Factors Affecting Self-selected Walking Speed of the Hemiplegic Patients

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ABSTRACT

The purpose of this study was to investigate factors affecting self-selected walking speed of hemiplegic patients. The relationships between the static and the dynamic balance scores and self-selected walking speed of the hemiplegic patients were investigated. Thirty male patients had stroke and were able to walk independently participated in this study. Their mean age was 53.3 ± 6.6 years. The mean time since stroke was 8.5 ± 2.2 months. Their mean total body weight was 66.14 ± 8.75 Kg. All patients were assessed for the stability index (SI), the dynamic limits of stability (DLOS), the weight bearing on the paretic and the non-paretic lower extremities and the speed of self-selected walking speed. Pearson correlations were used to measure the relationship between static and dynamic balance scores and the self-selected walking speed of the hemiplegic patients on a level surface. Other correlations were done between the scores of balance, stability index and the dynamic limits of stability (SI and DLOS) and the weight bearing on the paretic and non-paretic lower extremities. The results of this study showed that there was extremely significant negative correlation between the mean score of the stability index and the self-selected walking speed, at P <0.0001. There was extremely significant positive correlation between the mean score of the dynamic limits of stability and the self-selected walking speed, at P<0.0001. There was a negative significant correlation between the stability index (SI) and the weight on the paretic lower extremity, P <0.03. There was a positive highly significant correlation between the stability index (SI) and the weight bearing on the non-paretic lower extremity, P <0.006. There were no correlation between the dynamic limits of stability (DLOS) and either the weight bearing on the paretic or the non-paretic lower extremities, P <0.25, <0.07 respectively. This revealed that the disturbance of weight bearing on the affected and the non-affected lower extremities affecting the balance, which in turn, affecting the self-selected walking speed of the hemiplegic patients.
Key words: *Hemiplegia, self-selected walking speed, weight bearing and balance.*

INTRODUCTION

Balance has been viewed as a pre-requisite for functional competence because it is vital to the performance of activities of daily living. In addition, good balance is considered necessary to perform activities with great force, or great speed[28]. Balance is vital for all the activities of human performance. Balance refers to the ability to keep the center of gravity (COG) within the base of support (BOS) in various positions. Balance allows for body weight transfer smoothly and safety. It also refers to the ability to adjust against the outside perturbations[19]. Moreover, Walker et al.,[26] defined balance as an ambiguous term used to describe the ability to maintain or move within a weight bearing posture without falling.

Proximal (hip/trunk) muscles are the primary contributors to balance control, while the distal muscles (leg / thigh) are important in compensating for a gait disturbance. Postural activity from bilateral leg and thigh muscles and the co-ordination between the two lower extremities was the key to reactive balance control within one gait cycle Tang[21]. Balance is affected when a part of the control system is not working correctly, for example if the vestibular system is damaged or if CNS is not integrating the information correctly[11]. Following a stroke, disturbance in balance function occur and this will be demonstrated as increased sway during quite standing, uneven weight distribution with increased weight bearing on the unaffected limb, and abnormalities in postural responses. This disturbance will affect on the adaptation to various postures, the reaction to external disturbances and on the use of automatic postural responses that precede voluntary movements[8].

In hemiplegic patients the center of pressure (COP) is displaced away from the hemiplegic side indicating reduced weight supporting activity through the affected leg. The area of stability which is defined as the area circumscribed by the mean points reached the COP of subjects in each of the positions to which the subject was required to shift weight also significantly reduced. The hemiplegics borne a smaller percentage of body weight through the hemiplegic leg (36% of body weight)[7]. Functionally ambulant hemiplegic patients demonstrated marked limitations in the capacity to shift weight and possessed a reduced range of weight shift. The greater the weight borne by the paretic limb, the greater the distance the patient could shift his or her weight and a significant relation between postural stability and walking performance was found[25]. Asymmetry in dynamic posture and movement is the most common locomotor deficit identified with the hemiparesis resulting from a cerebrovascular accident[27]. During the stance portion of the walking cycle, the hemiplegic patient typically demonstrates relatively limited weight transfer to the paretic limb; and single stance duration is relatively shorter for the paretic limb than for the non-parteic limb. These mechanical and temporal asymmetries are further compounded by compensatory changes in the control of the non-paretic limb[17]. Therefore, enhanced inter-limb weight transfer capability would lead to a more symmetrical and effective walking pattern and speed[6].

