INTRODUCTION

A gait transition during human terrestrial locomotion naturally occurs as the speed of walking increases or the speed of running decreases. Although transition speeds reported by various researchers are relatively consistent, the difference between the walk-run (WR) and the run-walk (RW) transition speed varies considerably, ranging from -0.08 m·s\(^{-1}\) (Turvey et al., 1999) to 0.24 m·s\(^{-1}\) (Beuter & Lefebvre, 1988). The negative sign indicates that RW was greater than WR. The discrepancy in the amount of hysteresis reported may be partly due to methodological differences between the various studies. In six studies (e.g. Diedrich & Warren, 1998; Thorstensson & Roberthson, 1987) in which a constantly accelerating treadmill was utilized, an average hysteresis of 0.10 m·s\(^{-1}\) was reported. In six studies in which the treadmill speed was increased incrementally (e.g. Hreljac, 1995; Raynor et al., 2002), an average hysteresis of 0.04 m·s\(^{-1}\) was reported. No studies used both protocols, while several other studies did not report both WR and RW. Another factor which has an effect on WR and RW is the treadmill inclination. Increasing grade appears to decrease hysteresis (e.g. Diedrich & Warren, 1998). The purpose of this study was to determine whether hysteresis is affected by the protocol (continuous or incremental) or by the treadmill inclination.

METHODS

The preferred WR and RW of nine young, healthy subjects (6 males, 3 females) who were familiar with treadmill locomotion was found using two different protocols (continuous and incremental) and three inclination conditions (0%, 10%, and 15% grades). Conditions were randomly ordered, and repeated at least twice. To find WR using the continuous protocol, the treadmill was set to a slow walking speed, and continually accelerated until the subject was running. The instant of WR was determined from observation of a sagittal plane video recording (240 Hz), and defined to occur at toeoff of the step during which the subject switched from an inverted pendulum to a bouncing ball model. Treadmill speed at WR was found by digitizing a marker on the treadmill. To find RW, the process was repeated in reverse, with the RW defined to occur at heelstrike of the first walking step.

To determine WR using the incremental protocol, the treadmill was initially set to a comfortable walking speed. Subjects were given a 30 s decision period to determine whether walking or running was the preferred gait at this speed. After stopping the treadmill, subjects dismounted before the treadmill speed was increased by 0.2 mph (≈0.1 m·s\(^{-1}\)), and the subject remounted. This procedure was repeated until a speed
was reached at which the subject asserted that running was the preferred gait at that speed. The procedure was repeated in reverse for determination of RW. A repeated measures ANOVA tested for differences in speed between protocols, transition direction, and treadmill inclination (p < 0.05).

RESULTS AND DISCUSSION

Regardless of protocol, both WR and RW decreased significantly as inclination increased. At the 10% and 15% conditions, WR and RW were greater with the continuous than the incremental protocol (Figure 1), but there was no difference between WR and RW at the 0% condition.

With the incremental protocol, there was a significant difference between WR and RW at all inclination conditions. The differences between WR and RW (0.08, 0.08, and 0.09 m/s) was consistent with previous studies which used this protocol (e.g. Hreljac, 1995), and within the range of what was expected. Because of the stepping nature of this protocol, the expected amount of hysteresis would be equal to the speed increments employed. For all inclination conditions, speed increments were the same (≈ 0.09 m/s), so it is not surprising that hysteresis was unaffected by inclination with the step protocol.

With the continuous protocol, there was a significant difference between WR and RW at the 0% and 10% conditions, but no significant hysteresis at the 15% condition. This is consistent with the results of Diedrich and Warren (1998) who reported that the hysteresis effect decreased with increasing inclination when using a continuous protocol.

**Figure 1**: Preferred transition speed for Step-WR, Step-RW, Cont-WR, and Cont-RW (left to right bars) at each of the three inclination conditions.

SUMMARY

The results of this study suggest that the choice of protocol makes little difference in the determination of the preferred transition speed or in the amount of hysteresis found when using a level treadmill condition. When using inclined conditions, however, researchers should be aware that the choice of protocol may affect both the preferred transition speeds and the amount of hysteresis. Although it was not tested in this study, the amount of hysteresis found when using the incremental protocol appears to be related to the speed increments used.

REFERENCES