
Title

Sex Differences in Effects of Exercise on Physical Function in Aging: A Systematic Review with Meta-Analysis

Abstract

Purpose: Our objective was to synthesize and determine whether there are sex differences in physical function following exercise interventions in older adults. Materials and Methods: A systematic search was conducted in four databases from inception to July 8th, 2023 searching for prospective trials that conducted exercise interventions in older adults and results for physical function were reported by sex. Pooled standardized mean differences (SMDs) with their 95% confidence intervals (CIs) were estimated using a random effects method. The Sidik-Jonkman estimator was used to calculate the variance of heterogeneity (I^2). Results: A total of 19 studies involving 20,133 older adults (mean age ≥ 60 years, 33.7% female) were included. After exercise interventions, males reported significantly greater pre-post changes compared to females for upper body strength (SMD=- 0.40, 95% CI: -0.71 to -0.09; $I^2=75.6\%$; $n=8$), lower body strength (SMD=-0.32, 95% CI: -0.55 to -0.10; $I^2=52.0\%$; $n=11$), and cardiorespiratory fitness (SMD=-0.29, 95% CI: -0.48 to -0.10; $I^2=89.1\%$; $n=12$). Conversely, the pooled SMDs showed a significant effect favoring females for motor fitness (SMD=0.21, 95% CI: 0.03 to 0.39; $I^2=0\%$; $n=7$). Limited and inconsistent results were observed for flexibility. Conclusions: Our study suggests the existence of sex-related differences on physical function after an exercise intervention in the older population. © 2024 Korean Society for Sexual Medicine and Andrology.

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References

International Classification of Functioning, Disability and Health, (2001); den Ouden ME, Schuurmans MJ, Arts IE, van der Schouw YT., Physical performance characteristics related to disability in older persons: a systematic review, *Maturitas*, 69, pp. 208-219, (2011); Ferrucci L, Levine ME, Kuo PL, Simonsick EM., Time and the metrics of aging, *Circ Res*, 123, pp. 740-744, (2018); Izquierdo M, Merchant RA, Morley JE, Anker SD, Aprahamian I, Arai H, Et al., International exercise recommendations in older adults (ICFSR): expert consensus guidelines, *J Nutr Health Aging*, 25, pp. 824-853, (2021); Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Et al., Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association, *Med Sci Sports Exerc*, 39, pp. 1423-1434, (2007); Di Raimondo D, Musiari G, Miceli G, Arnao V, Pinto A., Preventive and therapeutic role of muscle contraction against chronic diseases, *Curr Pharm Des*, 22, pp. 4686-4699, (2016); Valdes-Badilla PA, Gutierrez-Garcia C, Perez-Gutierrez M, Vargas-Vitoria R, Lopez-Fuenzalida A., Effects of physical activity governmental programs on health status in independent older adults: a systematic review, *J Aging Phys Act*, 27, pp. 265-275, (2019); Cooper R, Kuh D, Hardy R., Objectively measured physical capability levels and mortality: systematic review and metaanalysis, *BMJ*, 341, (2010); Pavasini R, Guralnik J, Brown JC, di Bari M, Cesari M, Landi F, Et al., Short physical performance battery and all-cause mortality: systematic review and

