EVALUATION OF GAIT INSTABILITY INDUCED BY TORSO LOADING WITH VARIOUS MAGNITUDES AND DIRECTIONS

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INTRODUCTION

Carrying a load is a common part of many activities that we perform every day. These loads may be carried on the back as with backpacks or small children, or on the front in the case of boxes or babies. Ultimately these loads can lead to instability. Although it is difficult to directly measure gait instability we can observe changes in temporal spatial gait parameters, which the body may use to compensate for instability [2]. Clearly large loads lead to instability and tiny loads have no effect on gait, but where does the threshold lie? In addition, does it matter if the load is carried on the front or back? The main goal of this study was to determine where instability occurs in the spectrum of loading.

METHODS

Temporal spatial gait parameters were measured using a 20-foot GAITRite Mat. Twenty-four participants (12 females, age: 20 years, height: 170 cm, and weight: 73.6 kg) were enrolled in the study. Each participant signed an informed consent form approved by the IRB prior to beginning the study. Participants were instructed to walk barefoot, at a self-selected pace, back and forth across the mat under five different loading conditions. Unloaded (U) was used as the baseline. One condition was 20% of the participant's body weight carried in a backpack on the back (B20). Another was a load of 10% on the back (B10). Similarly, 20% and 10% loads carried on the front were also evaluated, (F20) and (F10), respectively. The order in which the loads were carried was block randomized. The same backpack was used for each participant and trial. Participants were instructed to adjust the straps for comfort. Data for the left and right legs were analyzed separately, but due to considerable symmetry only values from the right leg are presented. A repeated measure ANOVA was used to analyzed the data, $\alpha = 0.05$. A post hoc analysis was performed to evaluate differences between individual loading conditions (Table 1).

RESULTS AND DISCUSSION

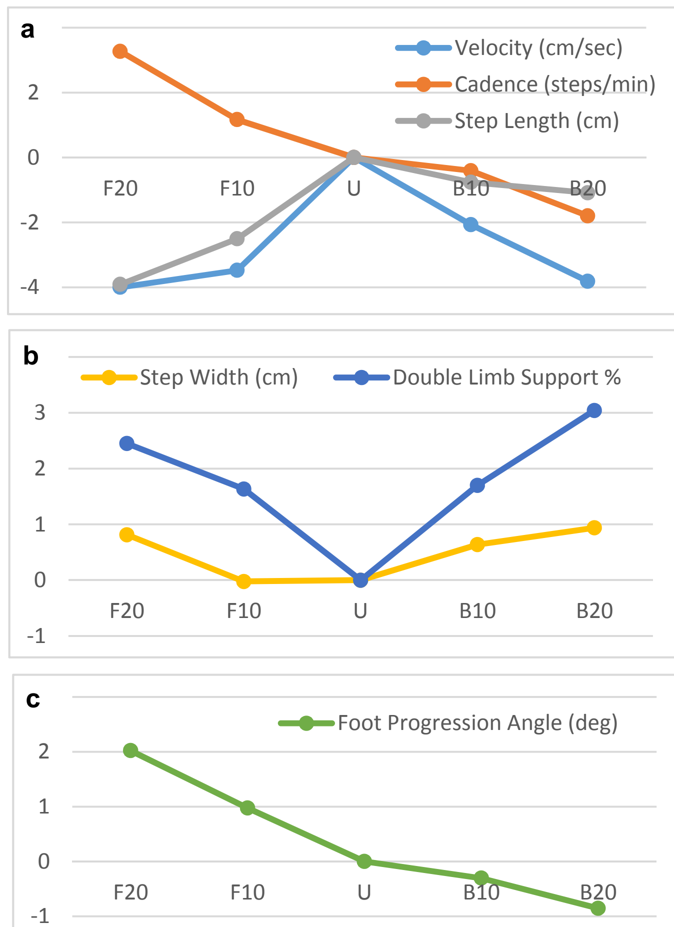

Figure 1: Temporal-spatial measures of gait and foot progression angle. Y-axis values represent differences from baseline (U: unloaded).

