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Short Communication

Heel Fat Pad and Lower Leg Muscle Evaluation Using Conventional Lab Based Biomechanical Techniques of Motion Analysis and Electromyography

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DESCRIPTION

Research studies have shown that during locomotion the heel fat pad acts as a shock absorber as the soft tissues undergo repeated loading that is distributed over the heel (calcaneus) [1-4]. The heel pad function is influenced by its material and structural behaviour including morphological and morphometrical attributes associated with its geometry, microstructure, and surrounding soft tissue interface. The thickness of the human heel fat pad on average is 18 mm from the calcaneus to the plantar skin [5]. Belhan and colleagues also measured the thickness of the heel fat pad and reported that the average thickness of the heel fat pad without pain at the point of the medial calcaneal tubercle and the average thickness of the first metatarsal fat pad of the feet without pain at the point of the first metatarsal head were 19.94 mm and 6.75 mm, respectively [6]. It is important to note that the human heel fat pad is inhomogeneous, anisotropic, and has been described as exhibiting non-linear viscoelastic behaviour due to its biphasic nature [7]. In addition, it regulates the transmission of loads to the bones, muscles, and joints of the lower limb during the performance of functional activities of daily living. These activities may range from low rate activities such as standing, walking and running to high rate incidents in the form of sports injuries for example [8].

Various methods and techniques have been developed to evaluate the structure of the heel pad in addition to assessing common foot pathology such as plantar heel pain. Clinically, among adults plantar heel pain is common and is associated with severe pain which could lead to the occurrence of significant disability and deficiencies in the performance of routine activities of daily living [9]. Plantar heel pain is commonly caused by plantar fasciitis, calcaneal stress fractures, heel fat pad atrophy, tibial nerve entrapment, medial calcaneal nerve entrapment, or entrapment of the first branch of the lateral plantar nerve (Baxter's nerve). Correct diagnosis is key and should include patient history evaluation and physical examination. In terms of diagnosis high-resolution ultrasound can be used to confirm the diagnosis of the plantar fasciitis, heel fat pad atrophy, and entrapment neuropathies. Like ultrasound, magnetic resonance imaging can be used to diagnose soft tissue pathologies and may be preferred to ultrasound for investigating bony disorders. Diagnosing the systemic causes of plantar heel pain can be achieved using laboratory experimentation. Electrophysiological studies are required to examine neurogenic causes of plantar heel pain. Lastly, the diagnosis of stress fractures of the calcaneus and bone tumours can be confirmed by radiographs and computed tomography [9].

Research studies have evaluated the material and structural properties of the heel fat pad using modern technology, however, it is still not well understood whether using conventional lab based biomechanical techniques of motion analysis and electromyography could be considered useful or at best an alternative mode of measurement when access to preferred clinical equipment and instrumentation is limited (particularly among developing countries that are unable to purchase and establish descent healthcare facilities). This commentary will anecdotally highlight some novel and recently published [10-12] conventional lab based biomechanical techniques of motion analysis and electromyography approaches that may be used to assess the function and characteristics of the heel fat pad from both foot deformation and foot muscle standpoints. It is well established that three-dimensional motion analysis equipment integrated with electromyography and force plates are expensive and potentially unaffordable by most biomechanical labs [13]. However, this type of experimental equipment is considered biomechanically efficacious particularly in terms of assessing the levels of deformation of the heel fat pad, tissue stiffness/ compliance as well as related muscle firing and activation patterns resulting from foot deformation. Recent publications by Ugbolue and associates have developed new methodological approaches to evaluate heel pad stiffness [12] and soft tissue deformation [11,12] based on heel pad dynamic unloading and loading conditions using 3 mm retroreflective markers attached

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to the left and right heels. Three-dimensional motion analysis cameras synchronised with force plates were used to collect the kinematic and kinetic data sets. This system was also fully integrated with electromyographic technology [10]. The results clearly revealed the potential of this methodology as capable of delineating and quantifying the function/characteristics of the heel pad soft tissues. Furthermore, from a diagnostic perspective this method can provide valuable indicators useful for assessing the risk of pathological foot conditions. For example, the thickness of heel fat pad in patients with plantar fasciitis was evaluated by Belhan and colleagues using ultrasonography in the diagnosis of plantar fasciitis and they reported that the heel pad was thinner in the painful heels of patients with plantar fasciitis. This outcome can potentially be detected using our methodological approach by observing the movement patterns of 3 mm retroreflective markers. Although we have investigated and reported simultaneous muscle activation from six lower limb muscles (gastrocnemius medialis, gastrocnemius lateralis, soleus, tibialis anterior, peroneus longus, and peroneus brevis) during concentric and eccentric phases of the standing heel raise using surface electromyography; pilot studies focusing on muscle activation recordings during a standing forefoot raise have been performed. Efforts to correlate the quadratus plantae muscle activation muscle patterns with heel pad deformation are underway but remain challenging. A recent study on surface electromyography of the foot by Branthwaite and colleagues suggests that there is still inconsistency in the reliability of surface electromyography in measuring the muscle activity of the foot [14]. This suggests that more work is needed with investment in this area if a correlation of foot deformation and foot muscles is to be established.

Finally, a database consisting of various patient groups is proposed where biomechanical properties will be categorized in terms of signs and symptoms based on the foot deformation 'retro reflective marker patterns' that could include potential electromyography foot muscle activation patterns. This we feel will (a) aid early foot diagnosis of common foot pathology such as plantar heel pain, and (b) lead on to the development of a framework that will lay the foundation for the integration of large population data from healthy and patient groups with foot pathology and pain using morphological and morphometrical computational and statistical techniques applied to pattern recognition.

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