THE EFFECTS OF ANKLE FOOT ORTHOSIS-FOOTWEAR COMBINATION ON DYNAMIC BALANCE IN ASYMPTOMATIC ADULTS

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SUMMARY
In this study, the effects of Solid AFO-footwear combination on postural stability were analysed in 24 healthy adults. Dynamic balance was assessed using the Limit of Stability and sit-to-stand test of the Balance Master System while subjects were walking with AFO-shoe and AFO alone. The results of this study reveal statistically significant differences in balance performance between wearing AFO with and without shoe.

INTRODUCTION
Balance is a complex skill necessary to maintain the centre of mass within the base of support or within the limits of stability (LOS)[1]. Limitations to joint range of motion, muscle strength, and sensory input can all considerably affect these stability limits[2]. AFOs are typically prescribed to ensure medio-lateral stability during stance and adequate toe clearance during swing[3].

Mojica et al.[4] found that wearing an AFO significantly decreased body sway and increased the maximum walking speed of hemiparetic patients. Rao et al.[5] reported that AFOs could contribute significantly to postural control in individuals with peripheral neuropathy by providing auxiliary sensory cues to intact tissues of the lower extremities. Wang et al.[6] documented that the use of AFO has made significant effects on weight bearing during quiet standing, and in movement velocity during the LOS test toward both the affected and the non-affected side, and also, maximal excursion toward the affected side.

AFOs are usually integrated with footwear[7]. Actually, proper tuned AFO realigned the ground reaction force (GRF) to optimize kinetics and kinematics of gait[8]. But AFO-footwear combination is not compatible with indoor barefoot walking, as is accustomed in some Asian cultures. So in those cultures that footwear is not used indoor, the AFO may not be able to provide the same clinical purpose. To the best of our knowledge, nobody had examined the effect of shoe combination with AFO on balance so far. Subsequently, the main objective of the current study was to compare the effect of AFO with and without shoe on dynamic balance in asymptomatic adults. It was hypothesized that there would be differences in balance performance between footwear-AFO and AFO alone on average.

METHODS
The ethics committee of Iran University of medical sciences approved the study design and the ethical aspects. Informed consent was obtained from all subjects prior to their participation. Asymptomatic subjects who did not demonstrate any of the exclusion criteria were selected. The exclusion criteria were included: previous head injury resulting in a loss of consciousness[9], history of lower extremity injury occurring within the past year[10], pregnancy [9], severe malalignment of lower limb such as genu valgum or varum, fracture or dislocation of lower limb within the last 6 months, and Lastly, the history of any orthopedic surgery[11].

Once selection criteria were met, the participant's dominant leg was determined based on the limb that the participants used in at least two of the three following tests: Recovering balance after a posterior push, stepping up on a box, and kicking a ball through a gate[12]. Then a custom-made solid AFO (SAFO) was manufactured for the non-dominant limb of the participants with an ankle joint which was set in neutral. Shoes were the same for all the participants with an approximately 1 cm heel height (i.e. the difference in thickness between the heel and sole)[13]. Limit of Stability (LOS) testing of the Balance Master System (version 8.0.3, Neurocom International, Inc., Clackamas, OR) was used in the study to record the subjects’ dynamic balance[6]. Composite measures used for this study were movement velocity (degrees per second) and maximum excursion (%LOS). This test measures how far and how quick the participant can move center of gravity (COG) in one of four directions—i.e. forward, backward, AFO side and sound side- to targets set at 100% theoretical LOS for each individual. The weight transfer time (second) and COG sway (degree per second) during the sit-to-stand (STS) test of the Balance Master System were recorded, too[14]. The paired sample t-testing was used to compare test performance between wearing and without wearing the shoe while using a SAFO.

RESULTS AND DISCUSSION
Twenty-four subjects who met our selection criteria— 12 males and 12 females—participated in this study. Among them, 7 wore the AFO on right leg, and 17 on left; The mean age of the subjects was 24.7 ± 4.84 yrs (range: 19–34 yrs); the results demonstrate the maximal excursion toward the forward side was longer with wearing SAFO without shoe (76.70±12.23% with shoe and 83.79±14.65% without shoe,
P. 0.02) but the maximal excursion toward the backward was decreased while wearing SAFO alone (73.25± 13.08% with shoe and 65.87±12.76% without shoe, P. 0.014). The LOS test results for increase in movement velocity toward the forward (3.25 ±1.02 deg/sec with shoe and 4.36 ±1.85 deg/sec without shoe, P. 0.004) and decrease toward the backward direction (2.61 ± 1.25 deg/sec with shoe and 2.1 ± 1.06 deg/sec without shoe, P. 0.033) when shoe is not used with SAFO in contrast to SAFO-shoe combination. The findings in mediolateral direction of LOS test were not different between wearing AFO with and without shoe. In addition, the COG sway velocity was increased (3.47±1.81 deg/sec with shoe and 4.5±1.5 deg/sec without shoe, P. 0.002) when wearing SAFO without shoe during STS test. However, the weight transfer times reduced while wearing SAFO alone in comparison with SAFO-footwear (0.67 ± 0.49 sec. with shoe and 0.46 ± 0.39 sec. without shoe, P. 0.006).

The present analyses show that SAFO-footwear combination is more strongly associated with anterioiposterior-LOS than mediolateral-LOS. Actually the anterior lean distance has been controlled by plantar flexors (PF) as well as the dorsiflexors (DF) take control on posterior lean distance within the LOS test[15]. When the AFO is placed in the shoe, the calf section was inclined 5° to 7° anteriorly due to the difference in heel to forefoot sole thickness[16]. So the ankle alignment adjusts to DF which it may help to increase DF in order to control the posterior lean in LOS test. Additionally, it is clear that the anterior tibia inclination reduces the ability to use momentum to move the COG forward during sit to stand; consequently, the weight transfer time was prolonged with wearing SAFO with shoe. On the other hand, the COG sway velocity was decreased while wearing AFO-shoe; it might be as result of the positive effect of shoe feature such as sole material or the heel height of footwear.

CONCLUSIONS
The results of the present study demonstrated that shoe is an important factor in the combination of solid AFO to determine the level of balance performance such as LOS and STS tests. The clinical implication of this finding is that in those cultures that do not use shoe indoor, the SAFO is not able to provide the same biomechanical effects indoor and outdoor.

REFERENCES
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