CORRELATION BETWEEN LEG MUSCLE ACTIVITY AND BALANCE IN STROKE PATIENTS

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Abstract

Background: loss of balance is a main challenging problem post stroke. Ankle strategy is the first line of defense against fall. It depends mainly on the activation of tibialis anterior and medial gastrocnemius muscles.
Aim: To identify the correlation between activity of leg muscles and balance in stroke patients.
Methods: Thirty male chronic stroke patients with balance instability, their ages ranged from 45 to 55 years. Stroke duration more than six months, Mini-Mental State Examination score > or = 24, Berg balance score ranges from 21 to 40 and spasticity grade < or = 2 according to modified Ashworth scale. Biodex balance system (BBS) and Electromyography (EMG) were used to assess postural stability indices (overall (OSI), anterio-posterior (API) and medio-lateral (MLI) stability indices) and muscle activity (tibialis anterior and medial gastrocnemius) respectively.
Results: There was a significant statistically negative correlation between muscle activities of both tibialis anterior and medial gastrocnemius with postural stability indices ($P < 0.05$).
Conclusion: Leg muscles strengthening is essential for improvement of balance abilities in stroke patients, as activity of leg muscles negatively correlated to postural stability indices in stroke patients.
Trial registration: This study was performed in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the Cairo University Faculty of Physical Therapy Research Ethics Committee with registration number (**F.P.T2207007**).

Keywords: Stroke, Balance, Biodex balance system, Muscle activity.

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1. INTRODUCTION

Stroke is still one of the leading causes of death and disability in the world. It impairs the sensory-motor system, which results in restrictions on everyday activities, a higher risk of falling, and a decline in functional independence [1, 2]. Stroke patients experience muscle weakness as a result of a reduction in the rate of motor unit recruitment and a weakness of selective type II fibers, as well as a reduction in the extension torque of the knee joints on both the non-paralyzed and paralyzed sides when compared to young, healthy controls [3, 4].
The modulation of balance is essential for physical stability, the hip and ankle joints have an essential part in this. Ankle or hip strategies are required to correct posture or maintain balance while standing. When there is no change in firm support, the first postural control approach, the ankle joint strategy, predominantly restores standing balance by contracting muscles controlling the ankle joint. When the medial gastrocnemius and tibialis anterior alternately contract to maintain balance during anteroposterior sway, stroke patients are unable to adopt the ankle method to hold their balance. [5].
For determining a patient's ability to maintain balance on an unstable surface, the Biodex Balance System provides a reliable and reproducible objective evaluation method. It permits accurate testing and quick printing of the results. They can be used to assess and record a patient's ability to

maintain balance in a dynamic environment as objectively as possible [6, 7].

Our research aimed to analyze the correlation between activation of leg muscles with EMG triggered FES and balance ability to provide basic data for stroke rehabilitation.

2. SUBJECTS AND METHODS

The study was carried out on thirty male chronic stroke patients. All patients were clinically diagnosed and referred from a general neurologist. Patient's age was ranged from 45 to 55 years, with mild to moderate ankle spasticity (grade ≤ 2 (according to modified Ashworth scale), recovery stage ≥ 4 (according to Brunnstrom), and duration of illness ranged from six months to one year.

Exclusion criteria included any other central or peripheral nervous system disorders, such as multiple sclerosis or polyneuropathy, musculoskeletal system disorders, such as fractures, apraxia, cardiovascular disease, hearing impairments, cognitive deficits, or disturbed conscious level were excluded from the study.

Outcome Measures

At the baseline evaluation and after completion of treatment all patients were evaluated for the following outcomes:

a-Postural stability indices:

Postural stability indices were assessed using Biodex Balance System (Model 950-300- E610, software version 1.02B). It is used to assess a patient's ability to keep their balance under dynamic stress and is made up of several axes. In contrast to the force plate approach, the BBS makes use of a circular platform that can move in both the anterior/posterior and medical-lateral axis at the same time [8, 9]. The degree of the platform instability is under control by the Biodex system. It is possible to change the surface instability from extremely unstable (level 1) to barely unstable (level 12). The balance test level chosen for all patients was Level 6. The patient stood on the platform and made an effort to keep their centre of mass in the center of the concentric circle that was displayed on the systems screen. [10 - 11].

b-Muscle activity:

Electromyography measures the electrical activity that arises from muscle contraction (EMG). It is the build-up of muscle fiber action potentials beneath the electrodes that are inserted into the skin. [12]. Neuro-EMG-Micro (LLC "Neurosoft") was used to assess muscle activity of both tibialis anterior and medial gastrocnemius muscles. To record muscle activity, hair was removed from the areas where electrodes were attached, and the skin above the muscle was cleaned with alcohol before the electrodes were put in place. With the EMG bandwidth set to 20-400 Hz and the EMG frequency set to 1000 Hz, electromyography (EMG) activity was captured [13].

