Correlation between Postural Sway and Dynamic Balance in Patients with Diabetic Neuropathy

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ABSTRACT

Aim and objectives of the study - To study and find out the correlation between postural sway and dynamic balance in diabetic neuropathy patients.

Method – Total 145 individuals were screened for MNSI and the individual who fulfilled the inclusion and exclusion criteria were included in the study according to the sample size, 60 patients were selected. Postural sway was assessed by Modified Clinical Test of Sensory Interaction on Balance (mCTSIB) test of posturography by balance master and Dynamic balance was assessed by Dynamic Gait Index (DGI). Data was recorded and then analyzed with Spearman’s correlation coefficient test.

Outcome measures: MNSI questionnaire, Modified Clinical Test of Sensory Interaction on Balance, Dynamic Gait Index

Results - The correlation between postural sway in 4 different situations (eyes open and eyes closed on firm surface and foam surface) and dynamic balance was correlated. The correlation of postural sway (eyes open, firm surface) and the total score of DGI showed statistically significant negative correlation. But the correlation coefficient indicated low negative correlation with r value of -0.312. The correlation of postural sway (firm surface eyes closed) and the total score of DGI showed statistically significant negative correlation. But the correlation coefficient indicated low negative correlation with r value of -0.44. The correlation of postural sway (eyes open, foam surface) and the total score of DGI showed statistically significant negative correlation. But the correlation coefficient indicated low negative correlation with r value of -0.317. The correlation of postural sway (foam surface, eyes closed) and total score of DGI statistically showed no significance.

Conclusion - There is no correlation between postural sway and dynamic balance in diabetic neuropathy patients.

Discussion - In the present study, which was done to correlate postural sway and dynamic balance in diabetic neuropathy patients. A weak negative correlation was found between postural sway on firm surface (EO), (EC), foam surface (EO) and dynamic balance in diabetic neuropathy patients and no correlation was found between postural sway on foam surface (EC) and dynamic balance in diabetic neuropathy patients.

Keywords - Postural sway, Dynamic balance, Diabetic neuropathy.

INTRODUCTION

Diabetes mellitus is fast gaining and one of the most common metabolic and chronic disorders across the world. Globally there were 366 million people affected with diabetes in 2011 and it is expected that it will rise to 552 million by 2030¹. Diabetic neuropathy (DN) is the common and most frequent complication of diabetes mellitus and the incidence increasing with the duration of diabetes².
Balance is the maintenance or restoration of a person’s centre of mass within their limits of stability. The balance depends on motor factors (ROM and muscle strength) and sensory factors (vestibular, visual, and proprioceptive). Lack of accurate proprioceptive feedback and loss or reduction of peripheral sensory information from the feet leads to an inability of central nervous system to appropriately integrate with available postural control information about balance. These factors might result in impaired balance in diabetic neuropathy patients. Postural sway is the movement of the COM in a standing position. Postural sway is often quantified by measuring the motion of centre of pressure (COP). COP shift profiles are closely related to sway of centre of mass. DN patients have been reported to have large changes in postural sway compared with normal individuals. A computerized dynamic posturography system is an assessment technique which can measure postural control by measuring postural sway.

Dynamic balance is ability to perform a task while maintaining stable position. Dynamic gait index is a clinical tool developed to assess dynamic balance and risk of fall. It evaluates both steady state walking and walking during more challenging tasks. Previous studies reported that postural sway increases with ageing. There are studies which concluded that increase in postural sway causes reduction in dynamic balance and in contrast to these, there are also studies done which stated that reduction in postural sway does not necessarily improves dynamic balance. There is dearth of literature regarding balance problem in diabetic neuropathy patients. So there was a need to find out correlation between postural sway and dynamic balance in diabetic neuropathy patients.

Study Population: Individuals with diabetic neuropathy.

Inclusion Criterion:
1. Patients diagnosed with diabetic neuropathy; on MNSI - 7 and Physical assessment - 2 to 8
2. Age more than 40 yrs
3. Patients who understand English.

Exclusion Criteria:
1. Diabetic ulcer and deformities secondary to them
2. Amputation
3. Diabetic retinopathy or blindness
4. Vestibular disorder.
5. Spinal and lower limb injuries.
6. Other Neurological and musculoskeletal impairments.

