MOTOR RECOVERY ASSESSMENT USING FORCE PLATES IN GAIT ANALYSIS

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INTRODUCTION

In Gait Analysis (GA) of neurological patients, the shape of the vertical and fore-aft Ground Reaction Force (GRF) components has a complex morphology and a qualitative comparison between different GA can be difficult. Numerical indexes described in literature (Morita et al. 1995) were computed from the GRFs of 16 normal and 39 pathological subjects in order to verify: the repeatability of normal and pathological values reported in literature, the relationships between these indexes and clinical scales of motor recovery such as the Fugl-Mayer Test Gait-Item (FMGI) and the walking speed, the sensitivity of these indexes respect to the motor recovery.

PATIENTS, MATERIALS AND METHODS

Thirty-nine neurological patients (29 of them affected by stroke, 6 by traumatic brain injury, 4 by neuropathy) under rehabilitation treatment were investigated in two sessions separated by at least 2 months. During each session a FMGI value has been assigned and a GA was performed using an optoelectronic Elite Plus system and two Kistler force plates. The sampling frequency was set at 100 Hz. Markers were placed according to the Davis protocol. At least five repeatable trials for each limb were required. In order to obtain inter-subject comparable values, the mean walking speed obtained by GA was normalised with respect to the body height and the GRF components with respect to the body weight.

From the vertical component Fz of the GRF, a load symmetry index A was computed as the ratio between the Fz of the affected and the non-affected limb. An index B, obtained as the ratio between the integral of Fz and its time duration, was computed for both limbs: healthy (Bh) and pathological (Bp). From the fore-aft component Fy of the GRF, the index C was computed as the ratio between the integral of the acceleration related component and the integral of the whole curve (deceleration plus acceleration) for both limbs: healthy (Ch) and pathological (Cp). Normality ranges were computed on the base of 220 strides of 16 normal subjects. The Kruskal-Wallis non-parametric test was used to investigate the distribution of the indexes with respect to the FMGI score. The linear correlation coefficient between A, Bh, Bp, Ch, Cp and the normalised velocity v/h, was computed in order to compare these indexes to a clinical indicator of motor recovery. A factor analysis was performed on v/h, A, Bh, Bp, Ch and Cp, with the aim of revealing the presence of underling relationships between indexes.

RESULTS

The range of A in normal subjects is 0.97±0.05; B varies within 0.82±0.04; C within 0.54±0.06 (mean ± 1 standard deviation reported). Index A is distributed around its normality value even in pathological subjects, whereas literature reports that A is lower than 1. Both normality ranges and pathological ranges obtained from our sample are consistent (except A) with data reported in literature.

The Kruskal-Wallis test indicates dependence of indexes median values from the scores of FMGI ($p<0,05$). The regression between the indexes and v/h is significant for Bp with $R^2 = 0.76$ and for A with $R^2 = 0.62$.

In all patients indexes Bh and Bp are lower than normal values, Ch and Cp vary between 0 and 1 approaching the normal value when v/h increases. In compromised patients, values of Cp as low as 0.1 were found.

Factor analysis on v/h, A, Bh, Bp, Ch and Cp splits indexes in three independent groups or factors: A, Bp and v/h are grouped together on factor 1, Bh is isolated on factor 2, Ch and Cp are symmetrical on factor 3.

DISCUSSION

The use of force plates allows understanding how an increase in velocity is achieved by neurological patients: with a better performance of the affected limb or with an exaggerated use of the unaffected one.

Proposed indexes summarise GRF information into a few numbers, related to FMGI and height normalized velocity, that describe the degree of symmetry (A), the load ability (Bh and Bp) and the competence of managing the acceleration and deceleration components (Ch and Cp).

Due to the identified relationship between these indexes, three of them can be selected to summarize the velocity and GRF related information. This selection allows using a simple representation of data into a 3D plot, where Bp, Bh and Cp are the axes, each GA session becomes a point and subsequent GA sessions define a trace. How a patient comes to or deviates from the point of normality can be investigated.

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