Impact of Arm Sling on Gait Pattern in Patients with Stroke: A randomized Cross-over Study

Eman S Fayez, PT.D, and Abeer A.B El-Wishy, PT.D
Department for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Egypt

ABSTRACT

Purpose: *this study was designed to evaluate the effect arm sling on temporal parameters of gait in stroke patients.* ***Methods:*** *in a randomized, cross-over study design twenty three stroke patients diagnosed as cerebrovascular accident participated in the study. The patients were able to walk independently and were in stage three or less according to Brunnstrom stages of recovery for the upper extremity. Three-dimensional gait data were collected with the QUALISYS ProReflex motion analysis system. Temporal parameters as: walking velocity, cycle time, cadence, double-support time and percentage of stance phase as well as excursion of the center of gravity in the sagittal, coronal, and transverse planes and finally the excursion of the hip, knee, and ankle in the sagittal plane were measured. Patients walked on a walkway bare footed twice on the same day, randomly with and without arm sling, at a self-selected speed.* ***Results:*** *when walking with sling, patients showed an increase in the velocity; the percentage of stance phase of the affected side and a decrease in the double support time which were statistically significant. In addition, excursion of the center of gravity decreased in all planes.* ***Conclusions:*** *during gait training sessions it is recommended that patients with stroke wore arm sling to improve gait pattern.*

INTRODUCTION

Subluxation of the shoulder has been associated with numerous negative outcomes including electromyographic findings consistent with denervation in the affected upper limb[1]. Chino reported delayed latency times, with the most notable slowing being in the suprascapular and axillary nerves[2]. This early traction neuropathy can result in a transient nerve injury that delays rehabilitative and functional progress by months[1] or can become a long-term injury that is resistant to treatment[3]. The subluxated position of the humerus may also contribute to the pathogenesis of other conditions by stretching neurovascular and musculoskeletal tissues around the shoulder joint[4]. These conditions include limited range of motion, pain, brachial plexus injury, reflex sympathetic dystrophy, adhesive changes, and subacromial impingement among others[5,6]. In addition, subluxation is related to poorer motor return in the upper limb[6]. All of these conditions can significantly affect a patient's physical, functional, and psychosocial rehabilitation[7].

However, the positioning of the arm produced by a sling not only interferes with functional activities but also enhances the flexor synergy of the upper extremity[8]. In patients with hemiplegia, gait problems such as poor gait performance, reduced walking endurance and decreased functional mobility are some of the more serious disabilities[9]. In addition, Bohannon et al.,[10] reported that most stroke patients rank the restoration of walking in the community as one of the most important goals of rehabilitation.

This study was designed to investigate the effect of an arm sling on gait patterns of patients with stroke.

METHODS

Participants

Twenty three patients with stroke were recruited to this study. Inclusion criteria for the patients were (1) first episode of cerebrovascular accident verified clinically and radiologically by computed tomography or magnetic resonance imaging, (2) ability to understand and follow commands, (3) ambulatory before stroke, (4) no medical contraindication to walking, (5) Brunnstrom stages of recovery[11] for the upper extremity≤ 3 and (6) ability to walk independently. All subjects provided written informed consent before data collection.

All patients wore a vest-type shoulder forearm support during the gait trials. The vest-type shoulder forearm support was designed and turned out to prevent glenohumeral subluxation and stabilize the shoulder joint more effectively than a Bobath sling or single strap[12].

All the patients walked on a walkway bare footed twice on the same day, randomly with and without arm sling, at a self-selected speed. Individuals assigned odd numbers walked without the arm sling first and vice versa for those given even numbers.

The walking patterns of the subjects were captured and analyzed by QUALISYS ProReflex motion analysis system. This system included: six camera system, wand-kit used for calibration of the system and PC computer with the Q-Trac software installed. Patients were instructed to walk at a self selected speed over a 10-meter walkway. Fifteen lightweight retro-reflective markers were attached to the skin over the following bony landmarks: sacrum, bilateral anterior superior iliac spine, middle thigh, lateral knee (directly lateral to axis of rotation), middle shank (the middle point between the knee marker and the lateral malleolus), lateral malleolus, heel, and forefoot between the second and third metatarsal head[13]. The mean of three trials was used in analysis. Temporal parameters as walking velocity, cycle time, cadence, double-support time, and percentage of stance phase; joint rotation angles of pelvis in sagittal, coronal, and transverse planes and excursion of hip, knee, and ankle in sagittal plane. Data were processed by using Q-Trace software.

