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The effect of exercises on the stiffness of the gastrocnemius-Achilles tendon complex: Systematic review and meta-analysis of randomized and quasi-randomized controlled trials

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ABSTRACT

Background: The stiffness of the gastrocnemius-Achilles tendon complex is vital for efficient functioning of the musculoskeletal system. Exercises induce mechanical changes to the gastrocnemius-Achilles tendon complex (GAT), which could enhance its role in regulating functional joint stability and movement. The study aimed to explore the effect of exercises on GAT stiffness using meta-analysis.

Study selection and data extraction: Data sources were the Cochrane Central Register of Controlled Trials and MEDLINE. The eligibility criteria were randomised controlled trials (RCTs) or quasi-randomized controlled trials (Quasi-RCTs) published in English exploring the effect of exercises on GAT stiffness in healthy adults or patients with musculoskeletal disorders (≥ 18 years). Two independent reviewers extracted the data using standardised Cochrane's form. Risk of bias was assessed using the Cochrane Risk of Bias tool. Seventeen randomized/ Quasi-randomized controlled trials on adults were retrieved. Effect sizes, sensitivity analysis and meta-regression of age and exercise intensity were conducted. Sub-analysis of gender effect was performed.

Data synthesis and results: Pooled analyses were based on random-effects model; 389 participants in the exercise group and 271 participants in the control group. No effect from exercises on the stiffness of the GAT was shown; effect size 0.026 with -0.372 to 0.424 95%CI. The sensitivity meta-analysis conducted after excluding three studies with high risk of bias showed good effect size of 0.421 with 0.153 – 0.688 95% CI. The meta-regression suggested no significant effect of age ($p = 0.148$), yet a significant increase in stiffness is associated with increasing the exercise intensity ($p = 0.0006$). The effect size of exercises in men is -0.218 with -1.162 to 0.727 95%CI, and -1.171 in women with -3.572 to 1.232 95%CI.

Conclusions: Clinical effects from exercises on GAT stiffness was revealed. Exercise intensity is essential for improving the stiffness, regardless of the age factor. It seems that exercises are more effective for women than men in enhancing the stiffness of the gastrocnemius-Achilles tendon.

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