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ANALYSIS OF THE TRUNK TILT AND LUMBAR LORDOSIS DURING LOCOMOTION AT DIFFERENTS GRADIENTS

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INTRODUCTION

The gait and the running are considered the main forms of locomotion of man for being activities basic motor and of high energy efficiency. Can be performed in various environments, making people often encounter inclined surfaces in their occupational or leisure activities [1].

There is evidence that the locomotion in slope is more likely to drop due to the risk of slippage and loss of balance. We know that this threat increases in surfaces steeper. Moreover, the possibility of muscle skeletal injuries increases during locomotion in downhill and decrease in uphill [2].

Note that it is important to understand how the slope of the surface affects the pattern of movement of the several body segments. It is known that the gradient change the ground reaction forces, the recruitment muscular and the articular movement of the structures of the lower extremities [2,3,4].

Moreover, few researchers have analyzed the posture of the trunk and spine during locomotion on inclined surfaces [4,5]. Therefore, the aim of this study is to analyze the trunk tilt and lumbar lordosis during walking and running at different gradients.

METHODS

The study included twenty-five men asymptomatic physically active and having the following characteristics: 26.6 ± 6.4 years, 1.78 ± 0.05 m in height, and 79 ± 10 kg body weight. The volunteers wore gym clothes and remained shirtless throughout the experimental protocol. Our study was approved by the university's institutional review board.

For postural assessment were used a treadmill, three digital video cameras (60 Hz) and reflective markers (10 x 12 mm). Five markers were set on the skin surface of the spinous processes of C7, T6, T12, L5 and S2 and five pairs of bilateral markers were placed on the height of these vertebrae. And finally, markers were fixed, regularly spaced 1.5 to 2 cm, along the line defined by cervical spinous processes to the sacrum.

After four minutes of warm up at 1.5 m/s began evaluating postural dynamics that had six different situations: gait (1.5 m/s) and running (2.2 m/s) in gradients of 0 º and ± 6. The order of each stage was selected randomly for each individual and lasted a minute.

All steps for 3D reconstruction of the markers were performed in the software dynamic posture [6]. To minimize the effects of noise we use a low pass digital filter type Butterworth fifth order and cutoff frequency of 6 Hz

The trunk was represented by the line segment defined between markers set at C7 and S2. Therefore, the inclination of the trunk in the sagittal plane was calculated using the angle obtained between the vertical and the respective segment. Since the spine was represented by the concept of geometric curvature [7] and the lumbar lordosis through the peak lumbar curvature in the sagittal plane.

In each situation locomotion, we used information from one complete cycle of the mean stride (total of 12 consecutive strides). We analyzed the mean of the trunk tilt and of the lordosis, obtained over the complete cycle of the mean stride.

To check if any of the investigated variables changed significantly, both in the gait as the running, due to the change in the slope of the treadmill was used to one way analysis of variance and multiple comparison test of Tukey. The Pearson correlation coefficient was used to assess the interaction between variables and statistical significance adopted was 5% ($p < 0.05$).

RESULTS AND DISCUSSION

Figure 1 shows the boxplot of mean values of the trunk tilt and lumbar lordosis of the volunteers in each gradient and type of locomotion.

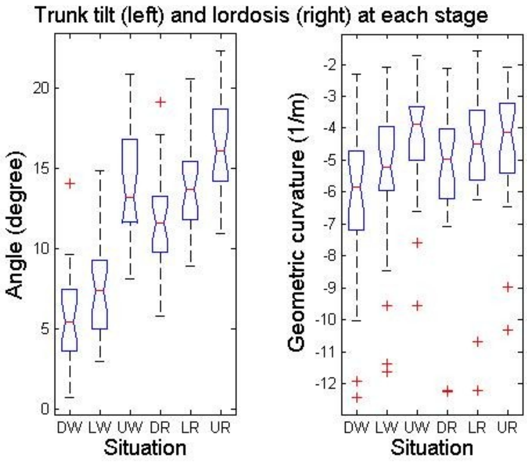

Figure 1: Mean of the trunk tilt and of the lumbar lordosis of the participants at each situation: downhill walking (DW); level walking (LW); uphill walking (UW); downhill running (DR); level running (LR); uphill running (UR).

There were significant differences in the trunk tilt at all situations, except between the in gait downhill and level. Moreover, lordosis was significantly different only between the gait in uphill and downhill. Based on figure 1 it can be seen that with the increased locomotion gradient, the participants design the trunk forward and rectify the lumbar spine in both the gait and the running.

There is evidence in the literature that the hip extensors muscles are significantly more active during uphill locomotion due to the need to raise the center of mass and move the body forward [3]. By tilting the trunk forward, the center of mass move ahead of the support base and, thus, assist in the forward propulsion of the body during uphill situation [4].

The increased lordosis during locomotion in surface declined corroborates the findings of other researchers [5]. These authors found statistically significant differences in lumbar curve among all gradients. This fact can be explained by methodological differences between the two studies, because [5] used another way to model the spine, other speeds and gradients locomotion, paired statistical method and the volunteers evaluation were female.

Note in the present study that the lumbar lordosis behavior seems to be closely related to the posture of the trunk, because the more leaning forward was the trunk was less lordosis ($R = -0.91$; $p<0.05$). This postural adjustment mechanism may be used to facilitate the generation and / or energy absorption during locomotion with different gradients [4].

The results of the behavior of the lumbar lordosis suggest that individuals suffering from spinal disorders which are aggravated by increased lordosis as, for example, stenosis and spondylolisthesis should be careful with locomotion in decline due at the fact the changes in vertebral geometry may exacerbate the symptoms related to dysfunction.

The high inter subjects variability related to the measurement of lordosis is linked to the peculiarities of spinal posture of each subject in response to movement imposed by locomotion. Therefore, the grouping of information seems to have contributed to we found no statistically significant differences in lordosis due to the gradients. Indeed, there are reports in the literature of the limitation of grouping information lordosis during locomotion [8].

CONCLUSIONS

The posture of the trunk and of the lumbar spine assist in the production and/or absorption of energy during locomotion on inclined surfaces. It is suggested that the analysis of variables related to spinal posture are made on an individual basis, because the high inter subject variability makes it difficult to generalize about the parameters obtained. And finally, it is believed that individuals with spinal pathologies should be cautious with the surface slope of locomotion.

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