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QUANTITATIVE ANALYSIS OF GAIT PATTERN IN HEMIPARETIC PATIENTS

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ABSTRACT

Objective: To characterise gait pattern in hemiparetic patients quantitatively using clinical footprint method.

Design: A case control study.

Subjects: Sixteen hemiparetic patients (12 males and 4 females) aged 16 to 64 years who attended neurological clinic at Queen Elizabeth Central Hospital, Blantyre, Malawi.

Main outcome measures: Stride length, step width, foot rotation angle measured using footprint method.

Results: The difference in mean values of the three variables of gait between affected and unaffected sides in hemiparetic patients was not significant. However, strides were significantly longer in controls than in patients ($P < 0.001$) while patients had significantly broader steps ($P < 0.02$). In the controls, foot was rotated externally in 87.7% of steps and internally in 14.3% of steps. In the hemiparetic patients, intoeing pattern was observed in 41.3% of steps. The difference in variability of stride length and foot angle between affected and non-affected sides of patients was not significant. Stride-to-stride variability in stride length in patients was 1.6 times higher than in controls. Variability of step width and foot progression angle was 1.4 and 1.6 times higher in patients than in controls.

Conclusion: Footprint method provides fast and inexpensive tool for clinical gait analysis and is suitable for evaluation of hemiparetic patients. Our findings suggest that areas of emphasis for physical therapy of hemiparetic patients should include increasing stride length and decreasing step width and internal rotation of foot, particularly on the affected side.

INTRODUCTION

Several studies(1-4) have demonstrated the effect of Parkinson's disease, Huntington's disease, cerebellar ataxia, cervical myelopathy, and normal pressure hydrocephalus on the locomotion of patients. Quantitative assessment of the gait pattern of the hemiparetic patients has received less attention(5,6) despite its importance for diagnostic purposes, evaluation of effectiveness of medication and physical therapy, disability ratings and assessment of likelihood of experiencing falls and traumatisation of hemiparetic patients.

Movement disorders can be characterised by changes in tendon reflexes and muscle tone. The association between physical signs and symptoms observed under passive conditions and altered neurological mechanisms during active motions is weak(7). Moreover, qualitative description of locomotion is subjective. In addition, quantitative analysis of movements in specialised gait laboratories is expensive and non-affordable in most of the clinics. Besides this, gait analysis in neurological patients may be considerably

altered by applying devices and the artificial surrounding of a gait laboratory. Several studies(8-10) have demonstrated that more simple methods of gait analysis such as clinical footprint method allow to assess gait pattern quantitatively in a variety of clinical applications.

Footprint method involves application of ink to the soles of the patient's shoes or feet and walking along paper strips. Alternatively subjects can walk on thermosensitive paper. This method is easy to apply, is not time consuming and has high reproducibility(8). The purpose of the present study was to characterise gait pattern in hemiparetic patients quantitatively using clinical footprint method.

MATERIALS AND METHODS

The study was conducted at Queen Elizabeth Central Hospital, Blantyre, Malawi. All patients with hemiparesis who attended neurological clinic at the hospital during one month period were requested to participate after informed consent. Permission to conduct the study was also obtained from the hospital management. Clinical examination was carried out by a consultant neurosurgeon (AA). Total number of patients in the study group was 16 (12 males and 4

females) in the age range between 16 and 64 years. The causes of hemiparesis in the study group included post-traumatic head injury syndrome (7 patients), space occupying lesions (6 patients) and cervical spondilosis (2 patients). Subjects in the control group were recruited from among neurologically non-diseased patients. Control group was matched with study group by gender and age.

Gait at natural speed of patients and controls was recorded using clinical footprint method as described by Boenig(8). The ink and moleskin was applied on the subjects feet and footprints were recorded on white paper strip (6 m length) while the subject was walking without a cane along a paper strip at self-selected comfortable speed. The following parameters of the gait were measured: stride length, step width and foot rotation angle. Gait variables in patients were analysed separately for affected and non-affected side.

