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INFLUENCE OF LOAD AND VELOCITY IN GRADIENT WALKING STABILITY

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SUMMARY

Gait adaptations during walking in gradient and loaded backpack can alter walking control parameters. The behavior of trunk and stride parameters define stability gait. To investigate the walking stability, the coefficient of variation (CoV) of spatiotemporal parameters was analyzed. Were performed five walking speeds (1, 2, 3, 4 and 5 km h^{-1}), and all of them performed with a 9º positive inclination of the treadmill, with and without load (25% body mass). The biomechanical variables analyzed were CoV of Stride Length (SL), Stride Frequency (SF) and Trunk Range of Motion (TRM). The results show that walking, either with or without load, presented a minor variability in intermediate speeds. The lower speeds are the ones that resulted in a greater variability, either in length and frequency stride as trunk range of motion. The load effect could be observed in the CoV TRM, where the loaded situation presented greater variability. The bahavior of the CoV TRM is greater in loaded walking and CoV behavior of SL and SF seems to be influenced by speed.

INTRODUCTION

Normally, walking is a stable gait because of the small variability of spatiotemporal parameters that indicate an excellent dynamic stability and reduced cost of transport.
Adaptations in gait during walking of the terrain inclination and loaded backpack can alter the parameters of walking control. But there is a lack of studies which investigate these adaptations, inclination and load, in the stability of walking. The loaded walking with backpack is usually used by the military, athletes, students etc. The combination walking with load and terrain inclination could increase the pain, risk of falls and energy expenditure.
One way to investigate the walking stability is through coefficients of variation (CoV) of spatiotemporal gait parameters [1].

Because of this large use of loads (e.g. backpacks) when walking in terrains with different inclinations, this study investigated the modifications in CoV of the stride parameters and trunk range of motion walking with load (25% BM) on a slope (~ 9º) at five different speeds.

METHODS

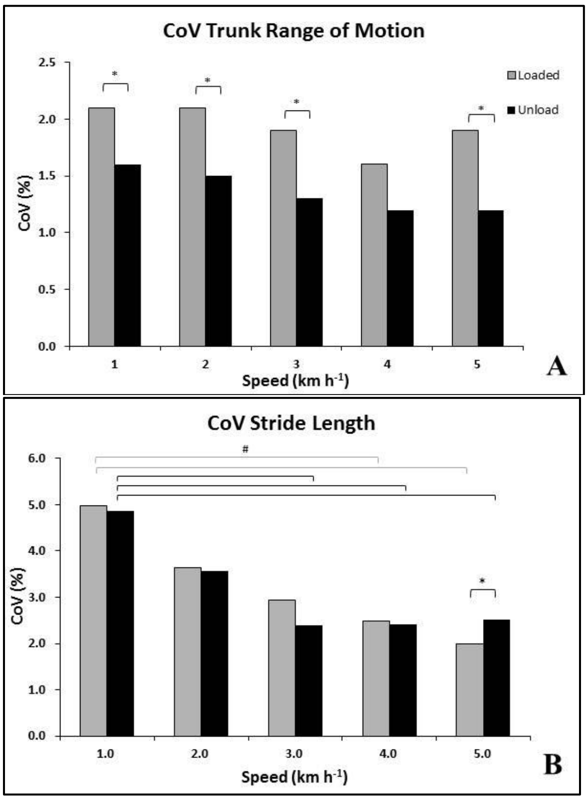
The study comprised of 10 young men aged 23.1 ± 2.9 years, height 1.78 ± 0.06 m, and BM 71.6 ±6 kg, each carrying about 17.9 ±1.5 kg (25% of BM) load and all healthy, non-athlete undergraduates. All the subjects were informed about the study and signed an informed consent. This study was approved by the ethics committee of the Federal University of Rio Grande do Sul (Brazil). Five different treadmill walking speeds (1, 2, 3, 4 and 5 km h^{-1}) were performed in 9º positive inclination, at an interval of five minutes between each walking situations. The movements of the treadmill walking were recorded using four cameras of 50 Hz of sampling frequency (JVC GR-DVL 9800, New Jersey, USA) synchronized and 3D reconstruction performed using software DVIDEOW 5.0 [3]. For the kinematic variables an 18-point anatomical model was employed [2]. Stride time (s) was calculated as the average time between consecutive heel strikes, and stride frequency (Hz) as 1 divided by stride time. Finally, stride length (m) was calculated as stride time (s) multiplied by treadmill speed (m/s) [4]. The trunk range of motion was calculated as the difference between the highest and the lowest inclination of the trunk during a stride cycle [5]. This CoV is calculated as the division between the standard deviation and the mean variable [1]. The normality of the dependent variables was verified by the Shapiro - Wilk test and homogeneity of variances with the Levene test. We used ANOVA for repeated measures two factors to verify that there was an interaction between the variable speed and load. When there was interaction between these variables (speed*load) was performed unfolding to verify the main effect of speeds using the variable speed ANOVA for repeated measures of one factor, with post-hoc Bonferroni (α = 0.05). For comparison between two load situations (unload and load) was used paired t-tests. All statistical tests were performed in SPSS (Statistical Package for Social Sciences).