meta-analysis, *BMC Med*, 14, (2016); Gurd BJ, Giles MD, Bonafiglia JT, Raleigh JP, Boyd JC, Ma JK, Et al., Incidence of nonresponse and individual patterns of response following sprint interval training, *Appl Physiol Nutr Metab*, 41, pp. 229-234, (2016); Higgins TP, Baker MD, Evans SA, Adams RA, Cobbold C., Heterogeneous responses of personalised high intensity interval training on type 2 diabetes mellitus and cardiovascular disease risk in young healthy adults, *Clin Hemorheol Microcirc*, 59, pp. 365-377, (2015); Shailendra P, Baldock KL, Li LSK, Bennie JA, Boyle T., Resistance training and mortality risk: a systematic review and meta-analysis, *Am J Prev Med*, 63, pp. 277-285, (2022); Sui X, LaMonte MJ, Laditka JN, Hardin JW, Chase N, Hooker SP, Et al., Cardiorespiratory fitness and adiposity as mortality predictors in older adults, *JAMA*, 298, pp. 2507-2516, (2007); Ross R, Goodpaster BH, Koch LG, Sarzynski MA, Kohrt WM, Johannsen NM, Et al., Precision exercise medicine: understanding exercise response variability, *Br J Sports Med*, 53, pp. 1141-1153, (2019); Gallagher D, Visser M, De Meersman RE, Sepulveda D, Baumgartner RN, Pierson RN, Et al., Appendicular skeletal muscle mass: effects of age, gender, and ethnicity, *J Appl Physiol* (1985), 83, pp. 229-239, (1997); Kozakai R, Ando F, Kim HY, Yuki A, Otsuka R, Shimokata H., Sex-differences in age-related grip strength decline: a 10- year longitudinal study of community-living middle-aged and older Japanese, *J Phys Fit Sports Med*, 5, pp. 87-94, (2016); Haizlip KM, Harrison BC, Leinwand LA., Sex-based differences in skeletal muscle kinetics and fiber-type composition, *Physiology (Bethesda)*, 30, pp. 30-39, (2015); Janssen I, Heymsfield SB, Wang ZM, Ross R., Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr, *J Appl Physiol*, (2000); Roberts BM, Nuckols G, Krieger JW., Sex differences in resistance training: a systematic review and meta-analysis, *J Strength Cond Res*, 34, pp. 1448-1460, (2020); Schoenfeld BJ., The mechanisms of muscle hypertrophy and their application to resistance training, *J Strength Cond Res*, 24, pp. 2857-2872, (2010); Jones MD, Wewege MA, Hackett DA, Keogh JW, Hagstrom AD., Sex differences in adaptations in muscle strength and size following resistance training

in older adults: a systematic review and meta-analysis, *Sports Med*, 51, pp. 503-517, (2021); Tieland M, Trouwborst I, Clark BC., Skeletal muscle performance and ageing, *J Cachexia Sarcopenia Muscle*, 9, pp. 3-19, (2018); Wu ZJ, Han C, Wang ZY, Li FH., Combined training prescriptions for improving cardiorespiratory fitness, physical fitness, body composition, and cardiometabolic risk factors in older adults: systematic review and meta-analysis of controlled trials, *Sci Sports*, (2023); Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, Et al., Cardiorespiratory fitness as a quantitative predictor of allcause mortality and cardiovascular events in healthy men and women: a meta-analysis, *JAMA*, 301, pp. 2024-2035, (2009); Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Et al., *Cochrane handbook for systematic reviews of interventions version 6.4 [Internet]*; Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Et al., The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, *BMJ*, 372, (2021); Sterne JAC, Savovic J, Page MJ, Elbers RG, Blencowe NS, Boutron I, Et al., RoB 2: a revised tool for assessing risk of bias in randomised trials, *BMJ*, 366, (2019); Sterne JA, Hernan MA, Reeves BC, Savovic J, Berkman ND, Viswanathan M, Et al., ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions, *BMJ*, 355, (2016); McGuinness LA, Higgins JPT., Risk-of-bias VISualization (robvis): an R package and Shiny web app for visualizing riskof- bias assessments, *Res Synth Methods*, 12, pp. 55-61, (2021); Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, Et al., GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables, *J Clin Epidemiol*, 64, pp. 383-394, (2011); Slade SC, Dionne CE, Underwood M, Buchbinder R., Consensus on exercise reporting template (CERT): explanation and elaboration statement, *Br J Sports Med*, 50, pp. 1428-1437, (2016); Cohen J., *Statistical power analysis for the behavioral sciences*, (1988); Borenstein M, Hedges LV, Higgins JPT, Rothstein HR., Front matter, *Introduction to meta-analysis*, pp. i-xxix, (2009); Capodaglio P, Capodaglio Edda M, Facioli M, Saibene F., Long-term strength training for community-dwelling people over 75:

