A 3-D KINEMATIC COMPARISON BETWEEN SINGLE-BELT AND SPLIT-BELT TREADMILL WALKING

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INTRODUCTION

Walking mechanics are often studied using a treadmill as one can collect multiple, consecutive steps in a small volume. Instrumented treadmills designed for walking studies have two belts, each associated with an independent force plate. These belts can either be arranged front to back or side-by-side (split-belt configuration). Altman et al, (2008) reported that base of gait widens by 4 cm when walking on a split-belt treadmill. This may lead to alterations of joint kinematics, particularly in the frontal plane.

Therefore, the purpose of this study was: a) to compare gait kinematics between single-belt and split-belt treadmill walking; and b) to determine whether split-belt kinematics are altered following an accommodation period. We hypothesized that there will be an interaction between belt configuration and time. Specifically, the rearfoot will be less everted (EV), the knee will be less adducted (ADD), and the hip will be less ADD in the split-belt condition. However, we anticipated that the split-belt mechanics would become more similar to the single-belt mechanics over the accommodation period.

METHODS AND PROCEDURES

Sixteen healthy subjects, experienced with treadmill walking, were recruited for the study (28 ± 9.3 yrs). A split-belt instrumented treadmill (AMTI, Watertown, MA) with one wide belt (0.66 m) and one narrow belt (0.33 m) was used in this study. Subjects warmed up on the single-belt for 3 minutes at a self-selected speed. Kinematic data were collected at 200 Hz using an 8-camera motion analysis system (VICON, Oxford, England).
Five stance phases were collected while subjects walked at 1.3 m/s. Baseline mechanics for the single-belt were then collected at 0 minutes (T0). Data were collected again following 10 minutes (T10) of walking. Subjects then rested for 5 minutes. Following the rest, the subjects repeated the walking protocol with one foot landing on each belt (split-belt) for 10 minutes. Data were again collected at T0 and T10.

3D angles at the hip, knee, and rearfoot were calculated using Visual 3D (C-Motion, Rockville, MD) and customized software (LabVIEW, National Instruments, Austin, TX). Peak angles during the first 75% of stance were calculated for each belt condition and at T0 and T10. The frontal plane angles of the hip, knee and rearfoot were compared statistically using a two-way, repeated measures ANOVA (belt x time) ($p < 0.05$). Results for the sagittal and transverse planes were analyzed descriptively.

RESULTS

Surprisingly, no belt x time interactions were noted. However, main effects were found for both belt and time (Figure 1). Rearfoot EV ($p = 0.03$) and knee ADD ($p = 0.05$) were lower by 1.5 and 1.2 degrees respectively, in the split-belt condition. In general, these differences were noted throughout stance (Figure 2). No differences were noted at the hip between belt conditions. Overall, frontal plane angles at the rearfoot and knee did not

change with time. However, hip ADD did increase (1.2 º) over time across conditions (p = 0.03).

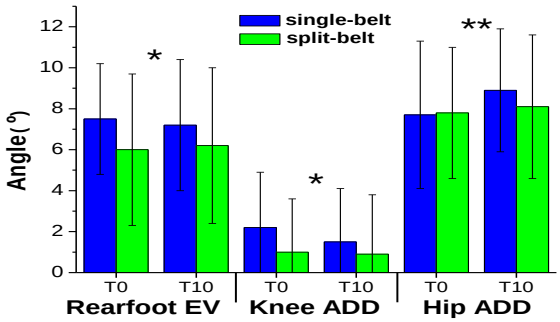

Figure 1. Mean (SD) peak angles in frontal plane in first 75% of stance. * significant belt effects, ** significant time effects.

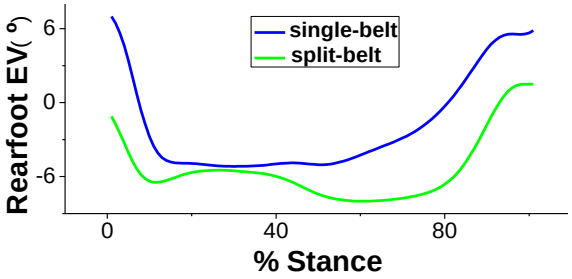

Figure 2. Mean rearfoot EV from one subject over stance. Note the offset between the belt conditions.

For the other planes of motion, the differences in peak angle were small across belts and time (Table 1).

Table 1. Mean (SD) peak angles in sagittal and transverse plane during the first 75% stance.

	T0		T10	
	single	*split*	*single*	*split*
Rearft DF (+)	11.6 (3.9)	11.8 (2.8)	11.7 (2.8)	12.2 (3.3)
Rearft ABD (-)	-10.4 (4.4)	-10.2 (4.4)	-10.0 (4.6)	-11.2 (7.8)
Knee FL (-)	-15.6 (5.8)	-15.2 (5.8)	-16.2 (6.5)	-16.0 (6.3)
Knee IR (+)	8.2 (11.8)	8.6 (12.0)	8.9 (12.8)	10.7 (15.7)
Hip FL (+)	22.0 (6.1)	21.8 (6.1)	21.7 (6.0)	22.1 (6.0)
Hip IR (+)	-2.1 (11.6)	-2.4 (11.2)	-2.6 (11.1)	-2.8 (11.7)

DISCUSSION

As split-belt treadmills become more common, it is important to understand the effects they may have on mechanics, and whether these effects are lessened with accommodation time. The results show that there were no interactions between time and belt configuration. This is mostly due to the lack of change over time in the split-belt configuration. These results are consistent with Zeni et al. (2008) who found no significant kinematic changes over 10 minutes on a split-belt treadmill. These findings indicate that either, subjects do not accommodate to the split-belt, or that more time is required.

The time effect for hip ADD resulted from the increased peak observed on the single-belt. We did not expect changes in single belt mechanics over time. However, it must be noted that this difference was only 1.2 degrees.

The same was true for the other frontal plane angles. The differences between peak angles in the split and single-belt configurations were less than two degrees. However, the total rearfoot eversion excursion is only eight degrees, indicating that a 1.2 degree difference can account for about 15% of the total excursion at the joint. In knee adduction, the total excursion is only five degrees, so a one degree change in peak angle is 20% of the joint excursion in the frontal plane. However, the clinical relevance of these differences is still questionable.

SUMMARY

Differences in the rearfoot and knee frontal plane movement were found in split-belt, compared to single-belt treadmill walking. These differences remained following a 10-minute accommodation period.

REFERENCES

Altman et al., (2008) ACSM National Conference (accepted abstract).

Zeni et al., (2008) *Gait Posture*, in review.