This study aimed to investigate factors affecting self-selected walking speed of the hemiplegic patients. The correlations between the distribution of weight bearing on the affected, the non-affected lower extremities, and the balance scores were investigated. Moreover, the impact of balance impairment on the self-selected walking speed of the hemiplegic patients also investigated.

MATERIAL, SUBJECTS AND METHODS

Subjects

Thirty male patients diagnosed as having hemiplegia, secondary to a cerebrovascular accident (CVA) based on careful clinical neurological assessment by a neurologist and radiological investigations including computed tomography (CT. Scan) and / or magnetic resonance imaging (MRI) of the brain. All patients were selected from the out patients clinic of the Department of Neuromuscular Disorders and its Surgery, Faculty of Physical

Therapy, Cairo University. The duration of illness was not less than six months. Patients were able to walk independently without assistive device. Patients were able to follow all the instructions. Patients with orthopedic problems, old lower extremities fractures, or balance disturbance due to neurological disorders other than stroke were excluded from this study.

Evaluation

A brief explanation about the protocol of evaluation was given to every patient. All patients were asked to read and sign a consent form before the conduction of the study.

Methods of assessment:

1- Static and dynamic balance assessment:

Static and dynamic balance were measured using the Biodex Stability System (Biodex corporation, Shirley, NY), at the Balance Unit of the Faculty of Physical Therapy, Cairo University. The validity and reliability of the Biodex stability system had been established with inter-class correlation coefficient (ICC) ranging from 0.6 to 0.95[18].

The Biodex Stability System is consists of a movable balance platform providing up to 20° of surface tilt in a 360° range, and is interfaced with a micro-processor based actuator. The actuator controls the manually preset degree of surface instability ranging from completely firm surface (stability level 8), to a very unstable surface (stability level 1). The test duration was set for 20 seconds for three successive trials at level eight (the most stable level).

The static balance test (SI) requires the patient to look straight a head while standing as still as possible with his eyes open, focusing on the display monitor using visual feed back to maintain the cursor within a centrally positioned in the bull's eye through the time of the test (20 seconds for each trial).

The dynamic balance test (DLOS) requires the patient to shift his center of gravity through weight shifting to eight targets positioned in ellipse, the perimeter of which corresponded to 50% of the limits of stability (LOS). The patient was asked to follow a cursor to each target as it was highlighted, and to fix at that target for three seconds before returning to the central target (neutral). Targets were highlighted in random order. Each target was selected only once.

2- Self-selected walking speed assessment:

For the assessment of walking performance, patients were asked to walk at their "most comfortable speed" (i.e, self-selected walking speed) for a distance of 10 meters for three times with rest for 10 minutes between the first and the second trials. Walking speed was calculated using the distance covered by the markers and the corresponding elapsed time (by using the stopwatch), during each gait cycle. The mean of the three trials (in meters per second) was calculated.

3- Weight bearing assessment:

Weight bearing was assessed by the use of two digital scales. The scales were arranged close to each other in a wide place on a flat ground. Before testing, each scale was calibrated by using a certified weight. The assessment was done in the following order: calculate the total body weight of each patient by using one digital scale, and then calculate the weight borne by the paretic and the non-paretic lower extremities of each patient by using the two digital scales. Three trials were done and the mean of the measurements was taken.