impact on muscle function, functional ability and life style, *Eur J Appl Physiol*, 100, pp. 535-542, (2007); Gommans LN, Scheltinga MR, van Sambeek MR, Maas AH, Bendermacher BL, Teijink JA., Gender differences following supervised exercise therapy in patients with intermittent claudication, *J Vasc Surg*, 62, pp. 681-688, (2015); Kim YH, So WY., Gender differences in home-based cardiac rehabilitation of post-percutaneous coronary intervention patients, *Aging Clin Exp Res*, 31, pp. 249-255, (2019); Smith K, Winegard K, Hicks AL, McCartney N., Two years of resistance training in older men and women: the effects of three years of detraining on the retention of dynamic strength, *Can J Appl Physiol*, 28, pp. 462-474, (2003); Bellew JW, Yates JW, Gater DR., The initial effects of lowvolume strength training on balance in untrained older men and women, *J Strength Cond Res*, 17, pp. 121-128, (2003); Marques EA, Mota J, Viana JL, Tuna D, Figueiredo P, Gui maraes JT, Et al., Response of bone mineral density, inflammatory cytokines, and biochemical bone markers to a 32-week combined loading exercise programme in older men and women, *Arch Gerontol Geriatr*, 57, pp. 226-233, (2013); Da Boit M, Sibson R, Meakin JR, Aspden RM, Thies F, Mangoni AA, Et al., Sex differences in the response to resistance exercise training in older people, *Physiol Rep*, 4, (2016); Kasovic M, Stefan L, Kalcik Z., Acute responses to resistance training on body composition, muscular fitness and flexibility by sex and age in healthy war veterans aged 50-80 years, *Nutrients*, 14, (2022); Ryan AS, Ivey FM, Hurlbut DE, Martel GF, Lemmer JT, Sorkin JD, Et al., Regional bone mineral density after resistive training in young and older men and women, *Scand J Med Sci Sports*, 14, pp. 16-23, (2004); Sherk KA, Bemben DA, Brickman SE, Bemben MG., Effects of resistance training duration on muscular strength retention 6-month posttraining in older men and women, *J Geriatr Phys Ther*, 35, pp. 20-27, (2012); Miller RM, Bemben DA, Bemben MG., The influence of sex, training intensity, and frequency on muscular adaptations to 40 weeks of resistance exercise in older adults, *Exp Gerontol*, 143, (2021); Jackson D, Turner R., Power analysis for random-effects metaanalysis, *Res Synth Methods*, 8, pp. 290-302,

(2017); Sidik K, Jonkman JN., Simple heterogeneity variance estimation for meta-analysis, *J R Stat Soc Ser C Appl Stat*, 54, pp. 367-384, (2005); Sterne JA, Egger M, Smith GD., Systematic reviews in health care: investigating and dealing with publication and other biases in meta-analysis, *BMJ*, 323, pp. 101-105, (2001); Balduzzi S, Rucker G, Schwarzer G., How to perform a metaanalysis with R: a practical tutorial, *Evid Based Ment Health*, 22, pp. 153-160, (2019); Rohatgi A., WebPlotDigitizer version 4.6 [Internet]; Rengo JL, Khadanga S, Savage PD, Ades PA., Response to exercise training during cardiac rehabilitation differs by sex, *J Cardiopulm Rehabil Prev*, 40, pp. 319-324, (2020); Timmons JF, Hone M, Duffy O, Egan B., When matched for relative leg strength at baseline, male and female older adults respond similarly to concurrent aerobic and resistance exercise training, *J Strength Cond Res*, 36, pp. 2927-2933, (2022); McGrath S, Zhao X, Steele R, Thombs BD, Benedetti A, Estimating the sample mean and standard deviation from commonly reported quantiles in meta-analysis, *Stat Methods Med Res*, 29, pp. 2520-2537, (2020); Morey MC, Zhu CW., Improved fitness narrows the symptomreporting gap between older men and women, *J Womens Health (Larchmt)*, 12, pp. 381-390, (2003); Bierbauer W, Scholz U, Bermudez T, Debeer D, Coch M, Fleisch-Silvestri R, Et al., Improvements in exercise capacity of older adults during cardiac rehabilitation, *Eur J Prev Cardiol*, 27, pp. 1747-1755, (2020); Sarrafzadegan N, Rabiei K, Kabir A, Sadeghi M, Khosravi A, Asgari S, Et al., Gender differences in risk factors and outcomes after cardiac rehabilitation, *Acta Cardiol*, 63, pp. 763-770, (2008); Trachsel LD, Boidin M, Henri C, Fortier A, Lalonge J, Juneau M, Et al., Women and men with coronary heart disease respond similarly to different aerobic exercise training modalities: a pooled analysis of prospective randomized trials, *Appl Physiol Nutr Metab*, 46, pp. 417-425, (2021); Barha CK, Hsiung GR, Best JR, Davis JC, Eng JJ, Jacova C, Et al., Sex difference in aerobic exercise efficacy to improve cognition in older adults with vascular cognitive impairment: secondary analysis of a randomized controlled trial, *J Alzheimers Dis*, 60, pp. 1397-1410, (2017); Pina IL, Bittner V, Clare

