Human Movement Science 58 (2018) 10–20

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Full Length Article

Relationship between jumping abilities and skeletal muscle architecture of lower limbs in humans: Systematic review and meta-analysis

J.D. Ruiz-Cárdenas[a,*], J.J. Rodríguez-Juan[a], J. Ríos-Díaz[a,b,c]

[a] ECOFISTEM Research Group, Faculty of Health Sciences, Catholic University of Murcia, Murcia, Spain
[b] Centro de Ciencias de la Salud San Rafael, Universidad Antonio de Nebrija, Madrid, Spain
[c] Fundación San Juan de Dios, Madrid, Spain

ARTICLE INFO

Keywords:
Ultrasonography
Muscles
Biomechanics

ABSTRACT

The aim of this study was to examine the influence of skeletal muscle architecture (SMA) features measured by 2-D ultrasonography on jumping performance in humans.

A systematic review and meta-analysis was conducted, registry number: CRD42016043602.

The scientific literature was systematically searched in eight databases, last run on March 14th, 2017. Cross-sectional studies focused on the association between SMA features and vertical jumping performance were selected. A random-effects model was used to analyze the influence of lower-limb SMA and maximal jump height. A total of 11 studies were included in the qualitative synthesis and 6 studies were selected for meta-analysis. 250 correlations were reviewed across studies. The vast majority were either not statistically significant (185; 74%), weak or very weak (169; 68%) for different jump modalities; counter-movement jump (CMJ), squat jump (SJ), and drop jump. There was insufficient data to perform meta-analysis on muscles other than vastus lateralis for CMJ and SJ. The meta-analyses did not yield any significant association between vastus lateralis SMA and SJ height. Only a significant overall association was shown between vastus lateralis thickness and CMJ height (summary-r = 0.28; 95% confidence interval (CI) = −0.05 to 0.48; p = .059) for a 90% CI level. No differences were found between summary-r coefficients for SMA parameters and jump height during both jumps (CMJ: $\chi^2 = 2.43$; df = 2; p = .30; SJ: $\chi^2 = 0.45$; df = 2; p = .80) with a low heterogeneity ratio. Current evidence does not suggest a great influence of lower-limb SMA on vertical jumping performance in humans.

1. Introduction

Skeletal muscle architecture (SMA) can be defined as the arrangement of muscle fascicles within a muscle relative to the line of action of the tendon (Lieber & Fridén, 2000). The most common method of measuring SMA is through B-mode ultrasonography, which has proven to be a reliable method (reported intra-class correlation coefficients higher than 0.7) when large limb muscles are imaged in a relaxed state and the joint remains in static position (Kwah, Pinto, Diong, & Herbert, 2013).

A single image from a portable ultrasound can measure SMA, including muscle fascicle length, pennation angle, and muscle thickness. Fascicle length is usually defined as the distance between the intersection composed of the fascicle and the superficial and

* Corresponding author at: Physiotherapy Department, Faculty of Health Sciences, Catholic University of Murcia, Campus Los Jerónimos, 30107 Murcia, Spain.
E-mail addresses: jdruiz@ucam.edu (J.D. Ruiz-Cárdenas), jjrodriguez@ucam.edu (J.J. Rodríguez-Juan), jrios@nebrija.es (J. Ríos-Díaz).

https://doi.org/10.1016/j.humov.2018.01.005
Received 16 April 2017; Received in revised form 5 January 2018; Accepted 5 January 2018
0167-9457/

deep aponeuroses (Blazevich, 2006; Kawakami, Abe, Kanehisa, & Fukunaga, 2006; Narici, Franchi, & Maganaris, 2016). Pennation angle is calculated as the angle between the muscle fascicle and deep aponeurosis whereas muscle thickness is the vertical line from the superficial aponeurosis to deep aponeurosis (Blazevich, 2006; Kawakami et al., 2006).