Data Analysis

- Data calculated by using the computer package SPSS 8.0.
- Descriptive statistics include the mean and the standard deviation of the stability index, the dynamic limits of stability, the total body weight, the weight borne by the paretic lower extremity, the weight borne by non-paretic lower extremity and the self-selected walking speed.
- Pearson correlations were used to measure the relationship between the static and the dynamic balance scores and the weight borne by the paretic and the non-paretic lower extremities.
- Pearson correlations were used to measure the relationship between the static and the dynamic balance scores and the self-selected walking speed on a level surface.

RESULTS

This study conducted on thirty male stroke patients. Their age ranged from 55 to 65 years with a mean age 53.3 ± 6.6 years. Their mean total body weight was 66.14 ± 8.75 Kg and the mean height was 167.7 cm, while the mean time since stroke was 8.5 ± 2.2 months, table (1).

Table (1): General characteristics of the patients.

Variables	Age (Years)		Height (cm)		Weight (Kg)		Duration (mo)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	53.3	6.6	167.7	5.6	66.14	8.75	8.5	2.2

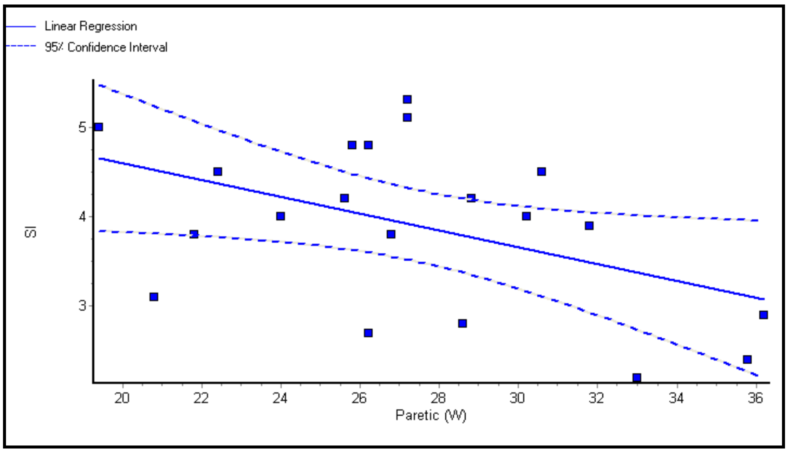
The results of this study showed that there was a significant negative correlation between the mean score of the stability index and the weight bearing on the affected lower extremity, the r value -0.46, at P<0.03, table (2) and figure (1). There was a highly significant positive correlation between the mean score of the stability index and the weight bearing on the non-affected lower extremity, the r value 0.59, at P<0.006, table (3) and figure (2).

Table (2): The correlation between the weight bearing on the affected lower extremity and the static balance (SI).

Variables	Weight on the paretic extremity		Stability Index (SI)		Significance	
	Mean	SD	Mean	SD	r	P
	27.42	4.6	3.9	0.39	-0.46	<0.03*

*Significant at P<0.05

SI



Paretic Weight

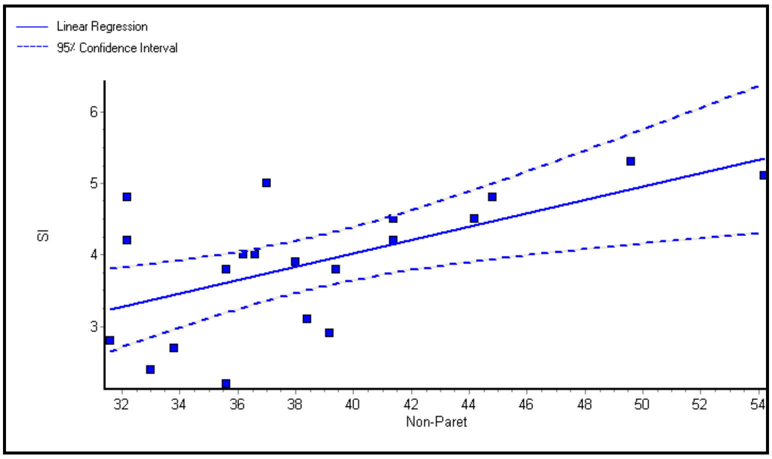
Fig. (1): The correlation between the weight bearing on the affected lower extremity and the static balance (SI).

