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Posterior Tibial Tendon Dysfunction: What does the single heel raise test mean in assessment?

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This paper aims to review the literature pertaining to single heel raise test, which is used for the assessment of PTTD. Whilst there is little published information relating to the origins of this test, there is also a clear paucity of information pertaining to the interpretation of the test findings. Understanding why clinicians utilize this test in the assessment of this debilitating pathology and how the result is interpreted is important in helping to bridge the remaining knowledge gap surrounding this condition. This review will contribute to the body of knowledge that is helping to explain why PTTD is an under recognized and underdiagnosed condition. Databases that were searched include PubMed, MEDLINE 1990-present, SportDiscus, AMED 1990-present, CINAHL 1990-present, BMJ Clinical Evidence, Cochrane Library, ISI Web of Knowledge (science) 1990 to present, Ingentaconnect, Science Citation Index, Science Direct and Wiley Interscience. Until recently there has been very little work isolating the tibialis posterior muscle activity in dysfunction. There has been even less work surrounding the individual elements of the assessment this condition such as the single heel rise test. Areas covered within the review are the history of the test, validity and reliability of the test, kinematic changes associated with the test in the presence of PTTD and the biomechanical changes in the presence of PTTD and how this may impact of the execution and interpretation of the test findings. The results from this review are inclusive in relating the single heel raise test to the assessment and diagnosis of PTTD. There is variable use of this test in clinical practice in addition to the clinical setting and patient groups where it is utilized. Further work is indicated surrounding validity and interpretation of the test findings.

Key words: single heel rise test, tibialis posterior dysfunction, kinematic, flat feet, musculoskeletal disease, tendon.

Various Musculoskeletal (MSK) conditions such as Posterior Tibial Tendon Dysfunction (PTTD) have been estimated to occupy approximately 30% of all referrals from General Practice Medical Professionals [1]. In addition, the prevalence of foot pain in middle aged and older adults is reported to be between 20-37% [2, 3] presenting a significant public health challenge.

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People with foot pain experience significant difficulties with ambulation and carrying out activities of daily living and PTTD is no exception [3]. A recent review suggested that the burden of musculoskeletal foot pain is set to escalate with the increasing number of older people [4].

Posterior Tibial Tendon Dysfunction has had much attention in the recent literature, exploring many of the complex facets of this disabling pathological flat foot condition. Included in the plethora of publications is new information on epidemiology, risk factors, treatment options and kinematic changes in the presence of PTTD [5-15]. A glut of new material to inform intervention for this condition, has inevitably meant less attention has been given to the clinical assessment of PTTD. The assessment classifications that currently exist [16-19] support the assertion that absence in the ability to perform a single heel raise test is indicative of insufficiency and dysfunction. However the evidence to support this assertion is not forthcoming. Therefore, the intention of this paper is to review the current and past literature pertaining to the single heel raise test to better understand why so many clinicians utilize this test in the assessment of this debilitating pathology. The review will focus on articles published within the last two decades and will contribute to the body of knowledge that is helping to explain why PTTD is an under recognized and underdiagnosed condition.

Methods and Search Strategy

Databases that were searched include PubMed, MEDLINE 1990-present, SportDiscus, AMED 1990-present, CINAHL 1990-present, BMJ Clinical Evidence, Cochrane Library, ISI Web of Knowledge (science) 1990 to present, Ingentaconnect, Science Citation Index, Science Direct and Wiley Interscience.

Key words used include: posterior tibial tendon dysfunction AND single heel rise test, posterior tibial tendon insufficiency AND calf raise test, posterior tibial tendon \function AND heel raise test, PTTD, TPTD, posterior tendon pathology, foot kinematics, foot AND/OR ankle kinematics AND heel raise test. All articles used were published in English language. Due to the exploratory nature of this review and a general lack of empirical evidence in the area of interest, a strict inclusion/exclusion criteria has not been applied.

