

## POSTURAL CONTROL IN HEMIPARETIC PATIENTS AFTER STROKE

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Postural control has been defined as the act of maintaining, achieving or restoring a state of balance during any posture or activity (1). As well as problems with moving and controlling limbs, many hemiparetic patients also experience difficulty in maintaining balance, because a defect in the "body image" causes them to ignore the affected side. They suffer from severe postural instability and postural asymmetry during quiet standing in the frontal and sagittal planes (2). They present an asymmetrical pattern of lateral movements and greater excursions of the pelvis (excessive excursion of the center of gravity) than healthy subjects walking at similar speeds (3). The accelerations are asymmetrical, with the highest values occurring when weight bearing is on the paretic side. This suggests difficulties in controlling the lateral motion of the trunk segment, which might be very important for maintaining balance in locomotor activities. Impaired balance is often related to uneven weight bearing, increased energy expenditure and may be associated with laterally directed falls and a high risk of fractures in these subjects (4,5).

Postural control is most commonly evaluated by force platform systems in terms of postural sway (increased displacement of center-of-mass (COM) within the base of support), symmetry (amount of weight on each side) and limits-of-stability measures (6). It has been shown that postural sway in the frontal plane is specific for the postural control (7)

and responsive to balance training after stroke (8). Force platform systems (posturography) are designed to provide visual or auditory feedback to patients regarding the locus of their COM or center-of-pressure (COP), as well as training protocols to enhance postural control. Posturographic data are also used as an outcome parameter to assess the effectiveness of the treatment. However, in controlled trials, if the control group has not received balance training by posturography, the experimental group has the advantage of experience with the system and may get higher scores in the post-treatment assessment. In order to avoid this 'learning effect', it is not advisable to use the same system for both treatment and assessment.

Quantitative gait analysis systems are an alternative to posturography to assess postural control via the COM path (pelvic excursions in sagittal, coronal and transverse planes) and symmetry in weight bearing. Control of pelvic motion is critical to the maintenance of total body balance since the weight of the head, arms and trunk acts downward through the pelvis. Kinematic and kinetic studies of upper-body motion in the frontal plane have shown that the trunk is precisely controlled and highly dependent upon the motion of the pelvis (9).

In stroke rehabilitation, recovery of postural control is a prerequisite for regaining independence in

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activities of daily living. Pre-ambulation programs are used to improve strength, coordination, and range of motion, facilitate proprioceptive feedback, develop postural stability, develop controlled mobility in movement transitions and develop dynamic balance control and skills. Parallel bar activities consist of moving from sitting to standing, standing balance and weight-shifting activities, hip-hiking, standing push-ups, stepping forward and backward, forward progression, and use of assistive device with appropriate gait pattern (1). Another way to address postural control deficits is to provide the individual with feedback from a force platform while balance activities are performed (10). In a previous study, we evaluated the effects of a task-oriented force platform biofeedback balance training on the walking velocity, postural control, weight shifting, symmetry, selective motor control and functional ambulation of hemiparetic patients with sub-acute stroke (11). Forty-one patients (mean (SD) age of 60.9 (11.7) years) with hemiparesis after stroke (median time since stroke 6 months) were randomly assigned to an experimental or a control group. The control group (n=19) participated in a conventional stroke inpatient rehabilitation program, whereas the experimental group (n=22) received 15 sessions of balance training (using force platform biofeedback) in addition to the conventional program. Outcome was based on the walking velocity, symmetry (step length and single support time asymmetry ratios), postural control (pelvic excursions in terms of the difference between peak and valleys of the curve in sagittal, frontal and transverse planes), weight bearing (peak vertical GRFs normalized by bodyweight on the paretic side), sagittal kinematics (excursion of the paretic hip, knee and ankle joints) and kinetics (peak extensor and abductor moments of the hip, peak extensor moment of the knee, and peak plantar flexor moment of the ankle during stance) of the paretic leg. The control group did not show any significant difference regarding gait characteristics. Pelvic excursion in frontal plane improved significantly ( $p=0.021$ ) in the experimental group. The difference between before-after change scores of the groups was significant for pelvic excursion in frontal plane ( $p=0.039$ ) and vertical ground reaction force ( $p=0.030$ ) in favor of the experimental group. It was concluded that balance training, using force platform biofeedback, in addition to a conventional inpatient stroke rehabilitation program is beneficial in improving postural control