Two active electrodes with a two-cm interelectrode spacing were placed on the upper third of the distance between the medial malleolus and the tip of the fibula in order to measure the activity of the tibialis anterior muscle. The fibula's tip served as the location for the reference electrode. To activate the muscle, each patient was asked to dorsiflex their ankles against the therapist's resistance. Two active electrodes were placed to assess the medial gastrocnemius muscle's activity

STATISTICAL ANALYSIS:

The data utilized in this investigation were analyzed using SPSS software, version 21. The mean and standard deviation of each variable were determined using descriptive statistics. The demographics of the two groups were compared using an unpaired t-test. The comparison of all variables was done using a multivariate analysis of variance (2 x 2 mixed design MANOVA). If (P 0.05), statistical findings were significant.

3. RESULTS

There was a statistically significant negative correlation between the tibialis anterior muscle's activity variations and the OSI, APSI, and MLSI postural stability indices (rs = -0.409, -0.522, and -0.559, respectively), and medial gastrocnemius muscle's activity variations and the OSI, APSI, and MLSI postural stability indices (rs = -0.359, -0.446 and -0.396, respectively), (P < 0.05) according to Spearman's correlation analysis (P 0.05). This indicates that higher muscle activity is correlated with lower postural stability indices. **Table (1).**

Table (1): Correlation between changes of muscle activity of tibialis anterior and medial Gastrocnemius and all postural stability indices (OSI, APSI and MLSI)

Variables	Muscle activity of Tibialis anterior		Muscle activity of medial gastrocnemius	
	rs	P	rs	P
Overall stability index	- 0.409	0.002*	- 0.409	0.003*
Antero / posterior index	- 0.522	0.001*	- 0.446	0.0001*
Medio / lateral index	- 0.559	0.004*	- 0.396	0.002*

Notes: rs = Spearman's Correlation coefficient, P-value: *Significant (P-value <0.05)

4. DISCUSSION

The current study aimed to correlate the activity of leg muscles to balance abilities in stroke patients. It revealed significant negative correlation between activity of leg muscles and postural stability indices which indicate that an increase of leg muscles activity will decrease the amount of postural sway that lead to improve balance abilities in stroke patients [14, 15].

Balance maintaining strategy using the four movements that occur at the ankle joint dorsiflexion, plantar flexion, inversion, and eversion is known as an ankle joint strategy. It is essential for maintaining balance abilities and functional tasks. It plays an important role as the first line of defense against perturbations so, ankle joint training and ankle muscles strengthen is essential for treatment of postural instability and improvement of functional abilities [16-17]. Our results came in agree with **Vlutters., rt al (2019)** who stated that maintaining balance is related to the movements of the ankles. It controls how the foot interacts with the ground, so the ankle is essential for balance [18]. It also agreed with **Marquina et al., (2021)** and **Jeon and Choi., (2015)** who reported that the ankle exercise was effective in improving balance in hemiplegic patients [19-20], and **Zheng et al., (2018)** stated that training of leg muscles with strengthening exercises in addition to functional electrical stimulation will help to improve balance abilities in stroke patients [21]. Our results were contradicted with **Guizelini et al., (2018)** who concluded that there was no significant correlation between maximal muscle strength and rate of force development after resisted training, therefore balance abilities might had no changes after resisted training. This contradiction might be due to different study design, sample size and assessment methods [22].

5. CONCLUSION

activity of Leg muscles strengthening is essential for improvement of balance abilities in stroke patients, as activity of leg muscles negatively correlated to postural stability indices in stroke patients.