Results were analysed using Epi Info 2000 and Excel 2000 software. Data are presented as means and standard errors of mean. Variables of study and control groups were compared using t-statistics. The level of statistical significance was fixed at $P < 0.05$.

RESULTS

The means and standard errors of mean of the three gait parameters are shown in Table 1. Due to the small number of females in the study group, the

gender difference in gait pattern was not analysed. All variables were normally distributed. The difference in mean values of the three gait parameters between affected and unaffected sides in hemiparetic patients was not significant. Strides were significantly longer in controls than in patients ($P < 0.001$) while patients had significantly broader steps ($P < 0.02$). The difference between the two groups in foot rotation angle was not significant. However, some difference between patients and controls was observed in the direction of the foot rotation. In the controls, the foot was rotated externally in 87.7% of steps and internally in 14.3% of steps. In the hemiparetic patients, intocing pattern was observed in 41.3 % of steps (26.2% of steps on non-affected side and 56.6% on affected side).

Table 2 demonstrates variability of the gait parameters in patients and controls. The difference in variability of stride length and foot angle between affected and non-affected sides of patients was not significant. Stride-to-stride variability in stride length in patients was 1.6 times higher than in controls. Variability of step width and foot progression angle was 1.4 and 1.6 times higher in patients than in controls.

Table 1

Means and standard errors of mean of different parameters of gait in hemiparetic patients

	Stride length		Step width	Foot angle	
	Affected side	Non-affected side		Affected side	Non-affected side
Patients	77.6±4.5	77.2±4.3	5.8±1.5	7.8±1.11	7.7±1.4
Controls	-	122.5±4.3	3.1±0.8	-	7.5±0.8

Table 2

Coefficients of variation (%) of different parameters of gait in hemiparetic patients and controls

	Stride length		Step width	Foot angle	
	Affected side	Non-affected side		Affected side	Non-affected side
Patients	22.7	21.8	53.1	55.9	68.2
Controls	-	13.6	38.7	-	42.6

DISCUSSION

The present study quantitatively describes gait pattern of hemiparetic patients using footprint method. Four parameters of gait were analysed, namely, stride length, step width and magnitude and direction of foot rotation angle. Gait pattern in hemiparetic patients in relation to controls was characterised by decreased stride length, increased step width, increased intoeing and variability of all parameters of gait. At the same time, the differences between affected and non-affected sides in mean values of analysed parameters and their variability was not statistically significant.

The gait pattern observed in this study is not unique for only hemiparetic patients. Decreased stride length and increased variability of gait parameters were observed in Parkinson's disease, cerebellar ataxia and Huntington's disease(1,2). Step width and foot rotation angle are considerably increased in patients with normal pressure hydrocephalus(3). However variability of these parameters was low(3). Probably increased proportion of steps with internal rotation of foot is the most characteristic feature of the hemiparetic gait. Direction of foot rotation was not assessed in most of the studies. Therefore it was not possible to compare hemiparetic gait with other neurological conditions in terms of this gait parameter.

Step width and foot rotation angle are thought to be determined by balance control mechanisms while stride length may be determined predominantly by the gait patterning mechanism(7,11,12). Alteration of the step width, stride length and direction of the foot rotation angle suggested that both balance controlling and gait patterning mechanisms were affected in hemiparetic patients. Bilaterality in changes of most of the gait parameters in hemiparetic patients might be important for maintenance of dynamic stability of the body while increased variability of these gait variables suggests that this mechanism is not perfect. Increased step width has been considered to be a factor favouring maintenance of a balance during locomotion. However, a study by Maki(13) has indicated that wider strides do not necessary increase stability but predict an increased likelihood of experiencing falls.

In conclusion, footprint method provides fast and

inexpensive tool for clinical gait analysis and is suitable for evaluation of hemiparetic patients. Our findings suggest that areas of emphasis for physical therapy of hemiparetic patients should include increasing stride length and decreasing step width and internal rotation of foot, particularly on the affected side.

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