Velocity and step length were found to decrease significantly when a load was applied to the body (Fig.1a). However, pairwise comparisons did not show a significant difference between the unweighted and back loads of 10% body weight. This implies that at low levels back loads are more tolerable than front loads. Cadence increased when load was added to the front of the body and decreased when load was added to the back of the body. Significant changes in cadence were not seen for loading conditions of less than 20% body weight. In total, this suggests that front loading caused short fast steps, possibly due to uncontrolled stumbling or interference in leg motion caused by the back pack being worn on the front of the body. On the other hand, back loading caused a reduction in both step length and cadence resulting in an overall decrease in velocity.

With one exception (step width - F10), step width and double limb support percentage (DLS %) increased for all loading conditions (Fig.1b). These increases are a strong indication of gait adaptation caused by instability. It was also observed that DLS % was the similar for both F10 and B10 loading conditions. This high level of symmetry between the front and back conditions implies that front and back loading have a similar effect on gait instability.

Foot progression angle (FPA) increased as load was applied to the front of the body and decreased as load was applied to the back of the body (Fig.1c). Significant change was not observed in back loading when loads were less than 20% body weight. The implications of increased FPA on gait stability are presently unclear. However, turning the feet outward does increase the base of support, which is a suspected compensation for gait instability [1].

CONCLUSIONS

The results indicate that loads added to either the front or back of the body cause instability in temporal spatial gait parameters. Front loading seemed to cause greater instability than back loading at lower loading levels. This was based upon the larger number of gait parameters that significantly changed from the baseline condition. The increased instability of the front loading conditions may be due to a lack of experience carrying weight on the front of the body or physical differences in anatomy. This leads to the question, will allowing participants to practice and become accustomed to front loading help to reduce these differences? If experience does not change the outcome of front loading, its unstable nature has serious implications when considering pregnancy, obesity, and any other conditions which involve moving the center of mass forward. People subjected to these conditions may be at greater risk of falling. Changes in FPA have been associated with changes in frontal plane knee moments, which in turn have been linked with knee osteoarthritis. More work is needed to establish a firm link between gait compensations for mass distribution and knee arthropathy.

REFERENCES

1. Rutherford DJ, et al. *Osteoarthritis Research Society*. **16**(8), 883-889, 2008
2. Winter DA, et al. **70**(6), 340-347, 1990

Table 1: Pairwise Comparisons. Significant p values indicated by *.

Parameter			F20		F10		U		B10		B20	
F20	V	C	-	-	0.702	0.014*	0.003*	0.000*	0.145	0.000*	0.879	0.000*
	SL	SW	-	-	0.002*	0.002*	0.000*	0.008*	0.000*	0.470	0.000*	0.674
	DLS	FPA	-	-	0.000*	0.005*	0.000*	0.000*	0.006*	0.002*	0.018*	0.000*
F10	V	C	0.702	0.014*	-	-	0.013*	0.245	0.148	0.018*	0.797	0.004*
	SL	SW	0.002*	0.008*	-	-	0.000*	0.929	0.000*	0.001*	0.001*	0.008*
	DLS	FPA	0.000*	0.005*	-	-	0.000*	0.004*	0.726	0.000*	0.000*	0.000*
U	V	C	0.003*	0.000*	0.013*	0.245	-	-	0.106	0.550	0.015*	0.041*
	SL	SW	0.000*	0.008*	0.000*	0.929	-	-	0.092	0.040*	0.036*	0.017*
	DLS	FPA	0.000*	0.000*	0.000*	0.004*	-	-	0.000*	0.000*	0.000*	0.000*
B10	V	C	0.145	0.000*	0.148	0.018*	0.106	0.550	-	-	0.038*	0.022*
	SL	SW	0.000*	0.470	0.000*	0.001*	0.092	0.040*	-	-	0.280	0.312
	DLS	FPA	0.006*	0.002*	0.726	0.000*	0.000*	0.000*	-	-	0.000*	0.022*
B20	V	C	0.879	0.000	0.797	0.004	0.015	0.041	0.038	0.022	-	-
	SL	SW	0.000	0.674	0.001	0.008	0.036	0.017	0.280	0.312	-	-
	DLS	FPA	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.022	-	-

(V=velocity, C=cadence, SL=step length, SW=step width, DLS=double limb support %, FPA=foot progression angle)