Results and Discussion

The results of this search led to a large number of articles being returned, 279 in total were initially included. Further refinement with the use of Boolean operators enabled only articles relevant to the heel raise test and/or in connection with the history of the heel raise test, its validity/ reliability both in general use and specifically to PTTD, the kinematic changes associated with its use, and the underlying biomechanical changes that may coexist in patients with PTTD that could help explain the test result. This lead to 12 articles being selected for this review.

From reviewing the literature surrounding assessment of foot and ankle pathologies, one overarching theme stood out; the method of assessment for foot and ankle problems varies considerably among health care professionals [20]. Investigators have raised doubt around the generalizability of the findings of such assessments [3, 4, 21]. Moreover and arguably more importantly, there is a paucity of literature reporting assessment methods for specific conditions. Many of the assessment practices currently in use are supported by the lowest form of hierarchical evidence falling within the remit of expert opinion. While this type of evidence has a place, it does not provide an understanding of the reliability or validity of such assessments.

For example, assessment for first ray motion and mobility has an historic presence in the clinical assessment foot and ankle. However, Cornwall, Fishco [22] report on the reliability and repeatability of this test and conclude that the validity is questionable. Results from this study demonstrate poor inter and intra-tester reliability, and the authors conclude that the reliance on measurement used to assess foot and ankle pain needs to be revisited [22].

Similarly, Wrobel and Armstrong [23] have attempted to describe the reliability and validity of current foot examinations. The study has highlighted similar issues to Cornwall et al [22] whereby various methods of lower extremity assessment are utilized by clinicians but few have been given rigorous attention to the measurement properties.

Previous work has alluded to a similar problems when executing the assessment of PTTD [24] acknowledged as an under researched area. The condition itself is known to be poorly diagnosed although the reasons for this are unclear. PTTD causes significant impairment for those that experience the condition, therefore to facilitate improvements to this unsatisfactory situation, further work is required exploring assessment and diagnostic procedures utilized in practice.

Clinical Assessment Criteria

The existing criteria suggest that it is possible to identify discrete stages in the clinical signs and symptoms of the progression of the pathology [16-

19]. The adoption of this approach will allow for the identification of a relationship between the presenting symptoms and clinical features of specific stages of PTTD. Such a framework for the classification of different stages of PTTD may be considered essential for successful clinical diagnosis, however the scientific rigor surrounding the validity of the clinical features at each stage is currently unknown. In spite of this, the assessment and diagnosis of PTTD has been organized around these staging criteria.

This situation presents a dichotomy to researchers and clinicians alike. There is evidence that PTTD is not well diagnosed among health care professionals [25,26] and yet the assessment criteria that many clinical staff uses to assess this condition are itself lacking in validity.

A common inclusion of the classifications currently used in practice detailing the presence of certain anomalies that characterize the condition, is the single heel raise test. However the evidence surrounding this test and its inclusion is difficult to ascertain.

The Heel Raise Test

Despite its common application in the assessment and diagnosis of PTTD, there is little documented evidence surrounding consensus in relation to the purpose of the heel raise test, the optimal test parameters, outcome measurements, or the appropriate normative values associated with it.

History of the heel raise test

The heel rise test is used to assess static weight bearing muscle function. The test is recommended for individuals with PTTD [16-18, 27, 28]. Weakness of the posterior tibialis muscle is thought to contribute to the inability to perform a heel rise task. Clinically, an abnormal heel rise test is observed when the individual cannot perform a heel rise or performs the heel rise with hind foot eversion (fails to invert on rising) [29] suggesting that the posterior tibialis muscle no longer is acting to invert the hind foot or that the patient is demonstrating progressing PTTD [28, 30].

Despite its adoption for assessing PTTD presence, the origins of the test are varied. Historically, the heel raise test, also known as the calf raise test, had been utilized to assess posterior muscle strength. Its early use was adopted between 1940 and 1955 when polio was at its most prolific. The "floor and ceiling" effects of manual muscle testing (MMT) was recognized as being problematic in grading maximal and minimal muscle strength, particularly in this group of patients. The floor effect is noted when individuals repeatedly score the lowest possible score and the ceiling effect when individuals repeatedly obtain the highest possible score. This phenomenon is partly due to the subjective strength of the examiner applying the manual resistance force [31, 32].

