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The Effect of Loaded Backpack Usage on Balance after a Functional Daily Stair Task

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Abstract

Purpose: The purpose of this study was to assess the effect of loaded backpack usage on balance by quantitatively measuring balance after a functional daily stair task (FDST) designed to resemble cardiorespiratory fatigue (CRF).

Methods: 7 male and 13 female collegiate students (mean age = 20.25 ± 1.02 years) participated in two data collection sessions. These subjects were free of any diagnosed lower extremity injuries within the past 6 months. For the first session, subjects performed balance testing using the BioSway (Biodex, USA) immediately before and after the FDST for an unloaded condition. The FDST was performed by subjects starting at a constant cadence and gradually increasing cadence until the subject reached 85% of their age-predicted maximum heart rate (HR_{max}). Once this HR_{max} was reached, subjects continued to climb at that cadence for 3 more minutes before completing the post-FDST balance testing. The Balance Error Scoring System (BESS) and Limits of Stability (LOS) test protocols were randomly assigned for each participant. Within 2 weeks after completing the protocol for the unloaded condition, subjects completed the same protocol for a loaded backpack condition.

Results: A paired samples t-test using SPSS Statistics 24 demonstrated no significance ($p \leq 0.05$) for any of the balance scores: BESS Double (0.047 ± 0.360), BESS Single (0.259 ± 1.371), BESS Tandem (0.567 ± 1.225), LOS Time (4.150 ± 23.922 sec), and LOS Accuracy (4.500 ± 21.117 %).

Conclusion: The data indicated when comparing balance scores before and after the FDST, adding a backpack load does not significantly affect the subjects' balance. This data could be applicable for students, the elderly, or individuals in the military.

Introduction

Backpack usage is common among many age groups, including college students. As students go through their daily routines, they may reach cardiorespiratory fatigue (CRF). Nardone et al. found that CRF, achieved via a fatiguing treadmill workout, significantly increased body sway during balance tasks compared to pre-fatigue values (1997). An increase in body sway corresponds to a decrease in one's balance ability. Similar to CRF, research shows that carrying a loaded backpack affects one's balance. One acute effect of carrying a loaded backpack may be muscle activity changes. One way of quantifying neuromuscular control is through measures of postural control (Gribble & Hertel, 2004). Postural control requires the recruitment of a variety of different muscle groups. Research shows that backpack use can increase the use of these specific muscle groups during balance. For example, increasing backpack loads have been shown to increase muscle activation specifically in the muscles that control the ankle, which can lead to a decrease in balance ability (Kim et al., 2014).

Research demonstrates that CRF and increasing backpack loads, assessed independently, cause a decrease in balance ability. The purpose of this current study was to combine these two ideas to assess the effect of loaded backpack usage on balance by quantitatively measuring balance after a functional daily stair task (FDST) designed to resemble CRF.

Methods

23 college students were recruited from Bethel University. All subjects met inclusion criteria which was verified by the informed consent and health history form. Due to factors such as falling out of cadence, lightheadedness and elevated heart rate during the second data collection, 3 subjects were excluded from data analysis. The remaining subjects (n=20) had a mean age of 20.25 ± 1.02 years. Subjects came in for two data collection sessions wearing athletic clothing and tennis shoes. The second session took place within two weeks of the first.

During the initial session, subjects completed the pre-FDST balance testing with no backpack, which will be referred to as the unloaded condition. Balance was assessed using the BioSway (Biodex, USA). Participants completed two balance tests, a Balance Error Scoring System (BESS) test and a Limits of Stability (LOS) test. For the BESS test, participants completed 3 consecutive stances of the BESS test lasting 20 seconds each. Picture 1 shows the single leg stance. For each stance, a sway index was recorded. For the LOS test, subjects completed one trial from which directional accuracy and time of the test was recorded. The order of the two balance tests was randomly assigned. This same order of tests was performed after the FDST for each participant.

After pre-FDST balance testing was completed, the subjects completed the FDST to induce CRF. For the FDST, each subject started at the bottom of two flights of stairs (48 total steps). Next, participants walked up and down the stairs, starting at a cadence of 100 steps per minute. The participant's cadence increased by 10 steps per minute each time they started a new ascent, until reaching 85% of their age-predicted maximum heart rate. Once the target heart rate was met, participants maintained the same cadence for 3 minutes to reach CRF. Once CRF was met, participants immediately began the balance assessments on the BioSway.

When subjects arrived for their second data collection session, they were fit with a backpack loaded with 13 lbs, which we will refer to as the loaded backpack condition. The backpack straps were adjusted so that the backpack was positioned in the lumbar region, which we defined as having the bottom of the backpack carried just above the posterior superior iliac spine (Picture 2). Each subject completed the same pre-FDST balance tests in the same order as the initial session, but this time wearing the loaded backpack. Once pre-FDST balance data were collected, the subjects completed the same stair task. Upon reaching CRF, each participant again completed post-FDST balance testing.

