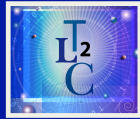


Evaluating the effects of various load-positioning methods on gait stability during the walk-to-run transition



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Introduction

Backpacks are useful for students to carry required items, however, when overloaded and carried improperly, backpacks may actually be more harmful than they are helpful. Several studies have been done to identify the optimum weight and position for a backpack by examining postural stability while standing. However, there are few studies examining the effect of backpack positioning on gait stability while walking. Thus, this study evaluates various load-positioning methods to find out which method maximizes gait stability and minimizes the risk of falling.



Background

Effects of Different Backpacks, Weight and Location on Static and Dynamic Stability in Children (N.R. Talbott, A. Bhattacharya, and K. Davis, 2004)

- Students who carry backpacks often describe falls and feelings of falling while wearing the backpack.
- These sensations in instability may be related to biomechanical changes associated with the type of backpack worn or the placement of the backpack on the spine.
- The purpose of this study was to determine if measures of stability change with the different types of backpacks placed on different locations on the spine.
- Sway length and sway area were calculated from the force plate measurements. Sway length and sway area were significantly greater with an increase in backpack weight.

Plantar force distribution and pressure center oscillation in relation to the weight and position of school supplies and books in student's backpack (Rodrigues S. Montebelo, 2008)

- Purpose: To determine if the weight and positioning of school supplies and books in backpacks had an effect on plantar force distribution and pressure center location, while standing
- Found that plantar force distribution was not influenced by different loads and backpack positions
- Also found that school backpacks should maintain a 10% body weight of the individual's body mass

The Effect of Backpack Weight on Functional Mobility and Balance (Robins et al. 2002)

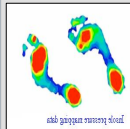
- Backpacks promote falls by affecting functional mobility and balance
- This study focused on functional reach and postural sway
- Functional reach was best with the light, intermediate with recommended, and worst with the heavy backpack weight
- Postural sway scores with eyes open and closed also were best with the light, intermediate with recommended, and worst with the heavy backpack weight

Techniques and Approach

Location	Preferred	Fr = 0.50
Back high	X	X
Back low	X	X
Chest	X	X
R. Shoulder	X	X
L. Shoulder	X	X
Baseline	X	X

As indicated in the chart on the left, this study involves 10 backpack conditions. 6 conditions which involve walking at a preferred speed, and 6 conditions of walking at the calculated walk to run transition speed at Froude number = 0.5 (see below).

Data Collection



This study uses Tekscan foot insoles for analyzing pressure distribution (see left). With Tekscan software, results can be analyzed in real-time graphic format to identify uneven pressure points and balance/alignment problems. To inflict kinetic disturbances and analyze gait pattern, we use a specialized VERTEC treadmill (instrumental split belt).

Froude Number

Like a swinging pendulum, humans are constantly converting kinetic energy into potential energy as the walk. This gives rise to the inverted pendulum model for bipedal walking, which helps conserve energy (Cavagna et al. 1077, Griffin et al. 2004). In this model, gravity provides the centripetal force need to keep the pendulum in contact with the ground. The ratio of centripetal to gravitational forces $(mv^2/L)/(mg)$ reduces to the dimensionless Froude number (v^2/gL) . The Froude number has three components: velocity, leg length, and gravity. In general, humans and other bipedal animals switch from a walk to a run at a Froude number of approximately 0.5 (Gatesy and Biewener, 1991).

$$F_r = \frac{(\text{centrifugal force})}{(\text{weight})} = \frac{mv^2/L}{mg} = \frac{v^2}{gl} \approx 0.5$$



Analysis

Power analysis

When inducing a Stroop task, at least 150 strides were needed to detect modulations (Brujin, 2008). Thus, subjects walk at average walking speed (3mph), for 4 minutes per condition.

Floquet analysis

Floquet theory is a branch of the theory of ordinary differential equations relating to the class of solutions to linear differential equations of the form

$$\dot{x} = A(t)x,$$

with a continuous periodic function with period T .

Expectations

Many studies have been done to identify the optimum weight and position for a backpack by examining postural stability while standing. Researchers at USCSD have identified excessive pressure on the shoulder and low back pain to be two main results of carrying a load on the low back (5). Thus, we expect for the back high position to provide maximum gait stability, and thus minimize the risk of falling. We expect to see a change in gait stability at the walk to run transition for all six conditions, but the least amount of change in stability for the backpack in the high position. Researchers at the University of Cincinnati conducted static trials and found that the location of the backpack significantly altered postural stability and posture, and that the backpack worn in the high position provided the greatest amount of postural stability (4). Thus, we expect similar results for moving trials. The low position, as researchers at USCSD have found, causes shoulder tension that would decrease stability. The chest position would put too much weight on the front side of the body, making it harder to maintain posture while walking. The right and left shoulder positions puts more weight on one side of the body, and would thus alter the center of balance, which we hope to see using the Tekscan.



Application

The findings of this study will help to design backpacks that promote maximum stability. The findings will be used specifically in the field of space of exploration to develop safer, more stable backpacks for astronauts. This study can also be applied to the development of more secure army backpacks. In addition to answering the underlying questions we are asking in this study, we also expect this study to provide evidence of whether males or females have greater changes in stability. In addition, we hope to find whether a person's dominant hand has any influence on which shoulder position produces greater stability.

References

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