THE EFFECT OF BACKPACK ON DYNAMIC POSTURAL STABILITY IN YOUNG HEALTHY INDIVIDUALS

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ABSTRACT

Background: Several studies have studied the effect of external disturbances on postural stability. However spinal loading and its effects on dynamic posture have not been reported so far. Objective: To study the effect of backpack on dynamic postural stability in young healthy individuals. Study Design: Observational study. Methodology: 85 healthy, young adults (female, male) fulfilling the inclusion and exclusion criteria were recruited. SEBT was performed with backpack worn on high spinal level on 3 consecutive days with 20%, 10% and without weight. The maximum excursion distance were recorded in 3 excursion directions which are Anterior(A), posteromedial(PM) and posterolateral(PL) directions. Data Analysis: was done by using SPSS version 16. Tukey’s method was used for Pairwise comparison. Result: The result of the study shows that Backpack has significant effect on Dynamic Postural stability. Dynamic Postural Stability affected more by Backpack weighing 20% BW than Backpack weighing 10% BW. Posterolateral Direction without weight has maximum excursion distance i.e. 123cms. Conclusion: The study concluded that spinal loading significantly affects the postural stability.

Key words: Postural stability, backpack, SEBT, spinal loading.
1. INTRODUCTION

The ability to control our body's position in space relies on the complex interaction of the musculoskeletal and neural systems, collectively referred to as the postural control system. Human posture is inherently unstable since two-thirds of the body mass is located two-thirds of body height above the ground.

1.1 Biomechanical aspects and movement strategies of postural control

Postural stability depends on the control of both gravitational forces to maintain posture and acceleration forces to maintain equilibrium. Acceleration forces may be elicited from within the body as a result of voluntary movement or from outside as a consequence of unexpected external disturbance. Mandatory to postural stability is the ability to maintain the body's center of mass (COM) within the limits of the base of support (BOS). When this condition is satisfied, the standing person can resist destabilizing influences of gravity and actively move the COM. Postural control, even during quiet stance, is dynamic, since standing is a quite unstable position characterized by small amounts of spontaneous postural sway and periodic corrections to overcome the destabilizing influence of gravity. Dynamic stability describes the neuromuscular system's capacity to restore or maintain a function successfully, despite naturally occurring disturbances. Because quiet stance is characterized by body sway, movement strategies are required to maintain dynamic postural stability.

Controlling postural stability during walking also is quite different and far more complex than maintaining upright stance. The only stabilizing period during walking is the double-support phase, when both feet are in contact with the ground and the whole-body COM remains within the BOS.

1.2 Sensory system in postural control

Sensory control essentially contributes to the regulation of postural stability while standing as well as walking. Under normal conditions, peripheral sensory inputs from the visual, vestibular, and somatosensory systems are available to detect the body's position and movement in space with respect to gravity and the environment. Each of these sensory systems provides different information and therefore a specific frame of reference for postural control.

1.3 Neurophysiology of postural control

The involvement of spinal, brainstem, cerebellar, and basal ganglia circuits in mediating postural responses during standing could be demonstrated in animal models and by clinical studies in humans. The spinal neural circuitry by itself appears to be able to activate anti-gravity (extensor) muscles tonically for appropriate anti-gravity support. However, postural stability is not solely organized at the spinal level, but requires control by higher supraspinal centers like the brainstem and the cerebellum. Brainstem nuclei were shown to contribute to the regulation of anti-gravity muscle tone, the integration of sensory inputs for balance control, the organization of anticipatory control accompanying voluntary movements, as well as the restoration of equilibrium following disturbance of balance. The cerebellum is an important site for the integration of sensory information into the postural control scheme. It is involved in the adaption and coordination of reactive postural adjustments based on prior practice and experience. Furthermore, the cerebellum is thought to ensure the appropriate scaling of postural response magnitudes for anticipatory postural adjustments. The basal ganglia have been...
proposed to contribute to the ability to quickly modify muscle patterns with respect to changing task and environmental conditions. Correspondingly, it was shown that the dysfunction of basal ganglia due to Parkinson's disease results in an inability to alter the magnitude and pattern of postural responses for changes in postural demands\textsuperscript{21,22}. Therefore, it has been suggested that the basal ganglia are critical for pre-selecting a brainstem response pattern optimal for the initial conditions, with the result that an appropriate response can be rapidly triggered. Cortical involvement in shaping postural responses has been proposed to contribute (1) via a cerebellar-cortical loop to the adaption of postural responses based on prior experience, and (2) via a ganglia-cortical loop to the pre-selection and optimization of postural responses based on current context\textsuperscript{23}.