Data Analysis

Data analysis was performed by using SPSS for Windows version 8.0. Data are presented as mean ±standard deviation (SD). Comparisons of the variables was done using the paired t test for temporal parameters: walking velocity, percentage of stance phase, cycle time, cadence and double-support time; joint rotation angles of pelvis in sagittal, coronal and transverse planes and excursion of hip, knee, and ankle in sagittal plane with and without an arm sling. Statistical significance was accepted at a P level < 0.05.

RESULTS

As presented in table 1 the mean age was 55.1±9.3 years. Mean height and weight were 162.9± 8 cm and 87±6.9 kgm respectively. Fifteen patients were males and eight patients were females. For the side stroke eleven were right sided and twelve were left sided stroke. Time since stroke was 58.2±13.8 days. Eight patients were in stage I, twelve patients were in stage II and three patients were in stage III according to Brunnstrom stages of recovery for the upper extremity.

Table (1): General characteristics of patients.

Parameters	
Age (mean ± SD)	55.1±9.3 years
Gender Male Female	 15 8
Height	162.9±8 cm
Weight	87±6.9 kgm
Side of stroke Right sided Left sided	 11 12
Time since stroke (mean ± SD)	58.2±13.8 days
Numbers of patients according to Brunnstrom stages of recovery for the upper extremity	Eight patients in stage I Twelve patients in stage II three patients in stage III

Table (2): Temporal parameters of gait with and without the arm sling.

Temporal parameters of gait	Without arm sling	With arm sling	P value
Walking velocity (meter/second)	.34±.13	.45±.14	.036*
percentage of stance phase (affected side)	51.4 ±3.6	57.9±4.1	.021*
Cycle time(seconds)	.24±4.1	.27±2.8	.645
Cadence (number of steps per minute)	71.3±5.7	79.3±3.9	.001*
Double support time (seconds)	1.08±.09	.67±.03	.043*

*Significant at P≤0.05

Inspection of table 2 and figure 1,2 and 3 revealed that there was significant increase of walking velocity, percentage of stance phase and cadence whereas there was significant decrease in double support time as P was ≤ 0.05. Alternatively, there was no significant difference for cycle time (P=0.645) with the use of arm sling.

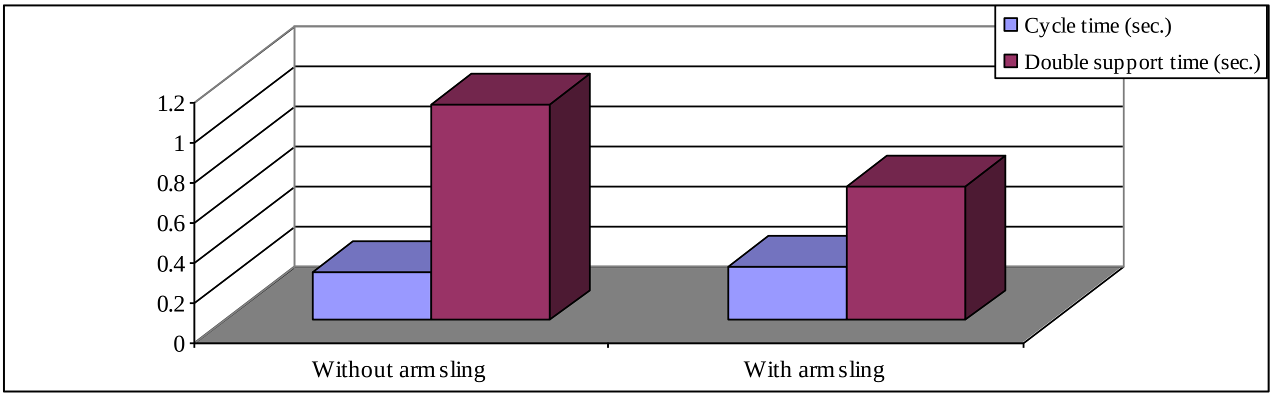

Fig. (1): Mean values of cycle time and double support time (seconds) with and without arm sling.

