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Use of the normalcy index for the evaluation of gait pathology

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Abstract

The normalcy index (NI) has been proposed as a method for quantifying the amount of deviation in a subject's gait, compared to the gait of the average unimpaired person. The NI was computed for a sample of 144 children affected by cerebral palsy, five idiopathic toe-walkers and 12 able-bodied subjects. It was sensitive enough to distinguish unimpaired subjects from idiopathic toe-walkers and to distinguish between the plegic and uninvolved limbs of hemiplegic patients. The NI was robust enough to categorize pathology, ranging from mild disorders to quadriplegia. The NI was found to be clinically applicable, reliable and easy to use, making it a valuable element in the quantitative evaluation of gait pathology.

Keywords: 3D-gait analysis; Cerebral palsy; Normalcy index

1. Introduction

Gait analysis (GA) is widely recognized as a central element in the quantitative evaluation of gait, and in the planning of treatments for subjects with movement disorders such as those caused by cerebral palsy (CP) [2–4]. A typical GA study, however, yields a vast amount of data. This often makes GA an instrument that is complicated to use and difficult to interpret. There is a growing clinical awareness of the need for concise indices that allow an objective, quantitative evaluation of gait pathology. The literature contains several reports of index calculation procedures that make it possible to focus on a specific joint, a specific muscle, or on the function of a muscle group. One example is the method of Davis and DeLuca [5] for calculating an index of ankle joint stiffness. Frigo et al. [6] extended the use of this index to the hip and knee joints, identifying characteristics typical of hemiplegic and of diplegic subjects. In another example, Eames et al. [7] investigated the use of GA data in the study of specific muscles. Their study showed that kinematic data from the knee and ankle joints could be used to define the length of the gastrocnemius. The gastrocnemius length was estimated for a group of healthy subjects and a group of spastic (hemiplegic and diplegic) subjects. Their results revealed that the length of the gastrocnemius differed according to the type of spasticity.

GA has also been used to evaluate the function of groups of muscles. Schwartz et al. [8] set out to establish a concise index (hip flexor index, HFI) that could quantify hip flexor function during gait. The index was applied to a group of spastic subjects and the results demonstrated a close correlation between the results of HFI-based evaluation and of the clinical evaluations routinely performed by clinical experts. The index was then used in a retrospective outcome study to examine the effect of intra-muscular psoas lengthening [9].

These studies used data obtained from GA to focus attention on a specific pathological feature, such as the behaviour of a single joint. Often, in clinical settings, there is a need to find more general parameters that relate to a subject's overall gait pathology. Schutte et al. [1] proposed a normalcy index (NI), that characterises a patient's gait in a global sense. It uses multivariate statistical methods to quantify the extent by which a patient's gait deviates from that of an unimpaired control group. The NI is computed using standard multivariate statistical techniques (principal component analysis) applied to kinematic variables acquired using GA. Kinetic variables are excluded, as their use would render the calculation procedure inapplicable to subjects who rely on walking aids.

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