1.4 Star Excursion Balance Test

SEBT is dynamic postural control test requires balance on one leg with maximum reach of the opposite leg. There are 8 directions for the stance leg, only 3 directions were assessed in this study limited to Anterior(A), posteromedial(PM) and posterolateral(PL) directions\textsuperscript{24}.

1.5 Additional loading & postural stability

The postural stability is also result of voluntary or involuntay movements in response to unexpected external disturbances.\textsuperscript{3} These disturbances can be overloading(OL) or underloading(UL). It is suggested that in OL, augmented ankle joint torques are compensated by quick reflex-induced postural reactions in distal muscles. Contrarily, UL is associated with diminished joint torques and thus, postural equilibrium may be controlled by the proximal segments to adjust the center of gravity above the. However spinal loading and its effects on dynamic posture have not been reported so far.\textsuperscript{25}

The purpose of the study was to find out whether backpack affects the postural stability of young healthy individuals. To find out which affects dynamic postural stability more, backpack weighting 10\% BW or 20\% BW. To find out in which direction reach distance is maximum.

2. METHODOLOGY

2.1 Design Overview : The study is observational

2.2 Sampling : Convenience sampling method

2.3 Sample

The Subjects for the study were recruited from T.D.T.R. DAV institute of physiotherapy and rehabilitation Yamunanagar and M.D.M. Dental College, Yamunanagar.

2.4 Inclusion criteria

- Age 18 to 25
- Both males and females
- Young healthy individual
- Not engaged in any athletic activity
- No joint pain
- No surgical procedure

2.5 Exclusion criteria

- prior balance training
- History of any dizziness
- Any inner ear disorders
- Any nervous system problems
- Any bone or joint abnormalities
- Any uncorrected problems with vision

2.6 Procedure
85 healthy, young adults (female, male) fulfilling the inclusion and exclusion criteria were recruited. All participants prior to the study signed a voluntary consent form that was approved by the college review board. Height, weight and leg length was measured. The test was explained to each participant verbally, allowing the participants to ask any questions regarding the test. Testing for each individual was separated. A test separation goal of 3 days was determined:
- On day 1st all participants performed SEBT without weight.
- On day 2nd all participants performed SEBT with a backpack worn at high spinal level i.e. (superior aspect of backpack being placed at C7) weighing 10% of their body weight.
- On day 3rd all participants performed SEBT with a backpack being placed at same level, weighing 20% of their body weight.

2.7 Tool Used
Star Excursion Balance Test- 3 excursion directions were assessed which are Anterior(A), posteromedial(PM) and posterolateral(PL) directions. The reach directions were evaluated by affixing three Measuring Tape to the gymnasium floor, one orientated Anterior (A) to the Apex and two aligned at 135° in the Posteromedial (PM) and Posterolateral (PL) directions. The participants was asked to reach as far as possible along each 3 reach directions. The researcher recorded each reach distance with a mark on the Measuring tape as the distance from the center to the point of maximum excursion by the reach leg. And return the reaching leg back to the center. All trials were conducted barefoot to eliminate additional balance and stability gained from shoes. Each participant undertook 4 practice trials in each direction to minimize learning effect immediately prior to the test session following a 5 min rest period, participants performed 3 trails in each of 3 reach directions. The trial was discarded and repeated if the Participants:-
- Failed to maintain unilateral stance.
- Lifted or moved the stance foot from the center of 3 consecutive lines.
- Failed to return the reach foot to the center point.

3. RESULTS
To find out the effect of backpack on dynamic postural stability in young healthy individuals, descriptive statistics, F-ratio, Pearson Moment coefficient correlations were computed by using SPSS version 16 and data pertaining to this, has been presented in Table 1 to 4 and depicted figure 1 to 6.
### TABLE 1 (a)
**COMPARISON AMONG ANTERIOR (A), POSTEROMEDIAL (PM) AND POSTEROLATERAL (PL) DIRECTIONS WITHOUT WEIGHT**

<table>
<thead>
<tr>
<th>Directions</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>Max. Execursion</th>
<th>Mini. Execursion</th>
<th>Range</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior Direction</td>
<td>88.52</td>
<td>13.69</td>
<td>85</td>
<td>115</td>
<td>58</td>
<td>57</td>
<td>6.79*</td>
</tr>
<tr>
<td>Posteromedial</td>
<td>92.48</td>
<td>13.81</td>
<td>85</td>
<td>120</td>
<td>61</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Posterolateral</td>
<td>96.27</td>
<td>13.63</td>
<td>85</td>
<td>123</td>
<td>64</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

