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The Effect of Symmetrical, Hand-held Load Carriage on Thoracic Rotation during Gait: An Observational Study

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INTRODUCTION

During unloaded ambulation, arm, trunk and leg motion produces reciprocal, anti-phase rotation between the pelvis and thoracic spine. Anti-phase rotation allows for efficient, stable gait patterns and promotes balanced segmental forces.

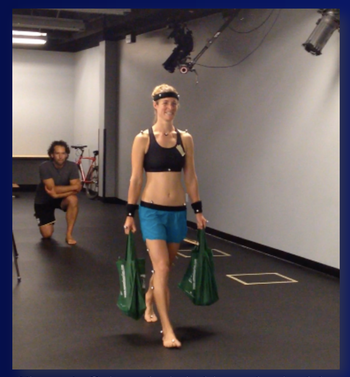

Figure 1. Gait analysis in biomechanics lab

Research demonstrates that several common factors cause in-phase thoracic spine and pelvic rotation resulting in decreased gait efficiency. Factors include load carriage, slow gait velocity, and locomotor pathologies that promote protective spinal stabilization, such as low back pain and pregnancy-related pelvic girdle pain.

Since painful spinal and pelvic conditions are frequently treated with physical therapy interventions that promote stabilization, clinicians should be cognizant of the degree to which such exercises may alter normal gait mechanics.

A previous, as yet unpublished study from our lab has shown that gait mechanics transition from anti-phase to in-phase rotation with as little as 5% of an individual's body weight carried as an asymmetrical hand-held load.

PURPOSE

The purpose of this study was to establish if altered gait kinematics, specifically thoracic spinal rotation relative to the pelvis, occur with symmetrical hand-held loads.

SUBJECTS

Adult volunteers conveniently sampled from the community, 18-30 years old, with no significant gait deviations or health complications.

METHODS

Subjects performed three trials for each of the seven conditions, walking at a cadence of 100 steps/minute along a 48-foot path. The sequence of conditions was randomized and subjects were blinded to conditions 2-7.

Loads were established as a percentage of body weight (BW) per condition. Once established, loads were divided equally and carried in each hand.

The conditions were:
1) Unloaded gait
2) Holding empty bags
3) Holding 2% of BW
4) Holding 4% of BW
5) Holding 6% of BW
6) Holding 8% of BW
7) Holding 10% of BW

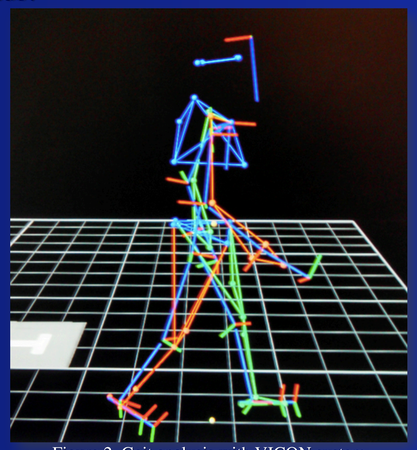

Figure 2. Gait analysis with VICON system

(I) Load	(J) Load	Mean Difference (I-J)	Std. Error	Sig.[b]
1	2	2.588*	.477	.001
	3	3.382*	.457	.000
	4	3.349*	.536	.000
	5	3.809*	.477	.000
	6	3.477*	.486	.000
	7	4.214*	.634	.000
2	1	-2.588*	.477	.001
	3	.794	.255	.140
	4	.761	.288	.375
	5	1.221*	.250	.004
	6	.889	.393	.801
	7	1.626*	.430	.034
3	1	-3.382*	.457	.000
	2	-.794	.255	.140
	4	-.032	.203	1.000
	5	.428	.187	.756
	6	.095	.278	1.000
	7	.832	.357	.696
4	1	-3.349*	.536	.000
	2	-.761	.288	.375
	3	.032	.203	1.000
	5	.460	.232	1.000
	6	.128	.244	1.000
	7	.865	.352	.541
5	1	-3.809*	.477	.000
	2	-1.221*	.250	.004
	3	-.428	.187	.756
	4	-.460	.232	1.000
	6	-.332	.283	1.000
	7	.405	.372	1.000
6	1	-3.477*	.486	.000
	2	-.889	.393	.801
	3	-.095	.278	1.000
	4	-.128	.244	1.000
	5	.332	.283	1.000
	7	.737	.431	1.000
7	1	-4.214*	.634	.000
	2	-1.626*	.430	.034
	3	-.832	.357	.696
	4	-.865	.352	.541
	5	-.405	.372	1.000
	6	-.737	.431	1.000

Figure 3. * indicates significant decrease in rotational relationship

ANALYSIS

Ten infrared cameras recorded each condition at 120 hertz. Gait kinematics were then analyzed with the VICON Nexus 1.8.4 motion analysis system.

In order to compare the average thoracic rotation relative to the pelvis for each condition a repeated measures ANOVA with Bonferroni adjustment was performed with alpha value $p<0.05$.

RESULTS

Compared to unloaded ambulation, each condition that required a hand held load demonstrated significant decrease in rotational angles of the thoracic spine relative to the pelvis ($p<0.001$).

Furthermore, carriage of as little as an empty canvas bag demonstrated a significant decrease in thoracic rotation.

Rotation diminished further with increased weight carriage, specifically 6% of BW ($p<0.004$) and 10% of BW ($p<0.034$).

CONCLUSIONS

Ambulation with as little as unloaded bags in each hand decreases thoracic spinal rotation. Diminished rotation was likely due to decreasing arm swing. Increased load generally decreased rotation further, consistent with the effects of muscular stabilization.

Figure 4. Gait analysis in biomechanics lab

RELEVANCE

Some loss of thoracopelvic reciprocal rotation is common in patient for whom stabilization exercises are prescribed.

Our finding suggest that training stabilization with hand-held loads might reinforce impaired transvers plane kinematics.

In these cases, clinicians should consider first reestablishing optimal transverse plane kinematics, then incorporating only the minimally necessary amount of hand-held load.

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IRB Approval
This study was granted approval for participation by human volunteers from the Institutional Review Board of the University of Puget Sound on May15, 2014; Protocol #0910-006.