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Ergonomics, anthropometrics, and kinetic evaluation of gait: A case study

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Abstract

This study aimed to develop appropriate changes in a pair of shoes in order to improve the gait of an individual selected for this case study. This analysis took into account ergonomic aspects, namely those relating to the individual's anthropometrics. Gait analysis was done with the adapted footwear both before and after intervention.A conventional X-ray was performed, which revealed a 29-mm left lower limb shortening and possible foot adduction. The anthropometric assessment confirmed a 27-mm asymmetry between the left knee and foot.Corrective changes were implemented in the left boot, with a 20-mm increase in the plantar aspect and approximately 30-mm in the calcaneus area.The pressure-mapping system WalkinSense was used for the kinetic gait analysis. Results showed some improvement in plantar pressure distribution after corrective changes in footwear. Peak pressure in the left foot decreased from 2.8kg/cm^2 to 1.6kg/cm^2. The second peak also showed a marked decrease. The right foot presented with a reduction in peak plantar pressure from 2.7kg/cm^2 to 2.3kg/cm^2.After identifying asymmetries, the associated pathologies and modifyingthe footwear, a kinetic analysis of gait before and after altering the footwear was undertaken, which showed improvements in the gait. According to the obtained results, it was possible to demonstrate that the initially proposed objectives were achieved, i.e., the changes in footwear resulted in an improvement of the analyzed individual.

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*Keywords:*Ergonomics; Anthropometry; Footwear alteration; Biomechanics; Gait analysis

1. Introduction

This case study pertains to a young man with a congenital deficiency in the left leg characterized by the absence of the posterior tibial tendon. He has barely any gastrocnemius, thus preventing him from performing extension of the foot and leg flexion [1]. The subject underwent surgery, where doctors transferred the short peroneal tendon to

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the Achilles tendon, and the extensor hallucis brevis to the posterior tibial, tenotenodese hallux extensor with common extensor [2]. Currently, he presents an apparent adducted foot and his left leg is 3cm shorter. This asymmetry is practically all located between the knee and the foot. The leg appears slimmer from the knee to the foot, and the left foot is smaller and presents with muscular atrophy [3].

The field of ergonomics deals with the improvement of the conditions of humans, which includes designing systems and ensuring that they can be comfortable, safeand efficient[4].The applied anthropometry, which can be considered as one of the sub-topics of ergonomics, contributes to ergonomics by identifying the body dimensions and through that a potential inadequate dimensioning and postures adoption, which may result in the prevention of a set of disorders, namely some related with the musculoskeletal system [5].

In its turn, applied biomechanics, which can be also considered a sub-topic of Ergonomics, studies the mechanics of biological systems, and the mechanical effects on body movement, size, shape, and structure (Whatkins, 1999 as cited in [6]). The main purpose of analyzing human movement is to understand the mechanical function of the musculoskeletal system while performing a motor task [6].

Altering footwear is commonly done to alter gait patterns, to improve comfort, and to treat a number of disorders of the lower limbs [7, 8, 9,10]. Orthopedic devices are also used to enhance skeletal function [11].

In this study, it was necessary to understand the biomechanics of gait, the behavior of the lower limbs during the gait cycle, weight transfer, and distribution of plantar pressure. Gait analysis is specific to the study of human walking, and is used to evaluate, plan for, and treat individuals with conditions affecting their ability to walk [6].

The main objective of this study was to implement appropriate changes to a pair of shoes in order to improve the individual's gait while taking into account the ergonomic aspects, and to perform gait analysis both before and after altering the footwear.

2. Methodology

An X-Ray and an anthropometric assessment revealed a left lower limb shortening of approximately 30mm [3]. Thus, a kinetic gait assessment was essential.

To this end, we used the WalkinSense device, which can gather and process quantitative and qualitative information in real time, communicating with a computer, laptop or PDA via Bluetooth (25 meters reach) or USB cable. This device measures foot pressure and velocity more accurately than the currently accepted visual inspection or other less sophisticated devices. Thus, WalkinSense allows a quick and useful way to prescribe corrective orthotics.

Patients can use this device outside the clinical setting, since it is an easy-to-use, compact device. The battery operates with an adjustable strap for easy attachment to the ankle and allows users to continue with their daily activities with minimal disruption. The advantage of WalkinSense is that it measures foot pressure and speed much more accurately than the current visual inspection or less sophisticated devices with limited functionalities. This facilitates analysis of the lower limbs in a rapid manner, allowing for effective preventive treatments through corrective orthotics (e.g., custom insoles or shoes) that reduce the need for major interventions [12].

This system allows simultaneous monitoring of dynamic plantar pressure and activity on both legs, allowing for comparisons and detection of asymmetries in human gait. Moreover, it allows for both static and dynamic characterization of load distribution in the foot's contact surface.

2.1. Procedure

Several strips of adhesive Velcro were cut and fixed to the insoles where the pressure sensors were to be placed, with the same layout for both left and right foot (Figure 1). The choice of location for each sensor was determined by which features were important to evaluate. Given that the participant walks on the left heel, it was decided to place a sensor directly on the heels (sensor 5) and to eliminate the sensor on the internal lateral foot arch. Two sensors were positioned side by side on the first support (heel, sensors 6 and 7), sensor 8 was placed on the outer lateral area of the foot arch area, sensor 1 under the first metatarsal, sensor 3 under the metatarsal II, sensor 4 under the metatarsal III, IV and V (plantar foot area), and, finally, sensor 2 under the hallux (big toe). The metatarsal area was pertinent to this study since the participant presented with almost no movement in the toes.