RM, Swank A, Kao A, Safford R, Et al., Effects of exercise training on outcomes in women with heart failure: analysis of HFACTION (Heart Failure-A Controlled Trial Investigating Outcomes of Exercise Training) by sex, *JACC Heart Fail*, 2, pp. 180-186, (2014); Sterne JA, Sutton AJ, Ioannidis JP, Terrin N, Jones DR, Lau J, Et al., Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials, *BMJ*, 343, (2011); Neves T, Ferriolli E, Lopes MBM, Souza MGC, Fett CA, Fett WCR., Prevalence and factors associated with sarcopenia and dynapenia in elderly people, *J Frailty Sarcopenia Falls*, 3, pp. 194-202, (2018); Ross R, Blair SN, Arena R, Church TS, Despres JP, Franklin BA, Et al., Importance of assessing cardiorespiratory fitness in clinical practice: a case for fitness as a clinical vital sign: a scientific statement from the American Heart Association, *Circulation*, 134, pp. e653-e699, (2016); Al-Mallah MH, Juraschek SP, Whelton S, Dardari ZA, Ehrman JK, Michos ED, Et al., Sex differences in cardiorespiratory fitness and all-cause mortality: the Henry Ford Exercise Testing (FIT) Project, *Mayo Clin Proc*, 91, pp. 755-762, (2016); Diaz-Canestro C, Pentz B, Sehgal A, Montero D., Sex differences in cardiorespiratory fitness are explained by blood volume and oxygen carrying capacity, *Cardiovasc Res*, 118, pp. 334-343, (2022); Montero D, Cathomen A, Jacobs RA, Fluck D, de Leur J, Keiser S, Et al., Haematological rather than skeletal muscle adaptations contribute to the increase in peak oxygen uptake induced by moderate endurance training, *J Physiol*, 593, pp. 4677-4688, (2015); Gonzalez-Alonso J, Calbet JA., Reductions in systemic and skeletal muscle blood flow and oxygen delivery limit maximal aerobic capacity in humans, *Circulation*, 107, pp. 824-830, (2003); Montero D, Lundby C., Regulation of red blood cell volume with exercise training, *Compr Physiol*, 9, pp. 149-164, (2018); Thomas E, Battaglia G, Patti A, Brusa J, Leonardi V, Palma A, Et al., Physical activity programs for balance and fall prevention in elderly: a systematic review, *Medicine (Baltimore)*, 98, (2019); Puszczalowska-Lizis E, Bujas P, Jandzis S, Omorczyk J, Zak M., Inter-gender differences of balance indicators in persons 60- 90 years of age,

Clin Interv Aging, 13, pp. 903-912, (2018); La Greca S, Rapali M, Ciapri G, Russo L, Vinciguerra MG, Di Giminiani R., Acute and chronic effects of supervised flexibility training in older adults: a comparison of two different conditioning programs, Int J Environ Res Public Health, 19, (2022)

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