# INPLASY PROTOCOL

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Conflicts of interest:
**Gokhan Yagiz, Esedullah Akaras, Hans-Peter Kubis and Julian Andrew Owen declare that they have not conflict of interest about the content of this systematic review protocol.**

# Effects of Exercise on Skeletal Muscle Architecture in Healthy Adults: A systematic review of randomised controlled trials (protocol)

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**Review question / Objective:** Does exercise alter the skeletal muscle architectural parameters in healthy adults?
**Condition being studied:** Architectural alterations of human skeletal muscles due to exercise interventions.
**Main outcome(s):** Magnetic Resonance Imaging (MRI) or Ultrasound (US) measured following muscle architectural parameters for one or more specifically defined muscle (i.e. biceps femoris long head): Fascicle length, pennation angle: muscle thickness: ACSA, PCSA, muscle length, muscle volume. Type of contraction during the skeletal muscle architecture measurements and training quantities (total training hours, hours per week, and total training weeks) will be considered for measures effect.

**INPLASY registration number:** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 19 May 2020 and was last updated on 19 May 2020 (registration number INPLASY202050074).

## INTRODUCTION

**Review question / Objective:** Does exercise alter the skeletal muscle architectural parameters in healthy adults?

**Rationale:** Skeletal muscle architecture is associated with muscle strength, sports performance and injury. Exploring effective exercise modalities to improve muscle architecture in healthy humans might be a reference point for the future directions of

either conditioning, prevention or treatment strategies for athletes, elderly or unhealthy people. Therefore, systematically reviewing the effect of randomised controlled exercise interventions, for gathering level one evidence, on skeletal muscle architecture in healthy adults is warranted.

**Condition being studied:** Architectural alterations of human skeletal muscles due to exercise interventions.

## METHODS

**Search strategy:** MEDLINE via PubMed, CINAHL Plus with Full Text via Ebsco, The Cochrane Central Register of Controlled Trials (CENTRAL) and OpenGrey databases will be searched. A combination of the following key terms will be used: "Exercis*", "Training*", "Architectur*", "Fascic*", "Fiber Length", "Fibre Length", "Pennat*", "Pinnat*", "Muscle Thickness", "Cross Sectional Area", "Cross-sectional Area", "Muscle Volume", "Muscle Structure", "Muscle Length". Key terms will be divided into two groups as intervention (I) and outcome (O). When "OR" bullion operator will be employed within groups, "AND" bullion operator will be used between the keywords groups. Key terms will be searched for title and abstract sections ("[Title/Abstract] ") for PubMed; title, abstract and keywords (":ti,ab,kw") for Cochrane Central Register of Controlled Trials database; abstract ("AB") for CINAHL Plus with Full Text. Database searches will be performed for all the dates in each database searches. The following search filters will be applied for each database; "Type of Study: Only Randomised Controlled Trials (RCT)" for PubMed; "limits: in Trials" for Cochrane Central Register of Controlled Trials; "Limiters - Exclude MEDLINE records; Randomized Controlled Trials" for CINAHL Plus with Full Text databases. For the OpenGrey database, no filters will be applied in the database search. When applicable, relevant MeSH terms will be operated for each database. For example, PubMed database search will be conducted by using the search strategy: #1 "Exercise"[Mesh], #2 (Exercis*[Title/Abstract] OR Training*[Title/Abstract]), #3 #1 OR #2 ,#4 (Architectur*[Title/Abstract] OR Fascic*[Title/Abstract] OR "Fiber Length"[Title/Abstract] OR "Fibre Length"[Title/Abstract] OR Pennat*[Title/Abstract] OR Pinnat*[Title/Abstract] OR "Muscle Thickness"[Title/Abstract] OR "Cross Sectional Area"[Title/Abstract] OR "Cross-sectional Area"[Title/Abstract] OR "Muscle Volume"[Title/Abstract] OR "Muscle Structure"[Title/Abstract] OR "Muscle Length"[Title/Abstract]), #5 #3 AND #4 ,#6 #3 AND #4 Filters: Randomized Controlled Trial.

**Participant or population:** Healthy adults between ≥ 18 and ≤ 50 years old.

**Intervention:** Interventions lasted at least four weeks of duration and solely investigating the effects of at least one exercise modality on at least one muscle architectural parameter.