6. REFERENCES

1. **Islam, J. (2019):** Fear of falling among stroke survivor in the selected community of Bangladesh-a cross sectional study (Doctoral dissertation, Bangladesh Health Professions Institute, Faculty of Medicine, the University of Dhaka, Bangladesh.).
2. **Li, W., Yue, T., & Liu, Y. (2020):** New understanding of the pathogenesis and treatment of stroke-related sarcopenia. Biomedicine & Pharmacotherapy, 131, 110721.
3. **Chow, J. W., & Stokic, D. S. (2014):** Variability, frequency composition, and complexity of submaximal isometric knee extension force from subacute to chronic stroke. Neuroscience, 273, 189-198.
4. **Pethick, J., Winter, S. L., & Burnley, M. (2021):** Physiological complexity: Influence of ageing, disease and neuromuscular fatigue on muscle force and torque fluctuations. Experimental Physiology, 106(10), 2046-2059.
5. **Bae, S., Lee, J., & Lee, B. H. (2020):** Effect of an EMG–FES Interface on Ankle Joint Training Combined with Real-Time Feedback on Balance and Gait in Patients with Stroke Hemiparesis. In Healthcare (Vol. 8, No. 3, p. 292). MDPI
6. **Chen, B., Liu, P., Xiao, F., Liu, Z., & Wang, Y. (2021):** Review of the upright balance assessment based on the force plate. International Journal of Environmental Research and Public Health, 18(5), 2696.
7. **Xue, X. A., Wang, Y., Xu, X., Li, H., Li, Q., Na, Y., & Hua, Y. (2023):** Postural Control Deficits during Static Single-leg Stance in Chronic Ankle Instability: A Systematic Review and Meta-Analysis. Sports Health, 19417381231152490.
8. **Miner, D. G., Harper, B. A., & Glass, S. M. (2020):** Validity of postural sway assessment on the Biodex BioSway™ compared with the NeuroCom Smart Equitest. Journal of Sport Rehabilitation, 30(3), 516-520.
9. **Jaworski, J., Lech, G., Żak, M., Witkowski, K., & Piepiora, P. (2023).** Relationships between selected indices of postural stability and sports performance in elite badminton players: Pilot study. Frontiers in Psychology, 14, 1019.
10. **Mallo-López, A., Fernández-González, P., Sánchez-Herrera-Baeza, P., Cuesta-Gómez, A., Molina-Rueda, F., & Aguilera-Rubio, Á. (2022):** The Use of Portable Devices for the Instrumental Assessment of Balance in Patients with Chronic Stroke: A Systematic Review. International Journal of Environmental Research and Public Health, 19(17), 10948.
11. **Daud, S. A. H., Rahman, M. U., Arsh, A., & Junaid, M. (2021):** Effect of balance training with Biodex Balance System to improve balance in patients with diabetic neuropathy: A quasi experimental study. Pakistan Journal of Medical Sciences, 37(2), 389.
12. **Bi, L., & Guan, C. (2019):** A review on EMG-based motor intention prediction of continuous human upper limb motion for human-robot collaboration. Biomedical Signal Processing and Control, 51, 113-127.
13. **Lee, K. (2020):** Balance Training with Electromyogram-Triggered Functional

Electrical Stimulation in the Rehabilitation of Stroke Patients. Brain Sciences, 10(2), 80.

14. **Christovão, T. C. L., Neto, H. P., Grecco, L. A. C., Ferreira, L. A. B., de Moura, R. C. F., de Souza, M. E., ... & Oliveira, C. S. (2013):** Effect of different insoles on postural balance: a systematic review. Journal of physical therapy science, 25(10), 1353-1356.
15. **Maktouf, W., Boyas, S., Beaune, B., & Durand, S. (2020):** Differences in lower extremity muscular coactivation during postural control between healthy and obese adults. Gait & Posture, 81, 197-204.
16. **Yoon, S. H., Lee, J. W., Lee, D., Hong, J. H., Yu, J. H., Kim, J. S., & Kim, S. G. (2021):** Immediately effects of static stretching of the ankle plantar flexor for 5 minutes on balance control and muscle activity in healthy young adults. The Journal of Korean Physical Therapy, 33(6), 272-277.
17. **Martínez-Jiménez, E. M., Losa-Iglesias, M. E., Díaz-Velázquez, J. I., Becerro-De-Bengoa-Vallejo, R., Palomo-López, P., Calvo-Lobo, C., & Rodríguez-Sanz, D. (2019):** Acute effects of intermittent versus continuous bilateral ankle plantar flexor static stretching on postural sway and plantar pressures: a randomized clinical trial. Journal of Clinical Medicine, 8(1), 52.
18. **Vlutters, M., van Asseldonk, E. H., & van der Kooij, H. (2019):** Ankle muscle responses during perturbed walking with blocked ankle joints. Journal of neurophysiology, 121(5), 1711-1717.
19. **Marquina, M., Lorenzo-Calvo, J., Rivilla-García, J., García-Aliaga, A., & Refoyo Roman, I. (2021):** Effects on strength, power and speed execution using exercise balls, semi-sphere balance balls and suspension training devices: a systematic review. International Journal of Environmental Research and Public Health, 18(3), 1026.
20. **Jeon, S. N., & Choi, J. H. (2015):** The effects of ankle joint strategy exercises with and without visual feedback on the dynamic balance of stroke patients. Journal of physical therapy science, 27(8), 2515-2518.
21. **Zheng, X., Chen, D., Yan, T., Jin, D., Zhuang, Z., Tan, Z., & Wu, W. (2018):** A randomized clinical trial of a functional electrical stimulation mimic to gait promotes motor recovery and brain remodeling in acute stroke. Behavioural Neurology, 2018.