and weight bearing on the paretic side while walking late after stroke. Vearrier et al. investigated the efficacy of standard physical therapy (based on the task-oriented approach) delivered in an intensive massed practice paradigm (6h/day for 2 consecutive days) on ten chronic stroke subjects (12). Therapy was mainly focused on the hemiparetic leg using tactile, verbal and auditory feedback regarding the gait symmetry. In agreement with our results they reported improvement in postural control and weight bearing symmetry, as well as a decrease in the number of falls.

Early after stroke some hemiparetic patients experience an altered perception of the body's orientation in space and become unaware of the location of their body weight line. Shepherd and Carr suggested that it may be helpful to draw the patient's attention to this in order to understand the mismatch between their feeling and reality in space (13). In an earlier study, we investigated the immediate arm sling effects on walking velocity, trunk movements, center of gravity excursions and paretic side weight bearing of 31 hemiparetic patients with sub-acute stroke (14). In a single-session, crossover (with and without an arm sling), controlled design, quantitative gait data of the patients were compared with those of age-matched and gender-matched able-bodied control subjects. The able-bodied group did not show any difference in gait parameters while using the sling. However, in patients with hemiplegia wearing a sling, increased walking velocity and weight bearing of the paretic side, decreased excursion of the center of gravity (COG) (improvement in postural control), and improved gait symmetry. It was concluded that an arm sling improved gait, especially during gait training sessions of patients with hemiplegia who have impaired body image and excessive motion of the COG. It is known that hemiplegic patients with an impaired body image fail to make postural adaptations. Arm slings may serve as a feedback mechanism and remind the patient of his/her arm, thus helping postural adaptations

There are conflicting results about the effects of an ankle-foot orthosis (AFO) on postural control. In a study by Gok et al. the biomechanical effects of metallic and plastic ankle foot orthosis on kinematic and kinetic gait characteristics of 12 hemiparetic patients had been investigated (15). Mean age of the group was 54 (range 39-65) years; mean time since stroke was 67 (range 30-270) days. Patients were using

either a single-point or three-point cane. Both a Seattle-type polypropylene AFO and a metallic AFO were specially moulded and fitted for each patient. Quantitative gait data without and with orthosis were compared. Walking velocity and ankle dorsiflexion at swing improved significantly, however, postural control or weight bearing on the paretic side did not change with wearing an AFO. On the other hand, Mojica et al. investigated the effect of an AFO on body sway in eight post-stroke hemiparetic patients and reported that an AFO decreased body sway in standing position (16). They noted that when patients were not wearing an AFO, the centre of foot pressure moved toward the nonparetic limb and the body sway was larger. With an AFO, the centre of foot pressure shifted to the mid-position and body sway decreased. Chen et al reported that postural sway and postural symmetry were not significantly affected with an AFO (17). Wang et al performed a similar study on 42 short-term (<6 months) and 61 long-term stroke patients (18). They reported improvement in body sway and weight bearing distribution with an AFO for only short-term stroke patients. They attributed this result to the increased proprioception via afferent feedback from cutaneous receptors. Pohl and Mehrholz reported that wearing an AFO significantly improved postural sway in short term stroke patients (19). In our study, in agreement with the findings of Chen et al (17), the AFO did not change the center of gravity (COG) excursions while walking. Control of the ankle joint is important to achieve a stable static balance by the so-called 'ankle strategy', in which the body is considered as a rigid mass pivoting about the ankle joints (20). Sensibility, neuromuscular control and strength of muscles around the ankle are needed to perform this strategy (21). None of our patients had proprioceptive deficit in the AFO study, so we concluded that an AFO did not bring any additional benefit to COG excursions. Moreover, by limiting ankle joint movement, the AFO might have physically prevented a normal ankle strategy while walking. The main reasons for the contradictory findings regarding AFO are the differences in the study population and the type of AFO investigated. Mobility and spasticity level of the patient, stiffness of the material used, the position of the ankle joint in the orthosis (plantarflexion versus dorsiflexion), the hinges and the stops all change the results.

## KAYNAKLAR

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