**Comparator:** A control group will be considered as a comparator.

**Study designs to be included:** Only randomised controlled trials.

**Eligibility criteria:** The following criteria will be considered as inclusion criteria for the study selection: Being full-text journal article in English language; lasting with at least four weeks of exercise interventions in healthy adults between 18 and 50 years old; solely investigating exercise interventions (studies containing other interventions will not be included such as electrostimulation, nutritional intakes etc.); Using MRI or ultrasonography for assessing a specifically defined muscle (i.e. vastus lateralis) architectural parameter (studies presenting broad and non-specific results for a muscle will not be included such as whole-body muscle mass, lower extremity muscle mass etc.).

**Information sources:** The first author will perform database searches. Firstly, the MEDLINE via PubMed, CINAHL Plus with Full Text via Ebsco and The Cochrane Central Register of Controlled Trials (CENTRAL) database searches will be

done, and citations will be exported to the Endnotex9 citation manager. Duplicates will be automatically and manually removed by using the Endnotex9 citation manager. After removing duplicates, the citations will be independently screened based on title and abstracts by the first and second authors by using Rayyan (http://rayyan.qcri.org), a free web and mobile app designed for screening eligible studies for systematic reviews. OpenGrey database will be screened online on its webpage. For OpenGrey database search, the following search entry will be employed: (Exercis* OR Training*) AND (Architectur* OR Fascic* OR "Fibre Length" OR "Fiber Length" OR Pennat* OR Pinnat* OR "Muscle Thickness" OR "Cross-Sectional Area" OR "Cross Sectional Area" OR "Muscle Volume" OR "Muscle Structure" OR "Muscle Length"). Disagreements about the selecting eligible studies will be eliminated by a discussion between the first and second authors. If the lead and second authors can not solve the disagreements, the third and last authors will be consulted. Once eligible studies selected, reference lists of the studies will also be screened by the lead and second authors. If full-text of articles not available, libraries of the universities or authors of the studies will be contacted for obtaining full-texts. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement, which is designed based on systematic reviews of randomised controlled trials, will be used as the guideline of this study.

**Main outcome(s):** Magnetic Resonance Imaging (MRI) or Ultrasound (US) measured following muscle architectural parameters for one or more specifically defined muscle (i.e. biceps femoris long head): Fascicle length, pennation angle: muscle thickness: ACSA, PCSA, muscle length, muscle volume. Type of contraction during the skeletal muscle architecture measurements and training quantities (total training hours, hours per week, and total training weeks) will be considered for measures effect.

**Quality assessment / Risk of bias analysis:** A Cochrane risk of bias assessment tool for randomised controlled trials will be used for assessing the risk of bias of the selected eligible studies. The lead and second authors independently score each eligible study, and any conflict will be solved by the same discussion mechanism defined for screening eligible studies. Each category in this risk of bias assessment tool will be graded as "low risk of bias", "unclear risk of bias" or "high risk of bias" for each selected study.

**Strategy of data synthesis:** Narrative data synthesis will quantitatively be employed in this systematic review due to the aim of comprehensively investigating all the skeletal muscles and broad exercise intervention types and modalities for having an overview. Extracted data from eligible studies will be presented in tables and figures based on assessment, intervention and outcome features.

**Subgroup analysis:** Type of exercise (i.e. eccentric, concentric, isometric, isokinetic, flexibility, warm-up, blood-flow restricted, sprint, endurance, plyometrics, balance, aerobic etc.); type of techniques used to assess skeletal muscle architecture (i.e. MRI and US); Type of muscle (i.e. vastus lateralis, supraspinatus etc.) will be considered as parameters for subgroup and subset analyses.

**Sensibility analysis:** Sensibility analysis is not considered to apply due to the proposed narrative synthesis method to present data.

**Language:** Only full-text journal articles in English will be screened.

**Country(ies) involved:** Turkey and the United Kingdom.

**Keywords:** ACSA; Exercise; Fascicle Length, Muscle Architecture; Muscle Thickness; Muscle Volume; PCSA; Pennation Angle; Systematic review; Training.

## Contributions of each author:

**Author 1 - Gokhan Yagiz - The lead author will run the database searches, will remove duplicates, will independently screen studies, will independently assess risk of bias and will extract data from the selected studies.**

**Author 2 - Esedullah Akaras - The second author will independently screen studies, will independently assess risk of bias and will extract data from the selected studies.**

**Author 3 - Hans-Peter Kubis - The third author will give feedback for data synthesis and possible unsolved conflicts of study selections between the first and second authors. The third author will provide feedback for the final manuscript.**

**Author 4 - Julian Andrew Owen - The last author will give feedback for data synthesis and possible unsolved conflicts of study selections between the first, second and third authors. The last author will provide feedback for the final manuscript.**