Review

Raising the standards of the calf-raise test: A systematic review

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Abstract

The calf-raise test is used by clinicians and researchers in sports medicine to assess properties of the calf muscle-tendon unit. The test generally involves repetitive concentric–eccentric muscle action of the plantar-flexors in unipedal stance and is quantified by the number of raises performed. Although the calf-raise test appears to have acceptable reliability and face validity, and is commonly used for medical assessment and rehabilitation of injuries, no universally acceptable test parameters have been published to date. A systematic review of the existing literature was conducted to investigate the consistency as well as universal acceptance of the evaluation purposes, test parameters, outcome measurements and psychometric properties of the calf-raise test. Nine electronic databases were searched during the period May 30th to September 21st 2008. Forty-nine articles met the inclusion criteria and were quality assessed. Information on study characteristics and calf-raise test parameters, as well as quantitative data, were extracted; tabulated; and statistically analysed. The average quality score of the reviewed articles was $70.4 \pm 12.2\%$ (range 44–90%). Articles provided various test parameters; however, a consensus was not ascertained. Key testing parameters varied, were often unstated, and few studies reported reliability or validity values, including sensitivity and specificity. No definitive normative values could be established and the utility of the test in subjects with pathologies remained unclear. Although adapted for use in several disciplines and traditionally recommended for clinical assessment, there is no uniform description of the calf-raise test in the literature. Further investigation is recommended to ensure consistent use and interpretation of the test by researchers and clinicians.
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Keywords: Review; Lower extremity; Physical examination; Sports medicine; Musculoskeletal system; Calf-raise test

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1. Introduction

Clinicians and researchers in sports science and medicine often use the calf-raise test to assess properties of the calf muscle-tendon unit (MTU).[1–6] The test was originally developed in the 1940s during the poliomyelitis epidemic to grade and detect plantar-flexor muscle weakness.[7–9] Today's calf-raise test generally involves repetitive concentric–eccentric muscle action of the plantar-flexors in unipedal stance and is quantified by the total number of raises performed.[7–9] Several disciplines have adapted the test for use including neurology,[8,10] gerontology,[11–13] cardiology,[10,14–16] orthopaedics,[17,18] and sports medicine.[19,20] The calf-raise test has traditionally been used to assess various calf MTU properties including endurance, strength, fatigue, function,

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and performance.[1–7,9,21–36] The test has also been employed to assist diagnosis, quantify injury, grade impairment, and measure treatment outcomes of the lower extremity.[17,37–39] A wide range of administrative protocols are currently available and detail multiple parameters, such as starting position, height of raise, pace of execution, balance support, termination criteria, and outcome measurements.

Normative values are often utilised to develop evidence-based clinical references.[40] In studies that employ the calf-raise test, normative values, such as the number of raises, are often reported and used as clinical reference. The research literature commonly recommends 25 raises as norm clinical performance targets for healthy subjects,[9,34] although higher and lower values have also been suggested.[1,2,5,14,35,36,41–46] Conversely, musculoskeletal assessment textbooks generally recommend lower target values ranging from 7 to 15 raises.[22,26,28]

In sports medicine, it has been suggested that as high as 30–50% of all sporting injuries are related to overuse tendon disorders.[23] Achilles tendinopathies are considered the most common tendon pathology affecting the lower extremity[21]; accounting for 11% of all running injuries[47] and a reported annual incidence of 7–9% in elite runners.[48,49] Rehabilitation of these disorders often includes eccentric exercises.[50,51] Eccentric exercises specific to Achilles tendon disorders utilise a modified form of the calf-raise test within exercise prescription protocols. Since both incorporate similar movements, the calf-raise test is frequently used to determine the treatment effects of the eccentric exercise regime.[52] The test is therefore not only used in the initial assessment of Achilles tendon disorders, but also during rehabilitation to quantify treatment outcomes and to monitor evolution of these conditions.[4,6,17,19,30–33,37,53–61]

Although the calf-raise test appears to have acceptable reliability and face validity, and is commonly used for medical assessment and rehabilitation of injuries, there are no universally accepted test parameters to guide clinicians in its administration and interpretation. The aim of this paper is therefore to systematically review the existing published literature relevant to the calf-raise test and to identify the consistency and acceptance of the test's evaluation purposes, parameters, outcome measurements, available normative values, and reliability and validity values. The paper primarily explores the calf-raise test in an orthopaedic and sports medicine context, with particular clinical consideration given to Achilles tendon pathologies. Investigating this test is vital to promote its uniform description, comprehension, utilisation, interpretation and standardisation in clinical practice.

2. Methods

Nine electronic databases were searched on May 30th and monitored until September 21st 2008: Ovid MEDLINE (1950–2008), Scopus (1841–2008), ISI Web of Science (1900–2008), SPORTDiscus (1800–2008),

EMBASE (1988–2008), AMED (1985–2008), CINAHL (1981–2008), PEDro (1929–2008), and The Cochrane Library (1991–2008). The calf-raise test has been previously identified by various combinations of the terms *calf* or *heel* or *toe* combined with *raise* or *rise* or *lift*. Therefore, the keywords; calf raise, calf rise, calf lift, heel raise, heel rise, heel lift, toe raise, toe rise and toe lift were combined by the Boolean OR; as were the truncated keywords evaluation (eval$) and test (test$). These two searches were combined with no limits applied (see Fig. 1).

Articles were included if they addressed evaluation, testing or assessment of function, endurance, strength or performance of the calf MTU. Papers were excluded if they had no full-text (complete) versions, such as conference abstracts or dissertations; had no statistical analyses; or referred to gait analysis, orthotic devices, isokinetic measurements, or the single heel-raise test (performance of a single raise) rather than the calf-raise test (performance of repeated raises).

Potentially identifiable information, such as authors, affiliations and source of publication, were removed from all articles to assure blinding of the reviewers and to reduce bias. The article selection process was initiated by excluding duplicates retrieved from the electronic search based on matching titles (see Fig. 1). The remaining articles were screened with respect to the inclusion–exclusion criteria by two independent reviewers (KH-L, RN-W), with foreign language articles being translated if not accessible in English. Screening results were compared and if no consensus was reached, a third independent reviewer was consulted (AS). Subsequently, abstracts and full-text articles were sequentially screened using the same screening procedure as for titles. A selection of sports medicine and orthopaedic journals and the reference lists of all retrieved full-text articles were hand-searched (see Fig. 1).

A modified version of the Downs and Black Quality Index[62] was employed to quality assess the articles that met the inclusion criteria. The original index has demonstrated high internal consistency (Kuder-Richardson 20: 0.89), good test–retest ($r = 0.88$) and inter-rater ($r = 0.75$) reliability, and high correlations ($r = 0.90$) with other validated quality assessment instruments ($r = 0.90$) used for non-randomised studies.[62] The reliability and validity of the modified quality assessment index used in this review were not assessed since other researchers have successfully applied similar modified versions of the initial quality index.[63,64]

For the purpose of this review, as performed in a prior systematic review,[63] eight questions (8, 9, 13, 17, 19, 24, 26, and 27) from the original 27 itemed index were excluded since they were not relevant to non-randomised control trials. The category "not applicable" was added to questions 4, 14, 15, and 23, as the questions were only pertinent to intervention type studies. Age, sex, physical activity level, height, weight, prior lower limb injury, dominance, and health condition were defined as the principal confounders for questions 5 and 25 with the first three considered core confounders. These confounders were selected since they have been documented a