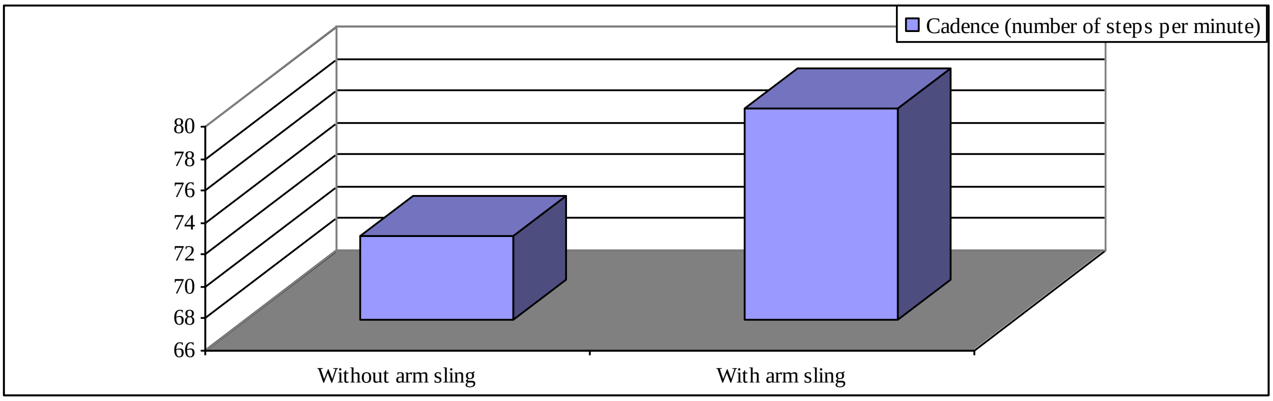

Fig. (2): Mean values of cadence (number of steps per minute) with and without arm sling.

Fig. (3): Mean values of percentage of stance phase with and without arm sling.

Mean values of pelvic excursion without arm sling were 11.7±4.5, 9.6±3.5 and 12.2±7.4 for sagittal, coronal and transverse plane respectively then decreased to 9.8±4.1, 8.7±2.9 and 10.43±6.4 with the use of arm sling. This decrease was significant as p was≤0.05. There was no significant difference for hip, knee and ankle excursion values with the use of arm sling. (Table 3 and figure 4)

Table (3): Pelvic excursion in sagittal, coronal and transverse plane and hip, knee and ankle excursion in sagittal plane.

Gait parameters	Without arm sling	With arm sling	P value
Pelvic excursion in sagittal plane(degrees)	11.7±4.5	9.8±4.1	.017*
Pelvic excursion in coronal plane (degrees)	9.6±3.5	8.7±2.9	.001*
Pelvic excursion in transverse plane(degrees)	12.2±7.4	10.43±6.4	.011*
Hip excursion (degrees)	22.6±9.3	22.9±9.0	.975
Knee excursion (degrees)	25.6±13.5	25.5±12.0	.950
Ankle excursion (degrees)	12.5±9.5	12.7±5.5	.929

*Significant at P≤0.05

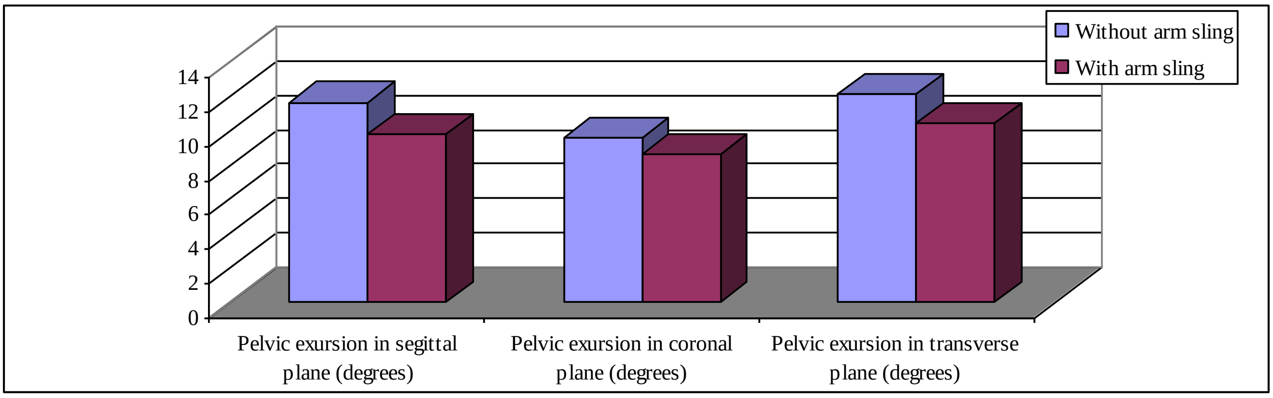

Fig. (4): Mean values of pelvic excursion (degrees) in sagittal, coronal and transverse plane with and without arm sling.

