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Discussion

An overview of podiatric biomechanics theory and its relation to selected gait dysfunction

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Abstract

This paper introduces the 'foot function' approach used by podiatrists in the treatment of lower limb musculoskeletal dysfunction. The aim is to demonstrate how podiatric theory has evolved its own perspective of mechanisms relating to normal and abnormal locomotion. Three individual podiatric paradigms are discussed, and a further theory allowing a working simplification of theory is introduced. Finally, an example of gait abnormality is discussed in relation to podiatric and physiotherapy perspectives.

An insight into podiatric theory should enable therapists working within this field to develop a more holistic and multidisciplinary approach. It is the view of the authors that a closer working relationship between physiotherapists and podiatrists with an interest in movement dysfunction provides a better quality service for appropriate patients.

Keywords: Gait; Podiatry; Theory; Dysfunction

Introduction

Specialists in physical medicine have developed systems of assessment and treatment to identify and correct faulty postures and patterns of movement [1–5]. These methods fall under the umbrella term of 'muscle imbalance'. By definition, muscle imbalance can be described as a deviation from a theoretically optimal posture or movement by a disproportional effort from muscles working around a joint or joint series [6]. In relation to gait, this can result in abnormal stress through the kinetic chain causing deformities, pathology and symptoms.

Podiatrists have also developed systems of assessment and treatment to identify and correct faulty postures and patterns of movement. This perspective focuses on how biomechanics of the foot influences the function of the lower quadrant. Theoretically, any abnormal foot function leads to pathological stress and microtrauma over time. With apparent justification [7], management of certain musculoskeletal pathology has been widely accepted by the podiatric community, with treatment aimed to improve movement dysfunction. Concomitantly, in-shoe appliances known as 'orthoses' have been developed to address these issues [8].

As a specialist in gait dysfunction, the podiatrist should be able to incorporate the knowledge of muscle function and testing to understand the possible multi-aetiological causes for abnormal gait. The same could be said to be true for the physiotherapist, with neuromusculoskeletal practitioners requiring adequate knowledge in the assessment of foot-based abnormalities.

Podiatric theory

Podiatrists have been treating gait-related symptoms using varied theories and therapies since the profession began to develop in the 18th Century [9]. The following section of this paper presents an overview of the three main emergent podiatric theories. A unifying approach is then introduced that can be used to understand the role of the foot in gait dysfunction.

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Subtalar joint neutral theory

The subtalar joint neutral (STJN) theory is based upon the premise that a foot is functioning ideally when the STJN position occurs just following heel strike and at the end of the midstance phase of gait. This model of management seeks to identify foot morphology that is 'abnormal', e.g. forefoot varus, and to prescribe an orthotic device to prevent subsequent 'abnormal' joint compensatory motion, e.g. excessive subtalar joint pronation [10–12]. It may be fair to assume that this method of podiatric assessment and treatment is the most popular biomechanical approach to foot function, used worldwide by both podiatrists and other professions [13–15].

According to the STJN theory, the orthosis is designed to balance any foot deformity with angled wedging applied to a rigid bespoke shell. Prescription protocol requires a cast of the foot in a non-weight bearing 'neutral' position [16]. The cast is then posted with an intrinsic forefoot post to place the bisection of the heel at the required angle. The degree of posting is arrived at by taking the value of the patient's neutral calcaneal stance position and subtracting a set number of degrees in order to allow 'normal' pronation [16]. The height of the subtalar joint axis is used to determine the amount of pronation to be allowed. To maintain the posting and shape of the orthosis, only rigid materials are recommended, such as acrylic or carbon fibre plus an acrylic rearfoot post. The shell is cut to 25% of the width of the first ray.

Critical review of this theory leads to questions in terms of reliability of joint position measurements, validity of the underpinning STJN position and a lack of outcome studies specific to the prescription protocol [17].

Sagittal plane facilitation theory

Dananberg first published his theories on sagittal plane facilitation in 1986 [18]. This theory highlights the importance of the foot as a pivot that rocks forward from heel to toe allowing adequate hip extension. Dananberg proposed that this hip extension allows a normal stride and therefore an efficient and erect gait [18–22]. He [23] cited ankle equinus and functional hallux limitus as examples of pathology that restrict necessary foot movement in what he terms a 'sagittal plane blockade'. Ankle equinus is stated to be a lack of 10° of dorsiflexion beyond 90°, and functional hallux limitus is defined as a first metatarsophalangeal joint that has a normal range of motion structurally, but which for any number of reasons, is unable to dorsiflex adequately in gait. Although this theory can be used to explain foot pains and abnormalities, Dananberg highlighted the effect on more proximal posture-related problems such as lower back pain [21–23].

The method of orthotic prescription is one of trial and error using in-shoe pressure system measures and video gait analysis. Therefore, the means of determining the posting, shell thickness, heel raise, etc. is done without reference to the forefoot to rearfoot relationship or the axis height as in the STJN model. Dananberg [22,24] also cites the use of shell modifications such as cutouts beneath the first ray and specific forefoot extensions to encourage medial propulsion.

Critical review of this theory leads to questions in terms of reliability and validity of video gait analysis and in-shoe pressure system assessment. Although both are now seen among practitioners as the most reliable and quantitative method of assessing gait, reliability and validity should not be taken at face value, with research questioning both reliability and absolute accuracy [25–27].

Tissue stress theory

This model is based upon assessment of the moments across the subtalar joint and methods of changing these to decrease stress upon anatomical structures [28–32]. Injured structures are identified and pathology is related mechanically to foot function. This approach emphasises physical laws including Newton's laws, elastic/plastic deformation, levers, moments, etc. The tissue stress theory emphasises the concept of kinetics rather than the kinematics of gait. The central concept is that it is not the pronation or supination that causes harm, but stopping the pronation or supination.

Foot-related musculoskeletal injury is treated via orthoses to reduce the abnormal forces upon injured structures by applying appropriate moments to the subtalar joint [30]. The choices are, therefore, forefoot or rearfoot posting in valgus or varus orientation. Posting is not dictated by the STJN position but by the magnitude of pathological moments. In contrast to the STJN theory, a change in magnitude of forces is required to reduce symptoms rather than a change in joint position. Large degrees of posting can be used, up to 5–10°, along with forefoot extensions that are also posted in varus or valgus orientation [33,34].

At present, there are no outcome studies available that use the tissue stress theory exclusively. Therefore, as yet, no conclusion can be established regarding the clinical efficacy of such orthotic modifications.

A unifying theory

It is fair to assume that no clinician would continue to use a theory that was not working to relieve their patients' symptoms. Therefore, there must be beneficial aspects of treatment from the STJN, sagittal plane facilitation and tissue stress theory perspectives. There may be a common underlying corrective mechanism, or there may be more than one way to improve symptoms with the use of orthoses. The authors, therefore, present a theory to explain normal and abnormal foot function which can be used to unify and explain benefits reportedly obtained from the three previous theories.