Significant at .05 level.  
F.05 (2, 252)=3.032

### TABLE 1 (b)
**TUKEY’S METHOD FOR PAIRWISE COMPARISON**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>PM</th>
<th>PL</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>88.52</td>
<td>92.48</td>
<td>-</td>
<td>3.96</td>
<td></td>
</tr>
<tr>
<td>88.52</td>
<td>-</td>
<td>96.27</td>
<td>7.76*</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>92.48</td>
<td>96.27</td>
<td>3.79</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at .05 level

Table 1 (a) and (b) indicates that calculated F value 6.79 is more than Table value that is 3.032 at 5% level of significance. So, Result is significant b/w Directions without wt. Pairwise comparison showing 7.76 significant difference b/w A and PL directions. So, Result is significant b/w A and PL directions. The difference were not significant b/w A and PM, PM and PL directions.

### TABLE 2 (a)
**COMPARISON AMONG ANTERIOR (A), POSTEROMEDIAL (PM) AND POSTEROLATERAL (PL) DIRECTIONS WITH 10% BODY WEIGHT.**

<table>
<thead>
<tr>
<th>Directions</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>Max. Execursion</th>
<th>Mini. Execursion</th>
<th>Range</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior Direction</td>
<td>85.15</td>
<td>13.87</td>
<td>85</td>
<td>109</td>
<td>52</td>
<td>57</td>
<td>6.16</td>
</tr>
<tr>
<td>Posteromedial</td>
<td>88.91</td>
<td>13.52</td>
<td>85</td>
<td>116</td>
<td>58</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Posterolateral</td>
<td>92.48</td>
<td>13.44</td>
<td>85</td>
<td>119</td>
<td>60</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level  
F.05 (2, 252)=3.032

### TABLE 2 (b)
**TUKEY’S METHOD FOR PAIRWISE COMPARISON**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>PM</th>
<th>PL</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.15</td>
<td>88.91</td>
<td>-</td>
<td></td>
<td>3.76</td>
</tr>
<tr>
<td>85.15</td>
<td>-</td>
<td>92.48</td>
<td>7.33*</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>88.91</td>
<td>92.48</td>
<td>3.57</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at .05 level

Table 2 (a) and (b) indicates that calculated F value 6.16 is more than Table value that is 3.032 at 5% level of significance. So, Result is significant b/w Directions with 10% BW. Pairwise comparison showing 7.33 significant difference b/w A and PL directions. So, Result is significant
b/w A and PL directions. The difference were not significant b/w A and PM, PM and PL directions.

TABLE 3 (a)
COMPARISON AMONG ANTERIOR (A), POSTEROMEDIAL(PM) AND POSTEROLATERAL(PL) DIRECTIONS WITH 20% BODY WEIGHT.

<table>
<thead>
<tr>
<th>Directions</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>Max. Execursion</th>
<th>Mini. Execursion</th>
<th>Range</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior Direction</td>
<td>81.94</td>
<td>13.81</td>
<td>85</td>
<td>106</td>
<td>50</td>
<td>56</td>
<td>5.50*</td>
</tr>
<tr>
<td>Posteromedi al Direction</td>
<td>85.36</td>
<td>13.35</td>
<td>85</td>
<td>111</td>
<td>55</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Posterolateral Direction</td>
<td>88.80</td>
<td>13.27</td>
<td>85</td>
<td>113</td>
<td>57</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level
F.05 (2, 252)=3.032

TABLE 3 (b)
TUKEY'S METHOD FOR PAIRWISE COMPARISON

<table>
<thead>
<tr>
<th>A</th>
<th>PM</th>
<th>PL</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.94</td>
<td>85.36</td>
<td>-</td>
<td>3.42</td>
</tr>
<tr>
<td>81.94</td>
<td>-</td>
<td>88.80</td>
<td>6.86*</td>
</tr>
<tr>
<td>-</td>
<td>85.36</td>
<td>88.80</td>
<td>3.44</td>
</tr>
</tbody>
</table>

*Significant at .05 level

Table 3 (a) and (b) indicates that calculated F value 5.50 is more than Table value that is 3.032 at 5% level of significance. So, Result is significant b/w Directions with 20% BW. Pairwise comparison showing 6.86 significant difference b/w A and PL directions. So, Result is significant b/w A and PL directions. The difference were not significant b/w A and PM, PM and PL directions.

