Force Imaging

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Abstract

The study of human locomotion has generated a substantial number of publications. Starting from evolutionary history, the authors try to give some insight into the transition from quadripedal to bipedal locomotion. The upright position and erect walking is accepted as one of the main characteristics that differentiate humans from animals.

The available area of support during bipedal activities is thus restricted to that determined by one or both feet. The anatomical structure of the human foot, as well as the neuromuscular and circulatory control must have evolved to a multijoint dynamic mechanism that determines the complex interaction between the lower limb and the ground during locomotion. Consequently, besides gravitation, the external forces acting on the human body act on the plantar surface of the foot and generate movement according to Newton's laws. Thus, studying the latter, called the ground reaction force (GRF), is essential to the understanding of human normal and pathological locomotion. The GRF may, however, vary in point of application, magnitude, and orientation, necessitating the the sensors have to conform to the sometimes irregular body shape, technical problems due to sensor bending or other factors will occur.

Foot pressure measurements, are of utmost importance in understanding the central role of biomechanical issues in treating the diabetic foot and other foot pathologies, as well as in the design, manufacture, and assessment of insoles and footwear for these patients. To this end, foot-pressure distribution was at first assessed visually by using a so-called podobarograph where the plantar surface of the foot is observed while standing on a glass plate. Because only barefoot images restricted to the equipment location could be studied, further developments aimed at systems that can be used to measure the pressure distribution between the plantar surface of the foot and footwear during free dynamic activities, in particular, during the gait. These insole measurement systems evolved during the last few decades from a unique, relatively large sensor placed under the foot location of interest to eight or more individual sensors placed under anatomical landmarks on the plantar surface of the foot. Measurement frequency was limited to the sampling rate of the analogue-to-digital converters and computers available at the time. The actual systems present an array of numerous small sensors distributed over the whole plantar surface of the foot, and

thus eliminate the need for precise anatomical positioning. Sampling frequency went up to 500 Hz per sensor and higher, meaning that the registration system passes on information every 0.002 seconds, significantly improving the quality. Simultaneously, the measurement platforms, which are built into a walkway, evolved accordingly in sensor technology and sampling equipment. The small measurement area of the first systems, which was not much larger than the maximal foot size, is now transformed to plates available in virtually any size that present a geometric array of relatively small sensors (more than one per square cm) sampled at several hundreds of hertz (≥500 Hz).