RELATIONSHIP OF RATE OF LOADING IN OVERGROUND AND TREADMILL GAIT

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INTRODUCTION

Ground reaction force (GRF) is regarded as a representative measurement of gait because it is the external force between the individual and supporting surface (Winter, 1990). It can be an evaluative tool for detecting normal or abnormal gait and joint loading (Goh et al., 1993).

There are two direct methods for measuring GRF in gait: 1) walking overground with an imbedded forceplate in the walkway and 2) walking on an instrumented treadmill. However, research suggests that there may be discrepancies in the GRF between treadmill and overground gait.

Riley et al. (2007) noted a lower push-off velocity in treadmill walking versus overground. The lower push-off velocity and subsequent reduced foot trajectory would explain the higher treadmill cadence noted by Warabi et al. (2005). However, what is unknown is whether these known differences between cadence and push-off velocity affect the foot's initial contact and rate of loading (ROL). Therefore, the purpose of this study is to investigate the relationship in overground and treadmill ROL in healthy women.

METHODS

Subjects: Five healthy women ages 18 to 30 years (mean ± standard deviation [SD]; age 22.4 ± 1.5 years; body mass 59.4 ± 9.1 kg; height 1.6 ± 0.06 m; body mass index 22.3 ± 3.3 kg/m^2) participated in this research study. All participants proclaimed to be free from lower extremity joint ailments and cardiovascular or neurological problems.

Gait Analysis. The protocol included two separate sessions, an overground gait analysis, followed by an instrumented treadmill gait analysis.

For the overground analysis, an 8-camera VICON Mx (ViconPeak) motion capture system was paired with an AMTI model OR/6-5-1000 (Advanced Medical Technology, Inc) imbedded forceplate capturing the participant's gait and GRF respectively. Each participant completed five successful gait trials, which consisted of the subject's dominant leg's foot fully stepping on the forceplate. The subject's dominant leg was assumed to be her gait initiation leg. Participants were asked to walk straight at a "normal" walking speed for a distance of approximately 15 meters with the forceplate positioned in the middle of the walkway.

For the treadmill analysis, a split-belt instrumented treadmill (Bertec Corp.) was used in conjunction with SIMI motion capture software (SIMI Reality Motion Systems). The treadmill was set at the predetermined speed found during the overground analysis. The participant became acclimated to this speed prior to the 3-minute analysis.

Parameters of interest included: gait cycle time, swing and stance time, cadence, stride length, and ROL. ROL was calculated from the vertical ground reaction force curve from initial contact to 50ms after contact and normalized by body weight (BW). For the treadmill analysis the third footfall and first footfall after 2.5 minutes were averaged, and all overground trials were averaged.

Statistical Analysis. Data analysis included a student's t-test between the treadmill gait parameters and overground parameters. The significance was set 0.05. Pearson's correlation coefficient assessed the relationship between overground and treadmill gait for parameters that were statistically significant. SPSS 15.0 (SPSS, Inc.) was used for the statistical analyses.

RESULTS

Pilot results (Table 1) from this study show that there are significant higher ROL in the treadmill gait compared to overground gait ($p = 0.048$). In this study there were no significant differences in gait cycle time, but there were significant differences between stance ($p = 0.039$) and swing ($p = 0.047$) times and percentages ($p = 0.032$ and $p = 0.44$, respectively).

The only significant differences noted were in ROL and stance-swing time and percentage. In these we noted a strong relationship between overground and treadmill ROL ($r = 0.850$). The relationships between stride (r = 0. 144), stance (r = 0. 445), and swing ($r = 0.346$) times in the two analyses were not strongly related. However, the stance ($r = 0.790$) and swing ($r = 0.790$) percentages were strongly related in the overground and treadmill gait analyses.

Table 1: Outcome parameters in the treadmill and overground analysis.

Gait Spatiotemporal Parameters	Treadmill Gait	Overground Gait
Gait Cycle Time (s)	0.99 ± 0.05	0.98 ± 0.04
Stance Time (s)	0.63 ± 0.07*	0.60 ± 0.03*
Swing Time (s)	0.36 ± 0.02*	0.38 ± 0.02*
Stance (%)	63.9 ± 2.5*	61.2 ± 2.4*
Swing (%)	36.1 ± 2.5*	38.8 ± 2.4*
Stride Length (m)	1.32 ± 0.1	1.31 ± 0.1
Cadence (steps/min)	122 ± 6.7	122 ± 5.0
Rate of Loading (BW/s)	13.7 ± 4.5*	11.5 ± 2.8*

* $p \leq 0.05$ between treadmill and overground gait

DISCUSSION & CONCLUSION

The purpose of this research was to determine if ROL differences exist between treadmill and overground gait. This research shows significant differences in ROL.

Though step length was not significantly different between analyses, on the treadmill analysis, we used a wired electromyography (EMG). EMG data was collected but not used. The EMG was positioned on the treadmill for stability, with cabling running to the subject. The cabling was short, and it may have affected the subject's gait because she could have felt restricted.

While these factors are notable, this and previous research suggest that treadmill results may not always be similar to how the individual walks overground. (Riley et al., 2007; Warabi et al., 2005) As such, it may be important to determine a prediction model that will relate treadmill and overground walking for those gait parameters that are significantly different in the two analysis settings. This research lays the foundation for further examination into the gait differences between overground and treadmill analyses, and the need for a predictive model.

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