Martins, F. M., de Paula Souza, A., Nunes, P., Michelin, M. A., Murta, E., Resende, E., de Oliveira, E. P., & Orsatti, F. L. (2018). High-intensity body weight training is comparable to combined training in changes in muscle mass, physical performance, inflammatory markers, and metabolic health in postmenopausal women at high risk for type 2 diabetes mellitus: A randomized controlled clinical trial. Experimental Gerontology, 107, 108–115. https://doi.org/10.1016/j.exger.2018.02.016

Miller, C. T., Fraser, S. F., Selig, S. E., Rice, T., Grima, M., van den Hoek, D. J., Ika Sari, C., Lambert, G. W., & Dixon, J. B. (2020). Fitness, Strength and Body Composition during Weight Loss in Women with Clinically Severe Obesity: A Randomised Clinical Trial. Obesity Facts, 13(4), 307–321. https://doi.org/10.1159/000506643

Orsatti, F. L., Maestá, N., de Oliveira, E. P., Nahas Neto, J., Burini, R. C., Nunes, P., Souza, A. P., Martins, F. M., & Nahas, E. P. (2018). Adding Soy Protein to Milk Enhances the Effect of Resistance Training on Muscle Strength in Postmenopausal Women. Journal of Dietary Supplements, 15(2), 140–152. https://doi.org/10.1080/19390211.2017.1330794

Pano-Rodríguez, A., Beltran-Garrido, J. V., Hernández-González, V., Nasarre-Nacenta, N., & Reverter-Masia, J. (2020). Impact of Whole Body Electromyostimulation on Velocity, Power and Body Composition in Postmenopausal Women: A Randomized Controlled Trial. International Journal of Environmental Research and Public Health, 17(14), 4982. https://doi.org/10.3390/ijerph17144982

Said, M., Lamya, N., Olfa, N., & Hamda, M. (2017). Effects of high-impact aerobics vs. low-impact aerobics and strength training in overweight and obese women. The Journal of Sports Medicine and Physical Fitness, 57(3), 278–288. https://doi.org/10.23736/S0022-4707.16.05857-X

Shamah-Levy, T., Cuevas, L., Romero, M., Gaona, B., Gómez, L., Mendoza, L., Méndez-Gómez, I. & Rivera-Dommarco, J. (2020). Encuesta Nacional de Salud y Nutrición 2018-2019. Resultados nacionales. 1ª ed. Encuesta Nacional de Salud y Nutrición sitio web. https://ensanut.insp.mx/encuestas/ensanut2018/doctos/informes/ensanut_2018_informe_final.pdf

Suetta, C., Haddock, B., Alcazar, J., Noerst, T., Hansen, O. M., Ludvig, H., Kamper, R. S., Schnohr, P., Prescott, E., Andersen, L. L., Frandsen, U., Aagaard, P., Bülow, J., Hovind, P., & Simonsen, L. (2019). The Copenhagen Sarcopenia Study: lean mass, strength, power, and physical function in a Danish cohort aged 20-93 years. Journal of Cachexia, Sarcopenia, and Muscle, 10(6), 1316–1329. https://doi.org/10.1002/jcsm.12477

Skelton, D. A., & Mavroeidi, A. (2018). How do muscle and bone strengthening, and balance activities (MBSBA) vary across the life course, and are there particular ages where MBSBA are most important? Journal of Frailty, Sarcopenia and Falls, 3(2), 74–84. https://doi.org/10.22540/JFSF-03-074

Womersley J. (1977). A comparison of the skinfold method with extent of 'overweight' and various weight-height relationships in the assessment of obesity. The British Journal of Nutrition, 38(2), 271–284. https://doi.org/10.1079/bjn19770088

Wu, F., Callisaya, M., Wills, K., Laslett, L. L., Jones, G., & Winzenberg, T. (2017). Both Baseline and Change in Lower Limb Muscle Strength in Younger Women Are Independent Predictors of Balance in Middle Age: A 12-Year Population-Based Prospective Study. Journal of Bone and Mineral Research: The Official Journal of the American Society for Bone and Mineral Research, 32(6), 1201–1208. https://doi.org/10.1002/jbmr.3103

Zeng, J., Peng, L., Zhao, Q., & Chen, Q. G. (2021). Effects over 12 weeks of different types and durations of exercise intervention on body composition of young women with obesity. Science & Sports, 36(1), 45–52. https://doi.org/10.1016/j.scispo.2019.10.011.

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