Relationship between Intra-foot Motion and the Free Moment during Human Gait

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Summary

The purpose of this study is to clarify the correlations between the free moment and intra-foot motion during human gait. Forty-one normal volunteers were participated in this study. Intra-foot motion during gait was assessed using a three-dimensional motion analysis system, and the free moment impulse were calculated. The abduction free moment impulse had a significant relationship with stance time (adjusted β; 0.37, $p<0.01$) and maximum adduction angle of mid foot (adjusted β; -0.4, $p<0.01$) ($R^2=0.34$). Midfoot abduction indicated that the collapse of the foot arch during gait may be a key variable in altering the abduction moment impulse during gait.

Introduction

The free moment is a torque applied on the vertical axis from the centre of pressure. It has a role in managing the change in body rotation during locomotion. The free moment is generated from ankle-foot kinematics and pelvis-trunk motion [1,2]. However, correlations between free moment and intra-foot motion and alignment have remained unclear. The purpose of this study is to clarify the correlations between the free moment and intra-foot motion during human gait.

Methods

Forty-one normal volunteers (23 males and 18 females, age; 20.5±1.7 years old, height; 165.1±9.4cm, body weight; 60.1±11.5kg) without a history of lower limb injury and pain at the time of testing participated in this study. Gait analysis was performed using a three-dimensional motion analysis system with 9 infrared cameras (Vicon, Oxford, UK) at 100 Hz and 2 force plates (Advanced Mechanical Technology Incorporation, USA) at 1000 Hz. Reflective markers were mounted following the Rizzoli foot model. Joint angles were calculated using Visual 3D (C-Motion, Germantown, MD, USA) for the rearfoot with respect to the shank (rearfoot), midfoot with respect to the rearfoot (midfoot), and forefoot with respect to the midfoot (forefoot). The free moment was calculated based on the previous study and both the abduction and abduction free moment impulses were calculated. The gait analysis was performed in 5 trials and the average of the 5 trials was calculated. The relationship between the two free moment impulses and the maximum, minimum and excursion of the three-dimensional angle in the hindfoot, midfoot and forefoot was assessed using the Pearson correlation coefficient. And multi regression analysis was performed with the free moment impulses as the dependent variable and the various parameters that had more than 0.4 of correlation coefficient. All statistical analysis was performed using SPSS statistics (IBM Corp., Armonk, NY, USA).

Results and Discussion

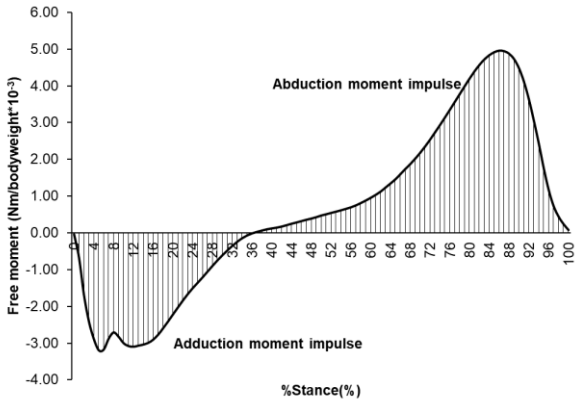

Figure1 Free moment impulse during gait

The adduction free moment increased in the first half of the stance phase of gait and the abduction free moment increased in the second half of the stance phase of gait. The impulse of the adduction free moment had no significant correlation with the foot motion during the stance phase of gait. Abduction free moment impulse showed significant correlation with stance time (r=0.48) and maximum (r=-0.5), minimum (r=-0.46) of midfoot adduction angle during stance phase of gait. Using multi regression analysis, the abduction free moment impulse had a significant relationship with stance time (adjusted β; 0.37, $p<0.01$) and maximum midfoot adduction angle (adjusted β; -0.4, $p<0.01$) ($R^2=0.34$). Chen showed that the robotic gait experiment demonstrated that the oblique axis of the transverse tarsal joint can mechanically generate free moments [3]. The coupling motion of both dorsiflexion and abduction of the transverse tarsal joint are rotated around the oblique axis of the transverse tarsal joint. In this study, the abduction moment impulse during the second half of the stance phase showed negative correlations with maximum midfoot adduction during gait.

Conclusions

Therefore, midfoot abduction indicated that the collapse of the foot arch during gait may be a key variable in altering the abduction moment impulse during gait.

References

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