Table (3): The correlation between the weight bearing on the non-affected lower extremity and the static balance (SI).

Variables	**weight on the non-paretic extremity**		**Stability Index (SI)**		**Significance**	
	Mean	**SD**	**Mean**	**SD**	**r**	**P**
	38.72	5.92	3.9	0.39	0.59	0.006

*Significant at P<0.05

SI



Non-Paretic Weight

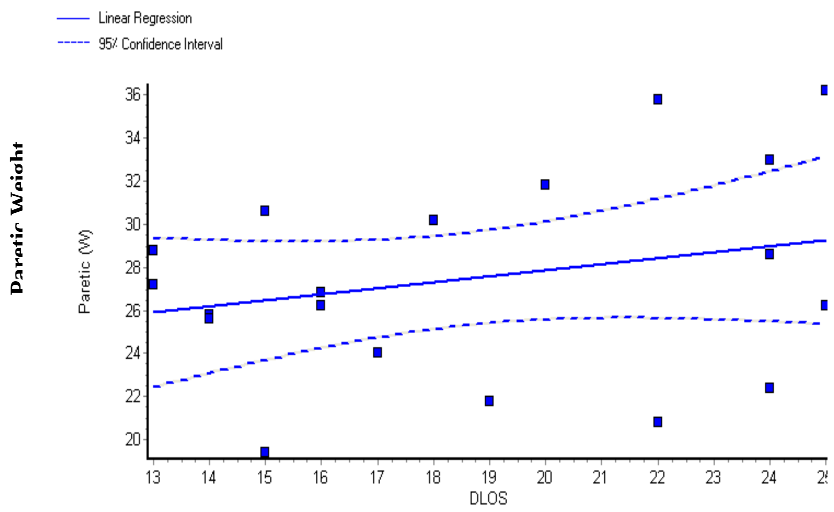
Fig. (2): The correlation between the weight bearing on the non-affected lower extremity and the static balance (SI).

The results revealed that there was no correlation between the mean score of the dynamic balance (DLOS) and the weight bearing on either the affected or non-affected lower extremities with the r value (-0.27 and 0.42), at P value were (<0.25 and <0.07) respectively, tables (4,5), and figures (3,4).

Table (4): The correlation between the weight bearing on the affected lower extremity and the dynamic balance (DLOS).

Variables	Weight on the Paretic extremity		Dynamic limits of stability (DLOS)		Significance	
	Mean	SD	Mean	SD	r	P
	27.42	4.6	18.45	4.40	0.27	<0.25

*Significant at P<0.05



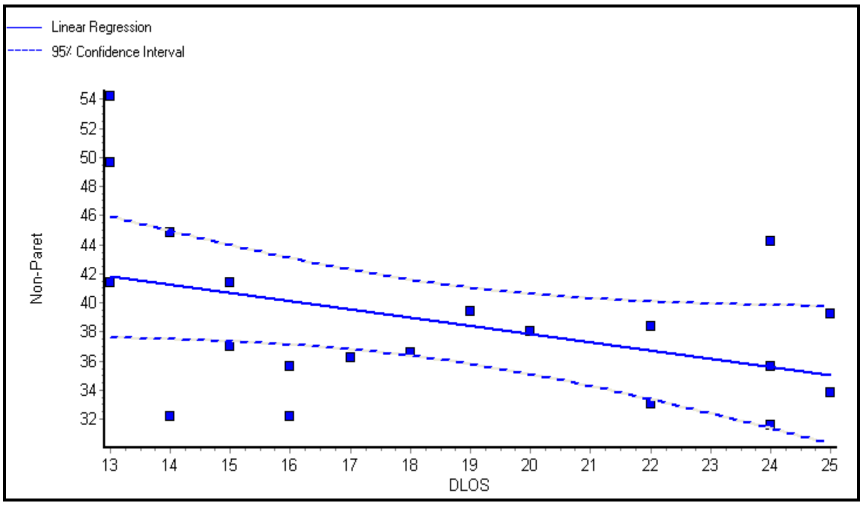
DLOS

Fig. (3): The correlation between the weight bearing on the affected lower extremity and the dynamic balance (DLOS).

