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Review Article

The heel-raise test for ankle plantarflexor strength: a scoping review and meta-analysis of studies providing norms

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Abstract. [Purpose] The heel-raise test (HRT) is sometimes used to quantify ankle plantarflexion strength. However, descriptions of the test vary and normative values are limited. This paper, therefore was generated to summarize procedures and provide normative values for the HRT in a younger and older age group of adults. [Methods] Electronic and hand searches were conducted to identify relevant literature. Meta-analysis was used to provide norms. [Results] Among 439 nonduplicative articles identified, 13 qualifying articles were ultimately included. Procedures for the HRT described in the studies varied considerably. The mean number of HRT repetitions was 28.7 for adults with a mean age less than 40 years and 11.8 for adults with a mean age greater than 60 years. [Conclusion] This study provides information on HRT performance and norms derived with them for younger and older adults.
Key words: Strength, Ankle, Age

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INTRODUCTION

The ankle plantarflexor muscles are contributors to the performance of many mobility activities including sit-to-stand, walking, running, negotiating stairs, and jumping[1–4)]. Quantifying the muscles' strength, therefore can be an important component of the physical examination of individuals with mobility limitations involving the lower limbs. As the plantarflexion muscles can be quite strong, alternatives to typical manual muscle testing have been developed to quantify weakness in the muscle group. Chief among these alternatives is the "heel-rise test" (HRT)[5)]. Numerous articles describing different procedures for performing the HRT have been described, but normative values have only been the focus of a few articles[5–9)]. As normative values obtained with specific procedures are necessary for the interpretation of measurements obtained from testing individuals[10)], I undertook the present review and meta-analysis of HRT performance.

METHODS

Relevant literature was identified via computerized searches of PubMed, Scopus, and CINAHL as well as by handsearches. All searches were conducted in July of 2021 and employed the search string "heel AND (rise OR raise), AND test". Inclusion required that an article presented HRT data from adults without pathology or athletic involvement whose mean age was less than 40 years or greater than 60 years. For the meta-analysis, inclusion also necessitated an article's indication of sample size as well as the mean and standard deviation (or standard error of the mean) of HRT repetitions. Where not available such statistical information was sought from authors. Following the aforementioned inclusion and exclusion criteria, I screened all titles and abstracts. Articles not thereby culled were subjected to a full text examination to determine whether they should be incorporated into the review.

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Information on study samples, procedures, and HRT repetitions was retrieved from qualified articles and tabulated. When more than one indication of HRT repetitions was obtained from the same sample (eg, left and right side HRT for the same age and gender stratum from the same study), the side from which data were used in meta-analysis was selected randomly. The Comprehensive Meta-analysis program using a random effects model was used to calculate effect sizes (HRT normative values) and homogeneity (using I^2).

RESULTS

The number of potentially relevant articles identified by PubMed (n=97), Scopus (n=314), CINAHL (n=280), and hand searches (n=3) was 694. After elimination of duplicate articles, 439 remained to be examined for inclusion and exclusion. Most of the articles (n=426) were excluded for one or more reasons. The most common reason was that an article focused on individuals with Achilles tendon rupture or other condition affecting the lower limb (n=264). However, articles were rejected based on other criteria listed heretofore. Ultimately, 13 studies qualified for inclusion[5–7, 11–19] (Table 1). Qualified studies were mostly conducted in Sweden (n=5) or North America (n=4), but one study was also completed in Australia, Taiwan, England, and India. Most studies included both males and females, but 2 involved just males, 1 included just females, and 1 did not specify gender. The number of participants contributed by individual studies ranged from 10 to 211 for participants with a mean age less than 40 (total n=699) and 22 to 176 for participants with a mean age greater than 60 (total n=216). By design, heel raises were conducted unilaterally. However, the heel raised was inconsistent- involving both, one side (eg, dominant), or an undesignated side. Heel- rise targets ranged from full excursion to greater than 50% of full excursion. Excursion was sometimes "eye-balled", but in other cases was more specific. That is, blocks, tape, goniometers, bands, or other instrumentation were used to mark excursion. The pace of heel-rises varied but was often guided by a metronome or other rhythmic driver. Most studies allowed participants to employ finger support, usually on a wall, for support or balance.