Kinematic changes during the heel raise test

Recognizing the inadequacy of the non-weight bearing test, the standing heel raise test was introduced as a substitute, providing a weight bearing method of assessing posterior muscle strength. Within the two recent studies investigating the kinematic changes associated with this test [28, 33], researchers in one study [28] revealed that the kinematic changes during a bilateral heel rise test showed a similar pattern to the non-PTTD control group. During the dynamic heel raise test the kinematics of rear foot eversion in the PTTD group was not found to be significantly different from controls.

However, the same study [28] demonstrated a significantly different segmental relationships. That is to say, that while the observable kinematic changes showed similar characteristics in terms of pattern, this was relative to the PTTD baseline being akin to a pronated foot type. Other interesting findings to note include: first metatarsal function which demonstrated a more dorsiflexed position than the control group, and first metatarsophalangeal joint dorsiflexion demonstrated reduced dorsiflexion in the PTTD group.

Notwithstanding the significance of these results, participants in this study [28] were required to perform a bilateral heel raise. The most common method for conducting this test is for patients with PTTD to perform a single heel raise. A single heel raise is preferable over bilateral heel rise because the contralateral limb could compensate for a loss of function on the ipsilateral limb being tested.

In a more recent study [34], investigating age related differences in performing a single heel raise test for stage 2 PTTD compared to controls, other factors were highlighted that differ between control and pathology groups. These differences, include, maximum heel height, differences in kinematic rearfoot, forefoot joint motion, increased first ray dorsiflexion and reduced maximal ankle plantar flexion in the PTTD group. Until now, these metrics have not been considered when assessing the results of the single heel raise test in PTTD.

Validity and reliability of the single heel raise test

A systematic review [35] investigating the calf raise test, found poor concordance to specific test criteria. No definitive normative values were determined. Utility of the test in patients with pathology remained unclear. Although adapted for use in several disciplines and traditionally recommended as a clinical assessment and rehabilitation tool, there is no uniform description of the calf-raise/ heel raise test.

Work conducted by Hébert-Losier and Holmberg [33] suggest that the functioning of the gastrocnemius/soleus musculature changes depending on knee position. The purpose of this study was to establish the relative contributions of the gastrocnemius/soleus musculature. Previous research had investigated this, however, the kinematic and kinetic changes when conducting the test on an incline has not been previously explored.

In a repeated measures design, participants were required to perform a single heel raise test on an incline under two test conditions; a zero degree and a forty five degree angle of knee flexion. In the older population, 40-60 years, (as would be the case for PTTD) the findings of this research [33] indicate that the height of the single heel raise decreases with increases in knee flexion angle. Suggestive that this may occur due to the effort to maintain a stable base of support, flexing the knee to lower the center of mass to improve balance. This finding also linked to the COP result which showed a minimal medial/ lateral shift at maximum heel height. Both these findings were accentuated following prolonged testing.

Several recommendations for standardizing the single heel raise test have been suggested [35]. By adopting these parameters for research the face validity of the test will improve. They include:

- Ankle starting position (i.e. position of the foot in relation to the tibia)
- Knee starting position (flexion/extension)
- Height of the raise
- Pace (raises/min)
- Balance support, e.g. Fingertip support
- Outcome measurements; e.g. Number of raises, force measurement, degrees of plantar flexion etc.
- Termination criteria e.g., pain, unable to maintain, fatigue etc.

Repetitive single heel raises have appeared in a number of investigations, ranging from 3 to 15 repeated single heel raise tests [31, 36-37]. This attempt to quantify the number of heel raises needed to determine normal posterior muscle function and thereby set the bench mark for normalcy, has added to the complexities of interpretation of findings.

