

PHASING OF TRUNK MOTION IS CRITICAL FOR THE EFFICACY OF GAIT RETRAINING AIMED TO REDUCE KNEE LOADS

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INTRODUCTION

Gait retraining may be a potential non-invasive intervention for patients with knee osteoarthritis (OA). For instance, it has been shown (Mündermann et al. 2006) that the amplitude of trunk sway has a strong negative correlation with the external peak knee adduction moments during walking for healthy subjects. However, it has also been observed that some subjects had very small reductions in the knee adduction moment despite a large increase in trunk sway (Mündermann et al., unpublished data). Mechanically, sway is described not only by the amplitude but also by the frequency and phasing of segment motion. Sway frequency is predetermined by the cadence of walking and will thus not change unless cadence changes. The purpose of this study was to test the hypothesis that both the magnitude and phasing of medio-lateral trunk sway contribute to the reduction in the adduction moment.

METHODS

Eleven physically active adults (4 female, 7 male; age: 29.0 ± 7.0 yrs; height: 178.2 ± 10.1 cm; mass: 73.4 ± 19.7 kg) participated in this study. None of the subjects had previously been treated for any clinical lower back or lower extremity condition or had any activity-restricting medical or musculoskeletal condition. Subjects performed walking trials at a self-selected normal speed in their own low top,

comfortable walking shoes with a) normal and b) increased medio-lateral trunk motion. Subjects were instructed to shift their trunk more in the medio-lateral direction without changing their walking speed. The external knee adduction moment was calculated from the position of the markers, ground reaction force measurements, and limb segment mass/inertia properties and normalized to body weight and height (% Bw·Ht) (Schipplein and Andriacchi 1991). Medio-lateral trunk motion was calculated as the medio-lateral sway amplitude of the upper trunk segment relative to the vertical axis. Medio-lateral trunk sway phasing was calculated as the time of heel-strike relative to time of peak medial and lateral position of the upper trunk segment. The relationship between the change in first peak knee adduction (KAM), change in medio-lateral trunk sway amplitude (SA) and medio-lateral trunk sway phasing (SP) was tested using multiple regression analysis ($\alpha = 0.05$) using the model equation

$$\Delta KAM = b_0 + b_1 * \Delta SA + b_2 * \cos(SP)$$

where negative (positive) phasing means that heel-strike occurs before (after) the trunk crosses the vertical.

RESULTS

Increased medio-lateral trunk sway typically resulted in a substantial reduction in the first peak knee adduction moment during walking. On average, subjects increased

their medio-lateral trunk sway by $7.9 \pm 3.9^\circ$ ($P = 0.002$) with an average phasing of $82.0 \pm 116.0\text{ms}$ resulting in an average reduction of the first peak knee adduction moment of $47.1 \pm 31.8\%$ ($P < 0.001$). Subjects with greater increase in medio-lateral trunk sway experienced greater reductions in the first peak knee adduction moment (Figure 1a). Differences in trunk sway amplitude alone explained 28.4% of variability in peak knee adduction moment. 74.5% of variability in peak knee adduction moment was explained by both differences in trunk sway amplitude and trunk sway phasing (Figure 1b; $P < 0.001$). The optimum phasing occurred at 0.201 radians which corresponds to approximately 33ms after heel-strike. Subjects walked at similar speeds for both conditions (normal trunk sway: $1.46 \pm 0.13\text{m/s}$; increased trunk sway: $1.47 \pm 0.16\text{m/s}$; $P > 0.999$).

DISCUSSION

The results of this study showed that both the magnitude and phasing of the medial-lateral shift contribute to the reduction in the adduction moment. The role of trunk sway phasing appears to be more important than trunk sway amplitude. Thus, a greater increase in trunk sway may not be reflected in a reduced knee adduction moment if the trunk is shifted to the ipsilateral side too early or too late. The results also suggest that there is an optimal phasing (trunk position at heel strike) for maximum reduction of the adduction moment. Subjects with a phasing of around 50ms (upper trunk segment vertical or slightly passed vertical at heel-strike) experienced the greatest reductions in the first peak knee adduction moment. Therefore, care should be taken when introducing increased trunk sway as gait retraining for patients with knee OA as both sway amplitude and correct sway phasing are important.

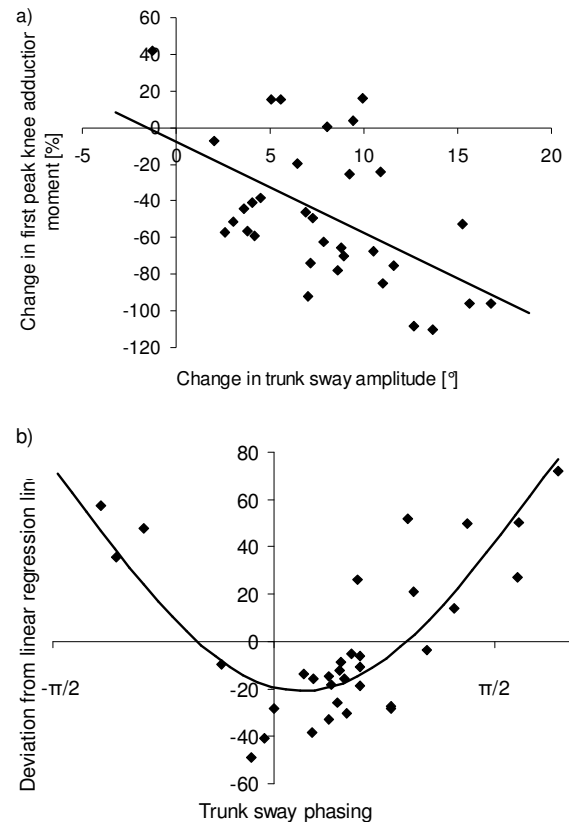


Figure 1: Contribution of a) change in trunk sway amplitude and b) trunk sway phasing to variability in the change in first peak knee adduction moment.

In summary, the results of this study showed that increased medio-lateral trunk sway may be a powerful non-invasive intervention with the goal to reduce medial compartment loads at the knee during walking. However, correct phasing of trunk sway is critical for the efficacy of this method of gait retraining.

REFERENCES

- Mündermann L. et al. (2006) *Trans Orthop Res Soc*, **52**, 170.
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