

FORCE CHANGES WHEN WALKING CONTINUOUSLY WITH EXTRA WEIGHT

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INTRODUCTION

It has been hypothesized that long duration walking (20 minutes) will cause quadriceps fatigue resulting in an increase rate of loading and an increase in the magnitude of ground reaction forces (Syed & Davis, 2000). Quadriceps act as shock absorbers, reducing the rate of loading on the knee during the weight acceptance phase of gait (Whittle, 1999). Quadriceps strength is predictive of both radiographic and symptomatic evidence of osteoarthritis (OA) of the knee, and a strong correlation exists between quadriceps strength, knee OA, and obesity (Slemenda et al., 1997; Slemenda et al., 1998). Syed and Davis (2000) theorized that the obese would reach a point of quadriceps fatigue sooner than normal when walking resulting in higher loads and rates of loading. The link between body weight and changes to limb loading measures for continuous walking has not been shown. An experimental model of weight manipulation is proposed to investigate changes to ground reaction forces over a continuous, 32-minute walk. We hypothesized that force measures during the weight acceptance phase of gait would increase over time, and that the increase would be more pronounced when walking with extra weight.

METHOD

Five subjects (3 males, 2 females, mean age = 33 years) with a body mass index (BMI) in the normal weight category (BMI between 20 and 25) walked at a constant

treadmill speed (between 1.34 ms^{-1} and 1.51 ms^{-1}) on two occasions; once with, and once without additional weight. Weight was added via a weight vest and weight belt to achieve a BMI equivalent to Obese I (BMI between 30 and 35). A minimum of 8 steps (right and left) of vertical ground reaction force data were collected within the first 3 minutes of walking on a force measuring treadmill, and at 8-minute marks over a 32-minute interval. Peak loading force during the first half of stance ($F1$) and the rate of rise of the loading force ($F1_R$) were calculated from the vertical force records. Dependent measures for the 8 steps were averaged for each subject treating right and left limbs separately. $F1$ and $F1_R$ from the original data sample were subtracted from each 8-minute sample, plotted against time and fit with a linear best-fit trend line. A paired t-Test was used to test for significant differences ($p < .05$) between the original and the last data sample.

RESULTS

There were no significant increases in end-point values (32-minute sample) and the original values for the normal weight condition ($F1$: $p = .08$; $F1_R$: $p = .21$) or the extra weight condition ($F1$: $p = .41$). The loading rate for the weighted condition was significantly less ($F1_R$: $p = .02$). The peak force during loading and the loading rate did not tend to increase over the duration of the walk (Fig. 1 & 2). There were no differences in this trend when walking with or without the extra weight.

DISCUSSION

Peak force and loading rate did not increase over time as had been predicted. (Syed & Davis, 2000). Subjects in this study were healthy, active and normal weight. It may be that the protocol did not fatigue quadriceps enough to affect the force measures. Knee extensor strength was measured within 3 minutes of completing the walk. It decreased for all subjects for the weighting condition (average = 8.5%); however, the change is low considering the reliability of retesting a maximum voluntary contraction. There was substantial between-subject variability in dependent measures. Forces are influenced by how an individual changes their “effective mass” to achieve greater shock absorption and lower impacts. The ability to adapt to fatigue is a factor and has been shown to influence impact forces when running (Derrick, et al., 2002). It may be that overweight individuals have insufficient strength or muscular endurance to adjust to loading. A treadmill was used to control walking speed but fatigue effects could have been masked if changes in the force measures reflect gait accommodation. All subjects had prior experience walking on a treadmill and force signals were collected about 3 minutes into the trial to account for accommodation. A previous study reported no significant within-day accommodation changes to vertical force measures over a 20-minute run after 30 seconds (White et al., 2002). Accommodation should not have had a major effect on the data.

The present study suggests that peak weight acceptance force and loading rate do not increase when healthy, normal weight individuals walk continuously over 32 minutes with or without extra weight. These results may not reflect changes that might be expected for overweight individuals.

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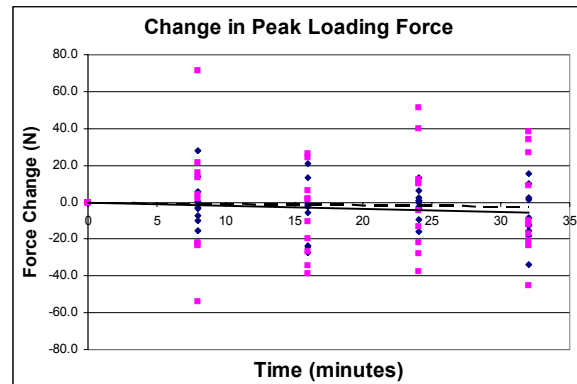


Figure 1. Change in peak force for normal (solid) and weighted condition (dashed). Measures are relative to initial data trial.

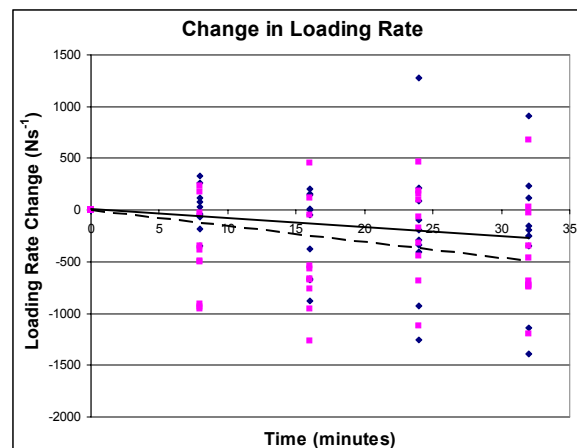


Figure 2. Change in peak loading rate for normal (solid) and weighted condition (dashed). Measures are relative to initial data trial.