SMA influences the ability of muscle to produce force as well as the velocity at which force can be produced. In terms of muscle architectural design, the greater muscles thickness and pennation angles, the more amount of skeletal muscle contractile tissue in parallel and therefore, more force can be generated (Abe, Loenneke, & Thiebaud, 2015; Blazevich, 2006). Longer fascicles are thought to possess a higher peak shortening velocity due to having a greater number of sarcomeres in series (Blazevich, 2006; Lieber & Fridén, 2000; Narici et al., 2016).

The architectural features of a muscle have been considered as the best predictors of force generation, strongly affecting function (Lieber & Fridén, 2000). However, although reviews of scientific literature have highlighted several mechanical determinants of jumping performance (Alexander, 1995; James, Navas, & Herrel, 2007), yet the influence of SMA on jumping performance in humans remains poorly understood and, to our knowledge, no systematic review has been previously conducted on this issue.

Therefore, the objective of this systematic review and meta-analysis is to evaluate the relationships between SMA features of lower limbs measured by B-mode ultrasonography and jumping performance.

2. Methods

2.1. Protocol and registration

This systematic review and meta-analysis was designed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) and registered on the International Prospective Register of Systematic Reviews (PROSPERO) in the Centre for Reviews and Dissemination (University of York, United Kingdom): CRD42016043602.

Confirmation that a review of this nature had not been published or was in progress was obtained prior to commencement through a search in the NIHR PROSPERO and the Cochrane Library databases.

2.2. Inclusion and exclusion criteria

Articles were identified by two independent reviewers for inclusion and in-depth examination. The inclusion criteria were (*i*) original cross-sectional studies focused on relating SMA features with respect to vertical jump biomechanical analysis [countermovement jump (CMJ), squat jump (SJ) and drop jump (DJ)], (*ii*) studies performed on sports practitioners and healthy participants, and (*iii*) studies using static B-model ultrasonography measures. Discrepancies in article inclusion between reviewers were resolved by consensus. The exclusion criteria disallowed studies developed with animals.

2.3. Study selection and data extraction

Electronic databases were searched by two reviewers (JJRJ and JDRC), using a systematic detailed and reproducible search strategy to identify published evidence. Databases were accessed via the Catholic University of Murcia, Spain, and included in PubMed/Medline, Web of Science Core-Collection, Science Direct, CINAHL, Sport Discus, Academic Search Complete, with the last search being run on March 14th, 2017.

The search procedure was performed using the following terms: "muscle architecture", "pennation angle", "pinnation angle", "fibre length", "fiber length", "fascicle length", "cross sectional area", "muscle thickness", jump*. Search terms were combined by Boolean logic (AND, OR) and had to be included in the title, abstract or keywords of studies:

#1: "muscle architecture" OR "pennation angle" OR "pinnation angle" OR "fibre length" OR "fiber length" OR "fascicle length" OR "cross sectional area" OR "muscle thickness"
#2: jump*
#3: #1 AND #2.

In order to reduce publication bias, the search was performed with no restrictions on date or language. The reference lists of included studies were scanned and the grey literature was also searched (i.e. dissertations) (Hopewell, Clarke, & Mallett, 2005). The authors of published papers were also contacted directly if crucial data were not reported in the original papers.

From the initial search, the titles and abstracts were reviewed to exclude any clearly irrelevant studies. The full texts of the remaining studies were then retrieved and read in full by two authors (JJRJ and JDRC) independently to determine whether the studies met the inclusion criteria. Any disagreement was resolved by consensus with the third author (JRD).

Using an *ad hoc* data collection form, data extraction from the included studies was performed by one reviewer (JJRJ) and cross-checked by a second (JDRC).

The Pearson product-moment correlation coefficients (usually noted as *r*) reported by the authors of included studies were interpreted, in absolute value, as very weak (< 0.20), weak (0.20–0.40:), moderate (0.40–0.60:), strong (0.60–0.80:) and very strong (0.8–1) (Feinstein, 2001).