Test retest reliability [32] of the single heel rise test, according to ICC and SEM results suggest the test is reliable for testing posterior calf musculature. Interestingly the use of this test in relation to PTTD was absent in this study [32]. Results confirmed that repeated single heel raises provided similar parameters in terms of number of raises performed, heel height measured, and maximum ankle plantar flexion, when carried out on different days. Limitations relate to the non-pathological participant group used in this study. Results for reliability/repeatability may be very different for a pathological conditions such as PTTD whereby symptoms tend to be progressive and variable.

A study utilizing the single heel raise test in women with myositis [31] comparing two methods of manual muscle testing (MMT) with the single limb heel raise test, support the notion of the problems associated with the ceiling and floor effects previously mentioned [31, 32]. Furthermore, Harris-Love et al [31], propose that the maximum number of heel raises is a poor indicator of muscle strength. The authors also found that MMT was not predictive of muscle weakness or dysfunction.

Biomechanics of the single heel raise test

Some publications have linked the function of the posterior muscle group to the biomechanics of the foot; considering function in relation to the proximity of the posterior muscle group insertions to the sub-talar joint axis. The premise being that in a pronated foot type, this axis position may shift more medially.

Previous work [38, 39] tested muscle activity using fine wire EMG. In both studies the activity of the PT muscle increased. The same authors also reported increases in the inversion moment during stance in participants with stage II PTTD compared to controls. Chimenti et al [34] identified that kinematic changes were present in patients with stage II PTTD. This suggests that there are alternative reasons other than muscle strength and activity to explain these differences. This point is not surprising since in PTTD the pathology lies with the tendon and not the muscle belly itself, therefore there is no reason for muscle activity to be compromised. The kinematic changes identified in stage II PTTD [34] include a reduced heel height compared to controls, reduced maximal ankle joint plantar flexion and increased first ray dorsiflexion. The increased first ray dorsiflexion is indicative of a pronated foot type, whereby the windlass function is impaired due to the foot failing to re-supinate at the mid/terminal phase of stance [40].

Perhaps a secondary effect due to the progressive nature of PTTD, and the gradual development of pes planus, is to effectively move the effort (the insertion of PT tendon) closer to the subtalar joint axis, thereby reducing the mechanical advantage. This could be one explanation why there is an increase in muscle activity in order to restore the net moment generated by the PT muscle contraction and subsequent application of the force via the tendon insertion.

Summary

The majority of the published work investigating the single heel rise test stems from its use to test plantar flexion muscle strength in poliomyelitis sufferers. Until recently, there has been very little work isolating the tibialis posterior muscle activity in dysfunction. The interpretation of this test and its significance in the assessment of PTTD is debatable.

The tibialis posterior muscle lies within the deep posterior muscle group and has a function in both sagittal plane ankle joint plantar flexion and frontal plane foot inversion. The single heel raise test used in PTTD, signifies pathology in the absence of heel inversion on rising. Therefore it could be argued that since the lever arm length is relative to the forces acting across the axis and that these forces would be generated by internal muscle contraction. If there is an internal force deformation in the presence of PTTD that is reduced due to pain performing the single heel raise test, then this may adversely affect the outcome of the test. Conversely, if patients with PTTD have normal unaffected muscle contraction, how would this affect the clinical observations alluded to throughout this paper. The test is not used to test ankle joint plantar flexion strength in the presence of PTTD, however the majority of the literature relates to the test used in this way. Therefore, the points made previously by other authors may not be valid for this particular patient group. The relative contribution the isolated PT muscle function makes to ankle joint plantar flexion and rear foot inversion is not known. Therefore the interpretation of assessment findings is inconclusive.

Conclusion

The results from the studies included within this review have failed to clarify the interpretation of results and validity of this test in the assessment of PTTD. It is yet to be established what the effect of foot type might have on the performance of a single heel raise. Further investigation would be welcome to ascertain the precise mechanism involved in the single heel raise test. Additionally, further work to clarify the validity of the test would help in improving the understanding of the assessment methods used in this debilitating chronic condition.

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