Anticipatory Postural Adjustments in Gait Initiation from Different Initial Stance Width

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由靜立起步至動態步行(GI)之準備時期，會產生足底壓力中心(COP)往後及往擺盪腳移動，與身體質量中心(COM)往站立腳移動之預期性姿勢調控(APA)機制。本研究目的在於探討此機制會不會受到不同起步步寬改變。本研究以健康正常人爲研究對象，受試者執行五種步寬下之起步。使用三維動作分析及 AMTI 測力板，以逆向動力學求得 1.COP 往後及往擺盪腳之位移，2.在額狀面及矢狀面兩平面上相對於站立腳的 COP，由擺盪腳推蹬力所造成的淨彎矩，3. 在前後方向上的 COM 速度，作爲 APA 參數。比較不同步寬對起步瞬間 APA 參數的影響，來探討人體由靜立起步至動態步行的控制策略。結果顯示 COP 之位移以及推蹬力的淨彎矩，都會隨著步寬增加而變大，然而 COM 速度在最大步寬時顯著變小。在最小步寬時，COP 往後及往擺盪腳沒有位移量，間接推翻擺盪腳藉牽張反射於起步的必要性。在中等步寬下的起步策略同時兼顧省力與效率，此發現有助於起步困難的神經病變患者，作爲復健治療計畫之參考。本研究並確立步寬對 APA 之影響對動作控制學領域之後續研究也有所貢獻。

關鍵字：預期性姿勢調控，起步，起步步寬，足底壓力中心，身體質量中心

INTRODUCTION:

Gait initiation (GI) is a complex motor task that entails the transition from a quiet standing posture to dynamic equilibrium. The preparatory phase of GI involves anticipatory postural adjustment (APA) in which the centre of pressure (COP) shifts backward and toward the swing limb, to move the body centre of mass (COM) forward and over the stance limb. The motor program of GI may change when characteristics of the task changes, such as initial stance condition [1].

The mechanism of generation of forward propulsive force (PF) during GI remains controversial in the literature [2]. According to Do and Michel [3], the generation of the PF results mainly from the oscillation of the swing limb. The motor program of GI may change when characteristics of the task changes, such as initial stance condition. However, whether this finding is influenced by initial stance width remain unclear.

Thus, this study aimed to evaluate the strategies and associated anticipatory postural adjustments (APA) by measuring the centre of pressure (COP) trajectory, anteriorposterior (A/P) progression velocity of the centre of mass (COM), and maximal net moment taken by the stance limb during GI with different initial stance width.

MATERIALS AND METHODS:

Ten healthy young adults participated in our study. Being each foot from two separated force plates, subjects initiate their gait with five initial stance conditions (Feet Aside, 50, 100, 150, and 200% of pelvis width (PW). Kinematic and kinetic data were measured using a Vicon system (U.K.) and two forceplates (AMTI, U.S.A.).

Maximal COP displacement in the mediolateral and anterioposterior directions, A/P velocity of COM at stance toe off, and the maximal net moment about the COP of the stance limb in the frontal plane were calculated and tested with a repeated measures analysis of variance for initial stance width effects (α=0.05) using SPSS 13.0. Those calculated moment were then normalized by BW and LL

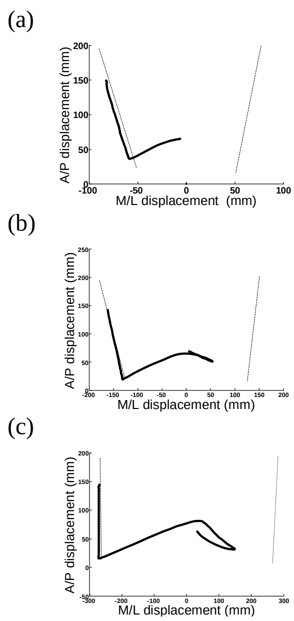

Figure 1 COP displacement in the A/P and M/L directions in three different initial conditions, (a) feet aside, (b) PW, and, (c) 2PW

RESULTS:

It was found that preparation for GI from wider stance width was associated with a significantly larger COP displacement towards to the swing limb (Figure 1). Maximal net frontal plane moments about the stance limb for wider stance width has also tendency of being greater than those for narrow initial stance width (Figure 2). However, A/P COM velocity at the moment of stance toe-off is not influenced by initial stance width (Figure 3).

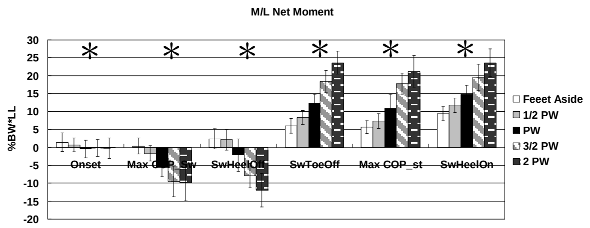

Figure 2 Comparison of maximal net frontal moment during GI from different initial stance widths of PW

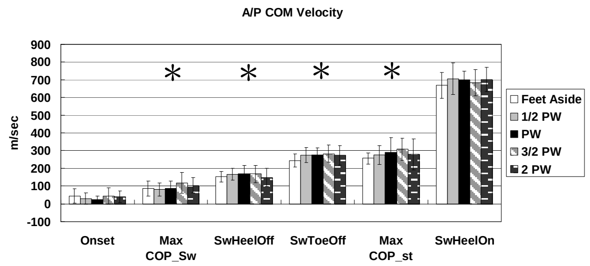

Figure 3 A/P velocities of COM at stance toe-off of GI of different initial stance widths of PW

DISCUSSION:

Backward A/P net moment were absent in feet aside condition and decreased in 2 PW condition as it appeared at the beginning of the cycle in the middle range PW conditions. The change in motor organization will be associated with biomechanical organization in terms of PF. The progressive velocity were increase when gait initiate with wider width, however, when the stance width being two times of PW, the velocity decrease significantly in a mild manner. The progressive velocity can be taken as an index of performance. The instantaneous velocity of COM results on the integration of all the PF acting on the body which is contained in the ground reaction. Its value is an expression of the peripheral effects of external and internal forces. The optimal solution may be related to how the motor program underlying the control of the progressive velocity of the COM is modified during the GI process. Our findings have some clinical relevance, in the difficulty with a predictive mode of control may underlie some of the problems with GI experienced by neurological patient.

REFERENCES

1. Rocchi, L., Chiari, L., Mancini, M., Carlson-Kuhta, P., Gross, A., and Horak, F.B., “Step initiation in Parkinson's disease: influence of initial stance conditions,” Neurosci Lett, 406, pp. 128-32 (2006).
2. do Nascimento, O.F., Nielsen, K.D., and Voigt, M., “Influence of directional orientations during gait initiation and stepping on movement-related cortical potentials,” Behav Brain Res, 161, pp. 141-54 (2005).
3. Michel, V. and Chong, R.K., “The strategies to regulate and to modulate the propulsive forces during gait initiation in lower limb amputees,” Exp Brain Res, 158, pp. 356-65 (2004).