Table (5): The correlation between the weight bearing on the non-affected lower extremity and the dynamic balance (DLOS).

Variables	Weight on the non-paretic extremity		Dynamic limits of stability (DLOS)		Significance	
	Mean	SD	Mean	SD	r	P
	38.72	5.92	18.45	4.40	0.42	<0.07

*Significant at P<0.05



DLOS

Fig. (4): The correlation between the weight bearing on the non-affected lower extremity and the dynamic balance (DLOS).

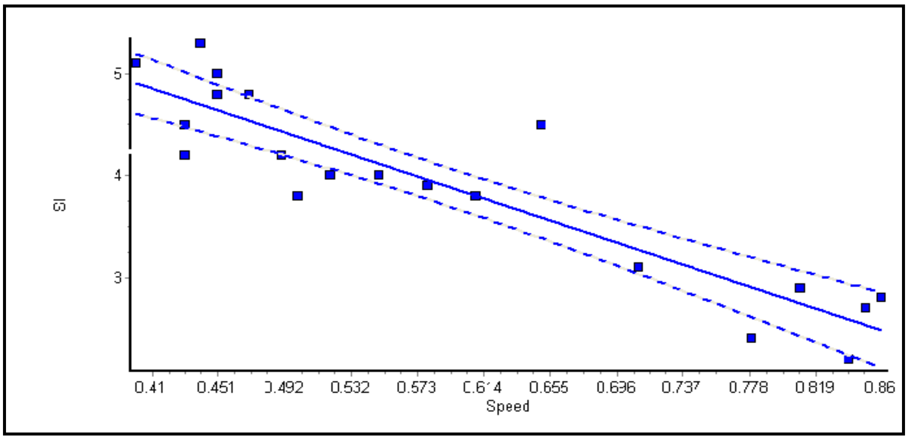
The results of this study also showed that the mean scores of the stability index (SI) was 3.9 ± 0.39, the mean scores of the dynamic limits of stability (DLOS) was 18.45 ± 4.40, and the mean score of self-selected walking speed was 0.59 ± 0.16 m/sec. There was extremely significant negative correlation between the mean score of the stability index and the self-selected walking speed, the r value -0.9090, at P <0.0001, table (6) and figure (5). There was extremely significant positive correlation between the mean score of the dynamic limits of stability and the self-selected walking speed with the r value 0.9497, at P <0.0001, table (7) and figure (6).

Table (6): The correlation between the stability index (SI) and the self-selected walking speed.

Variables	Stability Index (SI)		Self selected walking speed		Significance	
	Mean	SD	Mean	SD	r	P
	3.9	0.39	0.59	0.16	-0.9090	<0.0001

*Significant at P<0.05

SI



SI

Speed

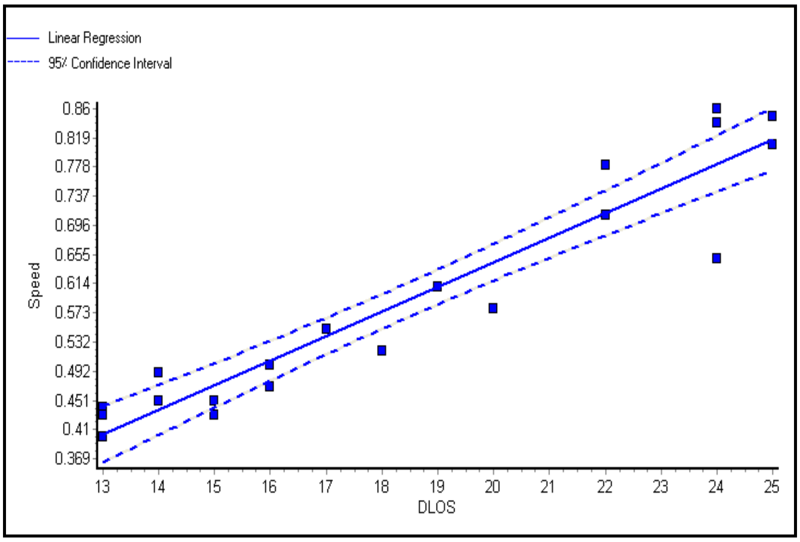
Fig. (5): The correlation between the stability index (SI) and self-selected walking speed.

