

OPTIMAL STRATEGY OF CANE USE DURING STAIR ASCENT

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INTRODUCTION

Going up and down stairs require strength, range of motion, balance, and coordination, therefore, presents a challenge for the elderly and individuals with disability, and assistive devices may be needed. Therapists and clinicians usually have several approaches for teaching stair locomotion while using an assistive device, i.e. a cane would be for the patient with pain at the lower extremity to start with the stronger leg first followed by the weaker leg and the cane [1]. Some therapist may alter this traditional approach by having the patient progress the cane first, then the stronger leg and weaker leg. However, there is no document in the literature supporting these techniques. The purpose of this study was to compare the effect of placement of a quadricane (four-point cane) during stair ascent on body posture, center of mass (COM), and joint position. The change in the COM and relative orientation of the trunk were examined during five methods: (1) ascending stairs without a cane with right foot stepped up first, then left foot; (2) forward placement of the quadricane at the initiation of stair ascent followed by the ipsilateral foot (ipsilateral to the cane), then contralateral foot (SA1); (3) forward placement of the cane followed by the contralateral, then ipsilateral foot (SA2); (4) lateral placement of the cane with ipsilateral foot stepping up, followed by the contra-lateral foot and the cane (SA3); (5) lateral placement of the cane with contra-lateral foot stepped up, followed by the ipsilateral foot and cane (SA4). All conditions were associated with step-to (non-reciprocal) walking pattern.

METHODS

A five-step wood staircase with a slope of 32.7°, a step height of 18 cm, a tread depth of 28 cm and a width of 90cm was used. Fifteen able-bodied participants in good general health aged from 24 to 30 years old were enrolled. Twenty-five reflective markers were secured to the participant's anatomical landmarks locating on the both sides of the body. An eight-camera Eagle Motion Analysis System (Motion Analysis Corporation, Santa, CA, USA) was used to capture the three-dimensional trajectory data of the markers.

The quadricane was adjusted to ensure that the handgrip was at the height level between the participant's wrist crease and greater trochanter. The participants were asked to ascend stairs with each of the five methods for three times in random orders. One gait cycle was completed as the three weight-bearing points (both legs and cane) were progressed from a tread to another tread one step above. The data were smoothed and normalized to stride period of 100% in one gait cycle. The data was analyzed utilizing repeated measures analysis of variance (ANOVA) at the 0.05 level of significance.

RESULTS AND DISCUSSION

The maximal range of motion of the trunk, hip, knee and ankle from neutral position were list in Table 1. Trunk movements,

including flexion, rotation and side-bending are significantly larger in lateral placement of cane, especially in SA4. It agrees with the clinical adaptation to prevent fall from lack of shoulder and trunk extension and the desire to keep the COM anteriorly. The leading leg always demonstrates more hip and knee flexion, and less ankle plantarflexion, no matter what the placement of cane is. As observing the excursions of the joint movement in a stride, some double peaks of the movement at the hip and knee joints of the leading leg in SA3 and SA4.

Table 1: Mean and standard deviation of maximal flexion in degrees of the trunk, hip, knee and ankle in sagittal plane

	No cane	SA1	SA2	SA3	SA4
Trunk	8.0 (2.4)	8.3 (2.3)	7.7 (2.2)	9.1(2.5)	10.9(3.2)
I.Hip*	57.9(4.3)	58.8(5.1)	27.8(7.0)	52.1(13.8)	36.8(7.4)
C.Hip *	27.7(4.7)	27.5(5.2)	58.7(4.6)	30.6(9.2)	56.8(5.1)
I.Knee	79.2(4.2)	80.2(4.1)	56.5(10.4)	73.8(19.5)	69.9(8.4)
C.Knee	55.6(5.6)	54.8(5.4)	77.1(5.3)	62.2(16.7)	79.5(5.0)
I.Ankle**	25.5(5.7)	23.8(4.5)	37.8(6.6)	21.8(6.0)	32.6(5.8)
C.Ankle**	38.6(6.6)	39.2(5.1)	22.54(3.6)	35.3(9.8)	23.4(3.8)

* I: the ipsilateral side; C: the contralateral side

** Degrees of maximal plantarflexion

The excursions of COM displacement in three directions are shown in Figure 1. Significant differences are found in the excursion and maximal medial-lateral COM displacement among five methods.

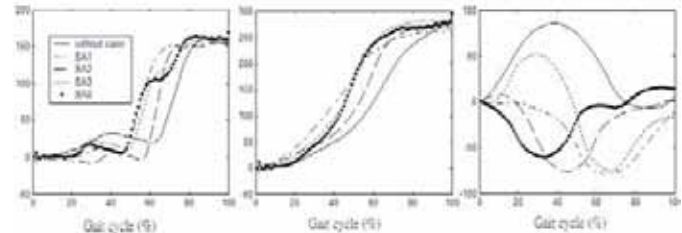


Figure 1: The plot at the left is the COM displacement (in mini-meter) in vertical direction, the plot at the middle is COM displacement in forward-backward direction, and the plot at the right is the COM displacement in medial-lateral direction.

CONCLUSIONS

In order to find an optimal strategy for stair walking while using a cane, not only causes of the disability, i.e. instability or pain at the leg, should be considered, but also the proximal control, such as how to progress with COM within a small base of support and maintain an unavoidable asymmetry posture etc.

REFERENCES

1. Vargo MM, et al. *Am J Phys Med Rehabil* **71**, 170-176, 1992.

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