TABLE 4
CORRELATION BETWEEN HEIGHT AND LEG LENGTH.

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Age</th>
<th>Height (in cms)</th>
<th>Leg length (cms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A without wt</td>
<td>- .229*</td>
<td>.450**</td>
<td>.513**</td>
</tr>
<tr>
<td>A '10% BW</td>
<td>- .231*</td>
<td>.436**</td>
<td>.490**</td>
</tr>
<tr>
<td>A '20% BW</td>
<td>- .223*</td>
<td>.413**</td>
<td>.455**</td>
</tr>
<tr>
<td>PM without wt</td>
<td>- .228*</td>
<td>.430**</td>
<td>.505**</td>
</tr>
<tr>
<td>PM '10% BW</td>
<td>- .217*</td>
<td>.437**</td>
<td>.500**</td>
</tr>
<tr>
<td>PM '20% BW</td>
<td>- .212</td>
<td>.437**</td>
<td>.490**</td>
</tr>
<tr>
<td>PL without wt</td>
<td>- .208</td>
<td>.427**</td>
<td>.533**</td>
</tr>
<tr>
<td>PL '10% BW</td>
<td>- .195</td>
<td>.452**</td>
<td>.544**</td>
</tr>
<tr>
<td>PL '20% BW</td>
<td>- .191</td>
<td>.443**</td>
<td>.529**</td>
</tr>
</tbody>
</table>

Significant at the 0.05 level r.05 (83)=0.213

Table 4 indicates that there is strong correlation between height and leg length at 5% level of significance.
**Figure 1:** Comparison between directions without weight.

**Figure 2:** Comparison between directions with 10% BW.

**Figure 3:** Comparison between Weights in Anterior direction.
Figure 4: Comparison between directions with 20% BW.

Figure 5: Comparison between Weights in Posteromedial direction.

Figure 6: Comparison between Weights in Posterolateral direction.

4. DISCUSSION

While carrying a Backpack, it may happen that the total weight on the body increases. Due to this the direction and magnitude of the resultant force changes that leans the body in forward direction. Finally the body's center of gravity changes affecting the postural stability. A healthy body compensates for this change to maintain stability commonly; the head is raised up to prevent falling forward. If body's adjusting capacity is exceeded, health is affected.
Depending upon the magnitude, direction, frequency and duration of the external forces due to Backpacks one or more of the following may happen either instantaneously or over time: Tiredness or muscle fatigue, swelling, pain in the head, neck, back, shoulders, arms or hands, muscle spasms or stiffness, tingling or numbness, curved or rounded back, Altered gait.

The immediate result of carrying too much unbalanced weight for too long is muscle soreness and strained ligaments. Researchers have found that Backpacks lead to restricted movement of spine and altered the fluid content of discs, making the individuals a prime candidate for permanent structural damage such as herniated (“slipped”) disc and degenerative arthritis of spine later in life. This arthritis leads to LBP. Chronic LBP leads to reduced proprioception in spine causes altered balance and postural stability.

Spinal joints between adjacent vertebrae are rich in mechanoreceptor nerve fibers that supply information to the brain. This reflex pathway is necessary for vestibular and ocular righting reflex actions, normal spinal coupling motions, balance and proprioception. As a joint is compressed inflammation result, as well as a decreased mobility of nutrients getting into the joint. Joints are not lubricated or nourished as efficiently and joint pathology results, which destroys the reflex arc to the brain. As the arc is destroyed: the individual will gradually lose his/her expected coupling motion, righting reflex actions, ability to maintain static and dynamic postural stability and balance under gravity. So, carrying external weights affect the dynamic postural stability.

5. CONCLUSION

- It is concluded that Backpack has significant effect on Dynamic Postural stability in young healthy individuals.
- Both Backpack weighing 10% BW and 20% BW affect the dynamic Postural Stability but Dynamic Postural Stability affected more by Backpack weighing 20% BW than Backpack weighing 10% BW.
- Posterolateral Direction without weight has maximum excursion distance i.e. 123cms.

6. LIMITATION

- Non-highly equipped instruments.
- This study recruited both males and females. Males and females are different in many aspects for example, there Anthropometric estimates are different. Hence, the application of different backpack weights may lead to different responses between genders.
- Learning effect may has being present since practice was provided before data collection these effects are throughout unlikely to have substantially influenced the experimental findings.

7. FUTURE SCOPE

- Effects of backpack weight on postural deviation.
- To determine gender differences on posture stability.

REFERENCES
