

INPLASY

Effects of Exercise on Elastography-Measured Stiffness of the Lower Extremity Muscle-Tendon Properties: A systematic review of randomised controlled trials with meta-analyses

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ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Formal screening of search results against eligibility criteria.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 17 June 2024 and was last updated on 17 June 2024.

INTRODUCTION

Review question / Objective The following review question is employed in this review: What are the effects of exercise modalities on the stiffness of the human skeletal muscles based on elastography using randomised controlled trials (RCTs)?

Rationale The stiffness of the muscles and tendons are important factors affecting human movement. It might change due to certain conditions including, but not limited to, ageing, cerebral palsy, musculoskeletal injuries, training, immobilisation and stroke. Previously, elastography measurements were used to examine cancer types, thyroids and liver diseases. With recent advancements, elastography measurements become increasingly visible for musculoskeletal applications. This allowed for the examination of individual muscles and tendons' stiffness, which differs from conventional techniques that do not

allow for the measurement of muscles or tendons individually. Existing systematic reviews related to the effects of exercise on elastography-measured muscle stiffness were screened, and only the effects of resistance training were measured by shear wave elastography or chronic stretching. Both meta-analyses performed quantitative syntheses to include all muscles in the same meta-analyses without considering possible differences in the reaction of muscles to the same exercise. For instance, a study investigating muscle stiffness after eccentric exercise did not find any significant alterations in the stiffness of the soleus muscle while finding significant alterations in the stiffness of the gastrocnemius muscle. Likewise, another study comparing the effects of modified cross-body stretch (MCS) and modified sleeper stretch (MSS) found that MCS decreases the stiffness of the teres minor muscle while not significantly affecting infraspinatus and posterior deltoid muscles. MSS decreases the stiffness of the infraspinatus muscle while not significantly

changing the stiffness of the teres minor and posterior deltoid muscles. Therefore, this systematic review and meta-analysis protocol aims to examine exercise- or a physical therapy modality stimulated direct, acute and chronic alterations in stiffness of individual muscles and tendons measured by an elastography machine (e.g. ultrasound strain elastography, ultrasound shear wave elastography and magnetic resonance elastography) in human.

Condition being studied Effects of exercise on human skeletal muscle stiffness.

METHODS

Search strategy On June 14, 2024, PubMed (57 articles), Cochrane Library (CENTRAL) (203 articles), and the ProQuest databases (141 articles; 71 databases) were searched using a combination of the following key terms. In total, 401 articles were retrieved based on the initial database searches. However, 90 duplicate records were detected and removed by EndNote X21 software. In summary, 311 citation records were exported into Rayyan software (Rayyan.ai, a web and mobile app for systematic reviews) for review by three authors (the first, second and last authors) in an independent and blinded status.

Participant or population Human studies will be included.

Intervention Exercise.

Comparator Control or placebo groups.

Study designs to be included Randomised controlled trials.

Eligibility criteria Inclusion criteria are as follows: a) Being an RCT including a control or placebo group, b) applying solely exercise as an intervention, c) having elastography measured muscle or tendon stiffness as an outcome, and d) being conducted on human participants.

Information sources PubMed, ProQuest, Cochrane Library databases and reference lists of included studies.

Main outcome(s) Stiffness of human skeletal muscles and tendons.

Data management The authors will perform data extraction in a blinded status. The following software will be used during data extraction and

analysis: EndNote X21, Microsoft Excel and Word RevMan, and GRADEPro GDT software.

Quality assessment / Risk of bias analysis

Cochrane Collaboration's risk of bias assessment tool for parallel group RCTs will be used to assess individual risk of bias in each included study. In the case of quantitative data synthesis, the overall evidence level will be graded using the GRADE approach.

Strategy of data synthesis The Review Manager (RevMan) of the Cochrane Collaboration or the Comprehensive Meta-analysis software will be utilised to conduct the meta-analyses. The GRADEpro GDT software will be used to determine the level of the body of evidence.

Subgroup analysis Subgroup analyses will be conducted based on the population, intervention, and outcome styles or across the risk of bias tables.

Sensitivity analysis If a meta-analysis contains high heterogeneity between studies, a sensitivity analysis based on methodological features and risk of bias assessments will be performed.

Language restriction English.

Country(ies) involved Republic Türkiye, Uzbekistan, Japan, United Kingdom, United States.

Keywords Stiffness; elasticity; elastography; hardness; tenderness; muscle structure; tendon structure.

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