

Is Quadriceps Endurance Reduced in COPD?

A Systematic Review

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BACKGROUND: Although the aerobic profile of the quadriceps muscle is reduced in COPD, there is conflicting evidence regarding whether this leads to reduced quadriceps muscle endurance. We, therefore, performed a systematic review of studies comparing quadriceps endurance in individuals with COPD with that in healthy control subjects.

METHODS: Relevant studies were identified by searching six electronic databases (1946-2011). Full-text articles were obtained after two researchers independently reviewed the abstracts. The results were combined in a random effects meta-analysis, and metaregression models were fitted to assess the influence of the type of measurement.

RESULTS: Data were extracted from 21 studies involving 728 individuals with COPD and 440 healthy control subjects. Quadriceps endurance was reduced in those with COPD compared with healthy control subjects (standardized mean difference, 1.16 [95% CI, 1.02-1.30]; $P < .001$) with a 44.5 s (4.5-84.5 s; $P = .029$) reduction in COPD (large effect size) when measured using a nonvolitional technique. The relationship between quadriceps endurance in those with COPD and control subjects did not differ when comparing nonvolitional and volitional techniques ($P = .22$) or when high- or low-intensity tasks ($P = .44$) were undertaken.

CONCLUSIONS: Quadriceps endurance is reduced in individuals with COPD compared with healthy control subjects, independent of the type of task performed.

CHEST 2015; 147(3):673-684

Manuscript received May 4, 2014; revision accepted September 22, 2014; originally published Online First October 23, 2014.

ABBREVIATIONS: MVC = maximal voluntary contraction; SMD = standardized mean difference

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FUNDING/SUPPORT: Dr Evans was supported with a National Institute for Health Research clinical lectureship.

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DOI: 10.1378/chest.14-1079

Skeletal muscle alteration is a recognized extrapulmonary consequence of COPD, with particular involvement of the larger muscles of locomotion.^{1,2} Although the precise causes and mechanisms are still being elucidated, deconditioning from inactivity, systemic inflammation, oxidative stress, hypoxemia, and steroid use have all been implicated (all of which worsen with increasing disease severity).^{1,3} Reduced quadriceps muscle mass and strength in COPD⁴ have been associated with a higher mortality^{5,6} and morbidity, as well as increased hospital admissions.⁷

There is also considerable evidence that the oxidative capacity of the skeletal muscle is reduced in COPD, with preferential reduction in the type 1 fiber cross-sectional area of the quadriceps muscle and a reduction in oxidative enzyme concentration, mitochondrial density, and capillary density.^{8,9} Collectively, these changes likely contribute to exercise and activity intolerance.¹⁰⁻¹² These adaptations are associated with a loss of the aerobic profile of the muscle. This is exemplified during cycling exercise, during which the muscle energy requirements are unable to be met, with a resultant decline in phosphocreatine and adenosine trinucleotide phosphate at very low absolute power.¹² Whole-body exercise tests, such as incremental cycling or treadmill walking, do not isolate the contribution of the peripheral muscles to the impaired aerobic capacity because the latter can also be attributed to ventilatory constraints¹³ and redistribution of cardiac output to the respiratory muscles.¹⁴ Therefore, tasks that specifically target localized muscle endurance are needed to determine the functional consequences of cellular

changes observed in the limb muscles of individuals with COPD.

Muscle endurance and fatigue of the quadriceps (the knee extensor muscle group) have been measured in individuals with COPD by using a variety of techniques. Muscle endurance has been defined as the ability of muscle to perform repeated work and to resist fatigue, whereas muscle fatigue has been defined as a decline in the force-generating capacity of a muscle.¹⁵ Muscle fatigue occurs as a result of impairment at one or more points along the pathway for muscle contraction (Fig 1). Because different tasks target different aspects of this pathway, the measurement protocol chosen (type, intensity, frequency, and duty cycle) can have an important effect on study results.¹⁶ Different approaches have been used to measure the two interrelated concepts of muscle endurance and fatigue in individuals with COPD, with various results.¹⁷⁻¹⁹ Consequently, it is not known definitively whether quadriceps muscle endurance is reduced in COPD or how different measurement protocols may influence the interpretation of results.

The primary aim of this study was to resolve the existing uncertainty about whether quadriceps muscle endurance is reduced in individuals with COPD compared with healthy control subjects and to quantify the difference. The secondary aims were to describe the methodologies reported to measure quadriceps endurance in COPD, investigate whether the type of measurement performed influenced the results, and determine whether disease severity affected the relationship between quadriceps endurance in those with COPD compared with healthy control subjects.

Materials and Methods

Study Design

We performed a systematic review of studies comparing quadriceps endurance in individuals with COPD with healthy control subjects; our study was consistent with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.²⁰ This study is a systematic review so no ethical approval was sought.

Eligibility Criteria

We included studies involving individuals with COPD and any measurement of quadriceps/knee extensor endurance. Eligibility required a comparison with a healthy control group. All languages were accepted and, if necessary, translated into English. Gray literature searches were performed by screening the references from all relevant review articles and international guidelines.²

Search Strategy

Relevant electronic databases were searched from inception to August 2013: PubMed, EMBASE, CINAHL, PEDro, OVID MEDLINE, and The Cochrane Library. An example of the search strategy used is as follows: (COPD OR chronic obstructive pulmonary disease OR chronic obstructive

lung disease OR pulmonary emphysema OR chronic airflow limitation OR chronic airflow obstruction OR chronic obstructive airway disease OR COAD) AND (quadriceps OR knee extensor OR lower limb OR leg OR knee OR thigh) AND (endurance OR contractile fatigue OR muscle fatigue OR muscle contraction). The full search strategy is available from the authors.

Study Selection

After duplicates were removed, the abstracts of all identified citations were reviewed independently by two assessors (R. A. E. and E. K.). The full-text citation was reviewed if one of the assessors concluded it was eligible. The full text was then reviewed by R. A. E., with the final decision for inclusion made by S. M.

Data Extraction

Two reviewers (E. K. and M. K. B.) performed data extraction, which was checked and, when needed, transformed by a third reviewer (R. A. E.) (see Statistical Analysis section). Baseline demographics, spirometry, details of the study design, measurement properties, and results of the measurement were extracted using a standardized form. Study authors were contacted if additional data were needed.

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