DISCUSSION

When walking with a sling, the stroke patients showed an increase in the velocity and the percentage of stance phase of the paretic side and a decrease in the double support time, which were statistically significant. With the application of the arm sling, excursion of the (center of gravity) COG was decreased in all planes.

Arm slings are still the most preferred treatment for shoulder subluxation in stroke patients[14]. The gait of hemiplegic patients with stroke is characterized by asymmetry in stride times and stride length, slow velocity, poor joint and posture control, muscle weakness, abnormal muscle tone and abnormal muscle activation patterns, mostly affecting the paretic side[15,16]. Restoration of normal movements of the trunk, pelvis, and lower extremity while walking; increasing the walking speed; and improved weight bearing on the paretic side are the most important goals of gait training in stroke patients[16,17]. In this study, with the application of an arm sling, walking speed and the percentage of stance period increased, double support time of the paretic side and the excursion of COG decreased.

Gait speed has a crucial effect on independence in patients with hemiplegia and may vary depending on the authors, but has mostly been reported to be 25–40 m/min.[18,19] Robinett and Vondron reported that gait speed enabling independent activities of daily living (ADL) in healthy people averaged 44.5 m/min. [20] In this study walking velocity increased from .34 to .45m/sec. after using arm sling.

In patients with stroke, gait rehabilitation, including increase of gait speed, is essential for the performance of independent ADL. Therefore, the result of the present study suggests that an arm sling may be a useful modalitiy in gait rehabilitation.

Clarification for the positive effects of the use of an arm sling on gait could be attributed to the following; because hemiplegic patients with an impaired body image are unaware of the location of their body weight line and they do not have any sense of instability, they fail to make any postural adjustments so the arm sling may serve as a feedback tool and remind the patient's arm to help postural adjustments. Likewise it may help hemiparetic patients with attention deficit or neglect pay more attention and position the paretic arm correctly[8].

Minimizing the displacement of the body's COG from the line of progression is a significant way to reduce the muscular effort of walking and, consequently, to save energy. Through a mixture of six motion patterns, called determinants of gait, the magnitude of vertical and horizontal displacements is reduced. In addition, abrupt changes in direction are avoided, which is another energy-saving maneuver. Pelvic motion in the three planes smoothes the path of the body's vertical travel and saves energy[21]. It has been shown that patients with hemiplegia display excessive excursion of the COG, which indicates the inefficiency of their gait[22]. The total excursion of the COG in sagittal, coronal, and transverse planes was investigated in current study and found a statistically significant decrease in the excursion of the COG when arm sling was used, indicating a more efficient gait.

Some investigators evaluated the effect of restricted arm swing in healthy subjects. Marks stated that restricted arm swing worsen kinematics for efficient locomotion in healthy adults[23]. Ford et al., found that constraining one arm increases the arm swing on the opposite side in order to maintain the coordination between upper and lower body movement[24]. Moreover the authors stated that reduced arm swing might affect walking in healthy adults. In the current study excursion of the centre of gravity decreased with the use of an arm sling. In contrast to the aforementioned studies, gait improved with use of an arm sling in the current study. The discrepancy may be a consequence of the study groups' characteristics. In healthy subjects, upper extremity muscle activity is not affected in contrast to patients with hemiplegia who have both upper and lower extremity impairments. Patients with hemiplegia may have different interactions and adaptations, unlike healthy subjects.

Although arm sling interferes with functional activities and enhances the flexor synergy of the upper extremity it seems to affect positively the stability and efficiency of walking.

Conclusion

Among other interventions, an arm sling can be applied to improve gait pattern, especially during gait training sessions.

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الملخص العربي

تأثير حمالة الذراع على كفاءه المشي في المرضى المصابين بالجلطه الدماغيه : دراسه عشوائيه

اجريت هذه الدراسه على ثلاثه وعشرون مريض بالسكته الدماغي ة . جميع المرضى كانت لديهم القدره على المشي بدون مساعده وفي المرحله الثالثه او اقل طبقا لمراحل برنستورم لشفاء الطرف العلوي . تم عمل التحليل ثلاثي الابعاد للمشي . قام المرضى بالمشي على الممر بدون حذاء مرتين خلال نفس اليوم بالسرعه المناسبة لهم وعشوائيا مره بدون حماله الذراع ومره اخرى بها . اظهرت النتائج زياده كبيره في المشي وعدد الخطوات في الدقيقة . توصي هذه الدراسة باستخدام حمالة الذراع خصوصا اثناء الجلسة الخاصة بتأهيل المشي .