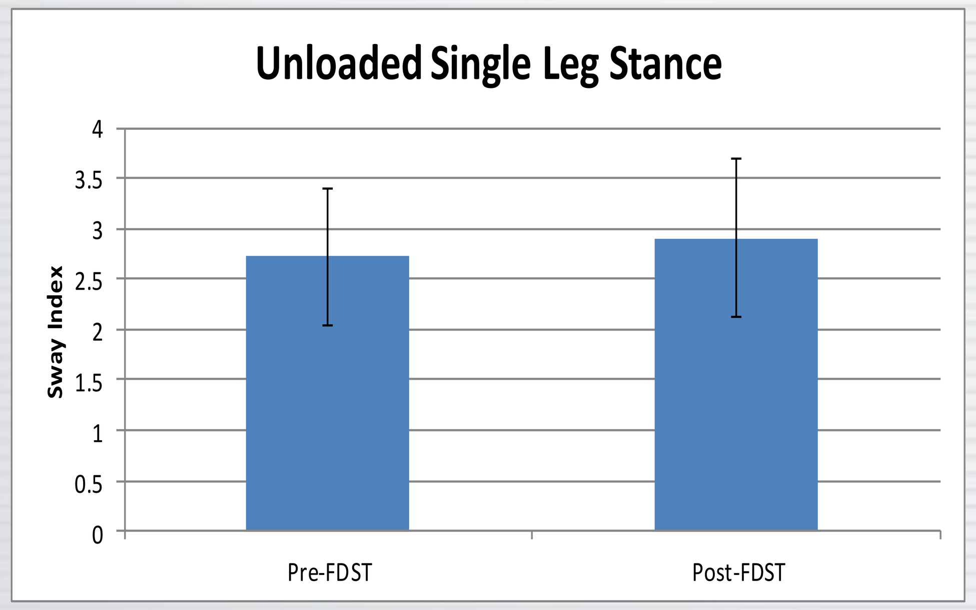

Figure 1

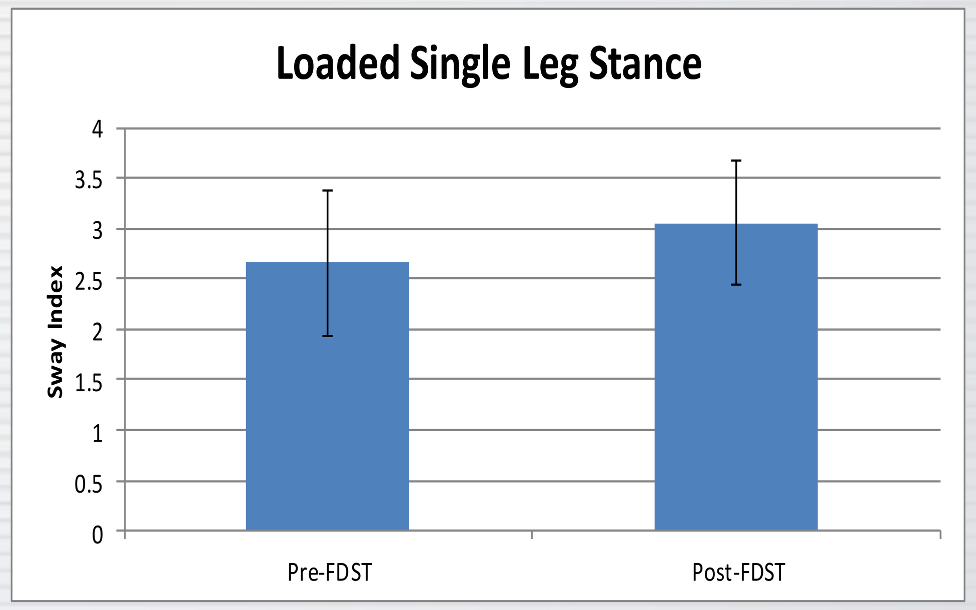

Figure 2

Results

After data was collected, the differences were found between pre-FDST and post-FDST for all balance scores. Then, a paired samples t-test using SPSS Statistics 24 showed no significance ($p \leq 0.05$) when comparing the unloaded to loaded conditions.

Differences Between Post-FDST and Pre-FDST

	UL Double	L Double	UL Single	L Single	UL Tandem	L Tandem	UL Time	L Time	UL Accuracy	L Accuracy
Mean	0.2255	0.2720	0.1360	0.3945	0.0290	0.5955	-5.60	-1.45	4.60	0.10
SD	0.35862	0.36561	1.05863	0.59342	0.99425	0.90274	14.442	11.500	12.902	13.325

Picture 1: BESS Single Stance

Picture 2: Backpack Placement

Conclusion

The data indicated when comparing balance scores before and after the FDST, adding a backpack load does not significantly affect the subjects' balance. Data showed that backpack use, when combined with CRF, does not cause a change in one's balance. CRF was achieved during the FDST by monitoring heart rate, but it was not able to elicit the neuromuscular fatigue needed to impact balance.

For future research, it would be beneficial to assess other variables that could impact balance while wearing a loaded backpack, such as muscular fatigue. Muscles targeted in this future research could include those used for backpack stabilization, such as the abdominal muscles. Prior research does look at muscular fatigue and backpack usage, but the focus was on lower extremity muscular fatigue. This data could be applicable for students, the elderly, or individuals in the military.

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