

Kinematical Changes in Lower Limb Muscle Activity during walking with round-back orthosis

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INTRODUCTION: Aging leads to various postural and gait dysfunctions. One of the most common postural changes in elderly people is a round back (RB) posture characterized by total kyphosis of the spine. RB posture is caused by age-related degenerative changes in osteoarticular structures and muscle weakness. [1-3] RB posture induces the biomechanical constraints in coordinating body movements during gait. Although many studies investigated the physical performance associated with RB posture of elderly people, there is no clear understanding of how RB posture affects muscle activities and lower limb movement during gait. [4-8] We hypothesized that gait performed by younger adults in a simulated RB posture would show the most efficient and optimal adaptive strategies, which could provide insight into the characteristics of elderly people with RB posture. Therefore, we investigate the effect of orthosis-induced RB posture on healthy young adults to clarify the effects of circular-back posture on gait. So, we aimed to present basic findings for establishing optimal rehabilitation interventions for RB posture by analyzing gait movements and muscle activities using a circular-back brace.

METHODS: The subjects were seven healthy young adults with no history of orthopedic problems in the lower extremities. The equipment used was a 3D motion analysis system, a treadmill with a built-in floor reaction force meter, and a surface electromyograph. First, maximum isometric contraction (MVC) was measured in each tested muscle (rectus femoris (RF), vastus medialis (VM), tibialis anterior (TA), semitendinosus (ST), biceps femoris muscle (BF), medial head of gastrocnemius (MG), and lateral head of gastrocnemius (LG)) using the surface electromyograph according to manual muscle testing methods. Next, according to the Plug-in-gait model, which is a gait analysis model, 39 infrared reflective markers were attached to the subject. The subjects wore RB posture orthosis to reproduce a RB posture and optimal walking speed was measured on a treadmill with built-in floor reaction force. The subjects walked for approximately 5 minutes to adapt to walking on the treadmill, and then 20 walking cycles were used as the measurement section. Then, the subjects walked normally at the same speed without orthosis as the optimal speed in the RB posture. In the two conditions, 10 of the 20 walking cycles were used as the analysis interval, and the kinematic and electromyographic data were analyzed. All procedure of the study was approved by the Ethics Committee of Saitama Prefectural University(2023-10 = 23051).

RESULTS SECTION: All subjects had a greater trunk flexion angle when wearing the orthosis than when not wearing the orthosis. In the static standing posture, hip and knee joint flexion and ankle joint dorsiflexion angles were greater in the condition with the orthosis to the without orthosis condition (Figure 1). During gait, the orthosis condition affected several parameters compared to the no-orthosis condition, as shown below. The angular change in each joint per gait cycle was greater for hip flexion, knee flexion, and ankle dorsiflexion angle. Maximum hip joint extension angle was predominantly limited throughout the gait cycle. In the RB posture, knee joint extension was found to be greatly limited at the end of the stance phase. The knee flexion angle peaked earlier in the swing phase. In the RB posture, the dorsiflexion angle of the ankle joint increased at the end of the stance, and then the plantar flexion angle of the ankle joint was limited from the stance cycle to the early swing phase (Figure 2-A). The hip joint moment exhibited a delay in the timing of switching from the flexion moment to the extension moment (Figure 2-B). The position of the foot was shown to be lowered in the phases of the initial swing, but clearance remained secured in the subsequent phases (Figure 3-A). During the stance phase, RF, VF, and BF were activated more, while MG was activated lower (Figure 3-B).

DISCUSSION: In this study, we demonstrated that young adults in the RB posture during gait, exhibited increasing hip flexion and knee flexion angles, ankle dorsiflexion angle, and activation RF, VM, and ST, while decreasing MG activity. During gait in the RB posture, hip extension movement was insufficient. Restricted hip and knee extension in the end stance phase were compensated for by increased ankle dorsiflexion. As a result, the percentage of the total stance phase spent in the flexed position was increased, which might have increased the activity of the extensor muscles. We concluded that the RB posture contributes to decreased lower extremity extension movements during gait, necessitating strategies to enhance the activity of the lower extremity extensor muscle groups. During the stance extension phase, an increase in the knee joint flexion angle lowers the activity of the gastrocnemius muscle, a biarticular muscle. As a result, ankle joint plantar flexion during the anterior swing phase is restricted. At this time, the lower limb, having lost forward propulsion by ankle plantar flexion, moves into the swing phase with accelerated flexion of the hip and knee joints. The lack of kicking by the foot causes a decrease in foot height, which is thought to increase the activity of the TA as a compensatory strategy to ensure clearance.

SIGNIFICANCE/CLINICAL RELEVANCE:

Our findings suggested that the elderly people in RB posture require increased activation of the hip and knee extensors, and ankle dorsiflexion during gait. If these results are harnessed therapeutically, such as rehabilitation, it could prevent elderly people from gait dysfunction or lower limb disorder.

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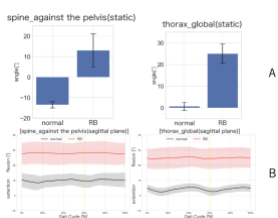


Fig.1

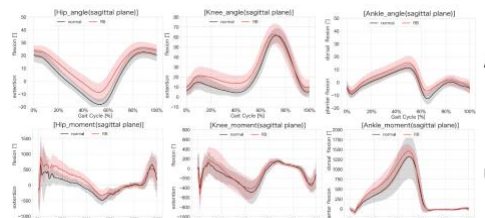


Fig.2

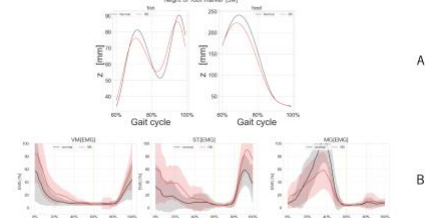


Fig.3

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