Meta-analysis (Table 2) showed an adjusted grand mean of 28.7 HRT repetitions for the younger age group and a grand mean 11.8 HRT repetitions for the older age group. The associated I^2 values were 39.9 and 97.1, respectively.

Table 1. Heel rise sample, procedures, and normative reference values providing interpretive perspective from 13 studies

Study	Sample	Procedure	Heel-raise test pepetitions Strata Mean (SD)*
Byrne et al. (2017)[11]	Healthy English, males (n=18) & females (n=20), age mean 36.0 years	Heel raised 5.0 cm on a 10° incline box monitored by encoder measurement device attached to the heel. Pace set with metronome @ 30 heel-rises/min. Used no more than finger-tip support.	38 left: 32.6 (11.4) 38 right: 34.7 (12.1)
Chitre & Prabhu (2017)[7]	Indians (n=200), age range 20–69 years	Heel raised to >50% maximum excursion & monitored by electrogoniometer. Pace set with metronome @ 1 beat/s (2 beats/cycle). Finger on wall for support.	40 20–29 years: 31.9 (9.1) 40 30–39 years: 28.4 (5.6) 40 40–49 years: 17.7 (5.2) 40 50–59 years: 14.5 (5.3) 40 60–69 years: 7.2 (3.1)
Hashish et al. (2015)[12]	North Americans not participating in vigorous exercise or frequent long walks, males (n=6) & females (n=16), age mean 71.0 years	Dominant heel raised to ≥50% of maximum and monitored by tape line on wall. Pace set with metronome @1 heel-rise/s. Single finger on wall.	22: 21.3 (6.1)
Hébert–Lousier et al. (2017)[9]	Swedes with good self-reported health, males (n=22) & females (n=10), mean age 28 years	Left & right heels raised on a 10° incline. Pace set with metronome @60 beats/min. Finger tips on walls for balance	32: 33.7 (10.9) left 32: 32.1 (11.6) right
Jan et al. (2005)[6]	Sedentary Taiwanese without lower limb problems, males (n=180) & females (n=180), age mean 49.6 years	Dominant heel raised >50% of maximum excursion & monitored by electrogoniometer. Pace set with metronome @ 1 beat/s (2 beats/cycle). Finger on examiners' for support	30 males 21–40 years: 22.1 (9.8) 30 males 41–60 years:12.1 (6.6) 30 males 61–90 years: 4.1 (1.9) 30 females 21–40 years: 16.1 (6.7) 30 females 41–60 years: 9.3 (3.6) 30 females 61–80 years: 2.7 (1.5)
Lunsford & Perry (1995)[5]	Healthy North Americans, males (n=122) & females (n=81), age mean 34.7 years males & 29.3 yeas females	Dominant heel raised >50% of maximal excursion while monitored with a goniometer. Pace set with metronome @ 1 heel raise every 2 s. Finger-tip support on tester.	122 males: 27.8 (11.5) 81 females: 28.4 (9.8)

*Data used in the meta-analysis are underlined.