Table (7): The correlation between the dynamic limit of stability (DLOS) and the self-selected walking speed.

Variables	Dynamic limit of stability (DLOS)		Self selected walking speed		Significance	
	Mean	**SD**	**Mean**	**SD**	**r**	**p**
	18.45	4.40	0.59	0.16	0.9497	<0.0001

*Significant at P<0.05

Speed



DLOS

Fig. (6): The correlation between the dynamic limit of stability (DLOS) and self-selected walking speed.

DISCUSSION

Normal limits of stability describe a theoretical cone extending around a person's feet, with a maximal displacement angle equal to six to eight degrees anteriorly, four degrees posteriorly, and eight degrees laterally to each side[9,12,14]. Pai and Patton[16] suggested that actual stability limits also depend on an interaction between position and velocity of the center of motion (COM). Thus, if one is very close to the edge of the base of support (BOS) and the velocity of the COM is high, it is more difficult to recover stability than if one is at the centre of the BOS with an equally high velocity. Perceived limits of stability defined as the distance a person is willing and able to move without losing balance and taking a step[13].

Balance is diminished in people with hemiplegia and hemiparesis[3]. Postural sway for patients with hemiplegia can be twice that of their age-matched peers[14]. Symmetry of weight bearing is also impaired following stroke, with patients bearing as much as 61% to 80% of their body weight through their non-paretic lower extremity[20]. In addition, hemiplegia can cause a reduction in patients' limits of stability, which is defined as the maximal distance that an individual can shift his or her weight in any direction without loss of balance.

As a measure of standing postural stability, Dettmann et al.,[5] calculated a stability index for subjects with hemiparesis and for age-matched control subjects. They defined the stability index as the percentage of the base of support over which the subjects could move their center of pressure (COP) during weight shifting without loss of balance. The stability index reported for patients with hemiplegia was only 2.3%, compared with 16.6% for age-matched peers without hemiplegia. Moreover, Bohannon[3] indicated that although 65% to 85% of people with stroke learn to walk independently by six months post-stroke, gait abnormalities, particularly reduced speed, may or may not be corrected.

In this study, the hemiplegic patients showed disturbance in the distribution of weight bearing on the affected and the non-affected lower extremities. There was a significant negative correlation between the mean score of the stability index and the weight bearing on the affected lower extremity. There was a highly significant positive correlation between the mean score of the stability index and the weight bearing on the non-affected lower extremity. This mean that the balance improved by increasing weight bearing on the affected lower extremity and decreased weight bearing on the non-affected lower extremity. The findings of this study supported by Badke[2] who indicated that several hemiplegic patients exhibited less weight-supporting activity by the involved lower extremity than do the healthy subjects. The abnormal weight distribution may be a source of reduced sensory feedback to the nervous system responsible for regulating lower level motor patterns, resulting in the inability to automatically adjust the variables of the postural task. Also Nichols et al.,[15] found that balance testing of patients with hemiparesis secondary to stroke has revealed a greater amount of postural sway during static stance, asymmetry with greater weight on the non-paretic leg, and a decreased ability to move within a weight-bearing posture without loss of balance.