RESULTS AND DISCUSSION

The results of the present study show that walking, either with or without load, presented in a minor variability in intermediate speeds. The lower speeds are the ones that resulted in a greater variability, either in length and frequency stride as trunk range of motion. That could be related with the self-selected speed, approximately 4 km h^{-1}, once it is the common speed of walking e the body is adapted to accomplish this task. Greater or lower speeds could contribute to an increase of variability [5]. However, analyzing the walking without load in level ground**,** the behavior is altered, once the spatiotemporal variability tend to decrease linearly with the increase of the walking speed [6,7]. In the length and frequency stride CoVs (FIG. 1B and C), only the 5 km h^{-1} speed presented a significantly difference ($p<0.05$). In that same speed, loaded walking presented minor variability than the unloaded walking.

The load effect could be observed in the CoV trunk range of motion (FIG. 1 A), where the loaded situation presented greater variability ($p<0.05$) than the unloaded situation. The loaded walking presented greater angular variability of segments in sagittal plane than unloaded walking, according other study [8]. This could be related with systems perturbations (gradient and backpack load), where there are greater variability due to a less consistent motor plane (inexperienced subjects in the task) and could be correlated to the preparatory stage of the movement [9]. However, due to the fact of the subjects are not trained with loaded walking in gradient, they could present reduced motor skill in this situation, what could increase the movement variability, especially in the loaded situation.

The behavior of variability differs between the stride parameters and trunk range of motion in the sagittal plane. The backpack seems to influence more the control of trunk movement than the control of the limbs during gradient walking.



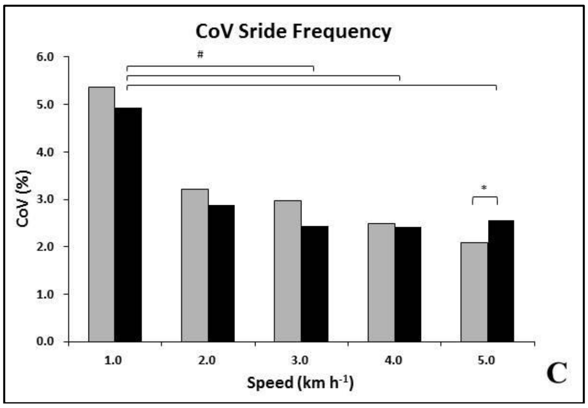


Figure 1: (A) CoV Trunk Range of Motion (%), walking loaded (gray bar) and unloaded (black bar). * represents significant difference (p<0,05) between the two conditions. (B) CoV Stride Length (%) loaded (gray bar) and unloaded (black bar). # represents significant difference (p<0,05) between the same condition of load at different speeds. * represent significant difference (p<0,05) between the two conditions at the same speed. (C) CoV Stride Frequency, walking loaded (gray bar) and unloaded (black bar). # represents significant difference (p<0,05) between the same condition of load at different speeds. * represent significant difference between the two conditions at the same speed.

CONCLUSIONS

The backpack alter the stability in gradient walking. The bahavior of the CoV TRM is greater in loaded walking and CoV behavior of stride length and frequency seems to be more influenced by speed than by the load.

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