Table 1. Continued

Study	Sample	Procedure	Heel-raise test pepetitions Strata Mean (SD)*
Möller et al. (2005)[13]	Healthy Swedes, males (n=10), mean age 37 years	Heel raised to 5.0 cm target, test device with light beam confirmed target reached. Pace set with metronome @ 40 beats/min. Hands on wall for support	10 left: 28.0 (4.4) 10 right: 29.8 (4.6)
Österberg et al. (1998)[14]	Healthy Swedes, males (n=10), age mean age 25.0 years	One heel raised maximally while standing on 10° wedge & monitored by electrogoniometer. Pace set with metronome to 92 beats/min to facilitate angular velocity of 60°/s. Finger tips on wall for balance support.	10 males: 36.0 (6.3)
Ross & Fontenot (2000)[15]	Healthy North Americans, males (n=13) & females (n=4), age mean 21.2 years	Each heel raised maximally to surgical tubing target. Pace set with metronome @ 1 beat /heel-raise every 2 s	17 right dominant: 32.7 (9.7) 17 left nondominant: 32.6 (9.7)
Sara et al. (2021)[16]	Healthy North Americans, males (n=14) & females (n=14), age mean 21.5 years males & 21.1 years females	Right heel raised to horizontal target plate. Pace set with metronome @ 60 beasts/min so 1 heel-raise completed/3 s. Light finger support included in horizontal plane.	14 males: 32.6 (6.9) 14 females 39.4 (14.8)
Sman et al. (2014)[17]	Healthy Australians, males (n=21) & females (n=190), age mean 24.0 years	Random heel raise using elastic band to standardize range. Set pace with metronome set at 46 beats/min. Finger tips of one hand on wall for support.	211: 23.010 (13.3)
Svantesson et al. (1998)[18]	Healthy Swedes, females (n=10), age mean 24.0 years	Right heel raised maximally while standing on 10° wedge & monitored by electrogoniometer. Pace set with metronome to facilitate angular velocity of 60°/s. Bilateral finger-tip support used.	10 right: 25.0 (1.0)
Whyte et al. (2021)[19]	Healthy Swedes, males (n=81) & females (n=95), mean age 72.3 years males & 72.0 years females	Each heel raised maximally while standing on a 10° wedge. Pace set with metronome to facilitate movement @ 60°/s. Light fingertip support of both hands for balance.	81 males right: 11.0 (8.0) 81 males left: 10.0 (9.0) 95 females right: 10.0 (8.0) 95 females left: 9.0 (8.0)

*Data used in the meta-analysis are underlined.

Table 2. Results of meta-analysis of 15 studies addressing normal heel rise performance

Studies	Data Groups	Grand Mean	Standard Error	Limits	I^2
Younger adults (11)	15	28.7	1.1	26.4–30.9	39.9
Older adults (3)	4	11.8	2.4	7.0–16.6	97.1

DISCUSSION

The HRT is a widely used measure of ankle plantar flexion strength suitable for patients who are able to stand without physical assistance. Variations exist regarding the standing test surface (eg, presence or absence of inclination)[12, 14], the ankle excursion criterion used (eg, full ankle range versus >50% range)[7, 12, 15] and rate of performance (eg, 1 raise/s vs. 2 raises/s.)[5–7, 11, 12]. Almost all studies documented using a metronome or some other instrument to establish HRT frequency, but the rate of performance, as indicated above, differed. All but one study noted the use of a hand or fingers to assist balance. Together, these differences may explain some of the heterogeneity of the study results[20].

The HRT repetitions in this study were summarized for two age groups, that is for adults with a mean age of less than 40 years versus a mean age of greater than 60 years). The number of HRT repetitions for the younger group in this review (mean=28.7) is comparable to the mean (27.9 repetitions) and criterion for normal (25 repetitions) reported by Lunsford and Perry[5]. However, the number of HRT repetitions for the older group in this review (mean=11.8) was much lower than for the younger group and the values reported by Lunsford and Perry[5]. Older adults, therefore, should not be expected to perform 25 HRT repetitions. This review as well as the paper by Hébert–Losier et al.[9], provide a much better standard.

This study had some limitations. First, normative values were provided for only 2 large age groups. While unavoidable based on the diversity of research samples, accounting for performance across smaller contiguous age spans as done by Hébert–Losier et al.[9], would provide more specific norms. Second, this was not a systematic review. A single individual searched and summarized the literature. Moreover, no quality rating of included articles was conducted.

This review summarizes specifics of the HRT. Normative values derived using meta-analysis are presented for a younger and older age group. These values should assist with the interpretation of clinically obtained measurements.

Conflict of interest

None.

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