The impairments of postural stability in post stroke patients are in the form of, an uneven weight distribution in stance with less weight placed on the affected leg and an increased sway during quite standing. There is also unsuccessful weight transfer in the frontal plane during transitions from bipedal to single-limb stance in hemiplegic patients[25].

In the present study, the patients with hemiplegia also showed impairment of the static and dynamic balance. There was extremely significant negative correlation between the mean score of the stability index and the self-selected walking speed. There was extremely significant positive correlation between the mean score of the dynamic limits of stability and the self-selected walking speed of the hemiplegic patients. These results supported by Holden[10], Burdett et al.,[4] and Trueblood, et al.,[22], who found that hemiplegia results in patterns that differ from normal gait in various ways, speed, time, and distance characteristics generally differ drastically between healthy and hemiplegic adults. There was much slower speed (15% of normal speed), much shorter stride length (37% of normal length), much longer stride time (250% of normal time). In another study, the ranges of walking speeds was examined in hemiplegic patients and the results showed that a decrease in walking speed resulting from a reduced stride length caused by poor standing balance[23]. This deficient of balance through the hemiplegic leg thought to contribute to the abnormal gait pattern of people who have stroke[24].

The static sitting balance in acute stroke was positively correlated with gait outcome. In particular, the initial lack of static sitting balance may be correlated with lack of independent gait at six weeks after a stroke[1]. Additional research indicates that balance performance on biofeedback/ force plate systems correlates well with measures of balance[18] and gait[5].

Conclusion

It is concluded from this study that the impairment of the static and the dynamic balance affecting the self-selected walking speed of the hemiplegic patients. Therapeutic exercise program delivered by physical therapists should stress balance re-education, including shifting weight through the affected leg in standing, as a means to improve gait pattern. In addition, improving balance of the stroke patients may include correction of gait disturbances and safe ambulation, improving mobility, stamina, and improving the activities of daily living. Specific training to improve static and dynamic balance of hemiplegic patients is essential to reduce the risk of falling, reduction in bone fractures. Further research is needed to identify specific interventions that enhance recovery of function and improving quality of self-selected walking speed after stroke.

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الملخص العربي

العوامل المؤثرة في سرعة المشي لمرضى الشلل النصفي الطولي

استهدف البحث دراسة العوامل المؤثرة في سرعة المشي في حالات الشلل النصفي الطولي . تم دراسة العلاقة بين الاختلال في مقاييس التوازن وتوزيع وزن الجسم على كل من الطرفين السفليين في حالات الشلل النصفي الطولي ومن ثم تأثير هذا الاختلال في التوازن على سرعة المشي في مثل هذه الحالات. اشتملت الدراسة على ثلاثين رجلا مريضا من المرضى المترددين على العيادة الخارجية بقسم العلاج الطبيعي للأمراض العصبية وجراحتها بكلية العلاج الطبيعي جامعة القاهرة ويعانون جميعا من الشلل النصفي الطولي الناتج عن السكتة الدماغية من مدة لا تقل عن ستة شهور. تم تقييم جميع المرضي بجهاز بيودكس للتوازن وتم قياس التوازن الساكن والحركي لجميع المرضى بالإضافة إلى قياس توزيع وزن الجسم على كل من الطرفين السفلين وقياس سرعة المشي في جميع المرضى وقد أسفرت النتائج عن وجود علاقة مباشرة بين الاختلال في مقاييس التوازن الساكن والحركي وتوزيع وزن الجسم على الطرفيين السفليين مما نتج عنة تأثير واضح على سرعة المشي في مثل هذه الحالات.ومن هنا تتضح أهمية الدراسة حيث أنها تلقى الضوء على ضرورة الاهتمام.بتقييم وعلاج الجوانب المختلفة للتوازن في كل مريض حيث أن الاختلال في التوازن يؤثر تأثيرا مباشرا على الوظائف الحركية الهامة للجسم ومنها التحكم في سرعة المشي.

الكلمات الدالة : الشلل النصفي – سرعة المشية المعتادة – التحميل على الطرفين السفلين - التوازن .