Outcome measures:
1. MNSI questionnaire
2. Modified Clinical Test of Sensory Interaction on Balance
3. Dynamic gait index

Study settings: Community based
Sampling technique: Purposive sampling

Sample size: Sample size was 60 with 19.1% prevalence, 5% level of significance and 90% power of test using Daniel formula. This sample size was calculated with the help of biostatistician using formula

\[ n = \frac{Z^2 \cdot p \cdot (1-p)}{d^2} \]

Where,
- \( n \) = The desired sample size
- \( Z \) = Level of confidence according to standard normal distribution
- \( p \) = Prevalence
- \( d \) = Margin of error acceptable

Procedure- Ethical clearance was obtained from the institutional ethics committee. Individuals from age above 40 years from community were approached for the study. Both males and females were included. Interested individuals were asked to fill the history part of the MNSI for the information about diabetic neuropathy and the other part of physical assessment was completed by
myself. Total 145 individuals were screened for MNSI and the individual who fulfilled the inclusion and exclusion criteria were included in the study. Written consent was taken from these individuals. Postural sway was assessed by using, Neuro-Com basic balance manager i.e. Basic Balance Master (Version 9.2) from Natus balance and mobility. Modified Clinical Test of Sensory Interaction on Balance of posturography was used to assess postural sway. Dynamic balance was assessed by dynamic gait index. Data was recorded and then analyzed with Spearman’s correlation coefficient test.

**Modified Clinical Test of Sensory Interaction on Balance (mCTSIB) foam and firm surface**

The mCTSIB provides a means to quantify postural control under various sensory conditions. It assesses patient’s postural sway under a variety of conditions to infer the source of instability. Standing on firm surface, (eyes open, eyes closed) Standing on foam surface,(eyes open and eyes closed). The patient performance is timed for 10 seconds each for 3 trails. Test is terminated when a subject's arm or feet change position. Time is stopped during a trial and recorded if, Patient deviates from initial crossed arm position, Patient opens eyes during an “eyes closed” trial condition, or Patient moves feet (takes a step) or requires manual assistance to prevent loss of balance. The best performance of 3 trails was used for data analysis.
Standing on firm and foam surface with eyes open and eyes closed.

**Statistical analysis**- The statistical analysis was done with Spearman’s correlation coefficient test. The estimated sample size for the study was 60 and the participants were selected according to inclusion and exclusion criteria. All the participants were assessed based on MCTSIB and DGI and analyzed further.

**Results**- The obtained results after analysis are plotted in the form of tables and graphs below.

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>FREQUENCY</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-50</td>
<td>9</td>
<td>15.0</td>
</tr>
<tr>
<td>51-60</td>
<td>19</td>
<td>31.7</td>
</tr>
<tr>
<td>61-70</td>
<td>21</td>
<td>35.0</td>
</tr>
<tr>
<td>71-80</td>
<td>11</td>
<td>18.3</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100.0</td>
</tr>
</tbody>
</table>

1. Table and graph of age wise distribution of subjects

<table>
<thead>
<tr>
<th>SEX</th>
<th>FREQUENCY</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALE</td>
<td>30</td>
<td>50.0</td>
</tr>
<tr>
<td>FEMALE</td>
<td>30</td>
<td>50.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>60</td>
<td>100.0</td>
</tr>
</tbody>
</table>

2. Table and graph of gender wise distribution
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<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. Error</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>60</td>
<td>61.42</td>
<td>9.30</td>
<td>1.20</td>
<td>34.00</td>
<td>44.00</td>
<td>78.00</td>
</tr>
<tr>
<td>FIRM EO</td>
<td>60</td>
<td>0.40</td>
<td>0.14</td>
<td>0.02</td>
<td>0.70</td>
<td>0.20</td>
<td>0.90</td>
</tr>
<tr>
<td>FIRM EC</td>
<td>60</td>
<td>0.54</td>
<td>0.22</td>
<td>0.03</td>
<td>0.90</td>
<td>0.30</td>
<td>1.20</td>
</tr>
<tr>
<td>FOAM EO</td>
<td>60</td>
<td>0.79</td>
<td>0.17</td>
<td>0.02</td>
<td>0.80</td>
<td>0.50</td>
<td>1.30</td>
</tr>
<tr>
<td>FOAM EC</td>
<td>60</td>
<td>1.58</td>
<td>0.35</td>
<td>0.04</td>
<td>1.50</td>
<td>0.60</td>
<td>2.10</td>
</tr>
<tr>
<td>TOTAL SCORE</td>
<td>60</td>
<td>20.82</td>
<td>2.42</td>
<td>0.31</td>
<td>7.00</td>
<td>17.00</td>
<td>24.00</td>
</tr>
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</table>

3. Table of descriptive statistics of each variable

<table>
<thead>
<tr>
<th>TOTAL SCORE OF DGI</th>
<th>FIRM EO</th>
<th>Spearman’s Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-0.312</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.015</td>
<td>(p&lt;0.05), Significant</td>
</tr>
</tbody>
</table>

Inference: Negative correlation

4. Correlation of total score of DGI and eyes open firm surface in mCTSIB test of posturography

<table>
<thead>
<tr>
<th>TOTAL SCORE OF DGI</th>
<th>FIRM EC</th>
<th>Spearman’s Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.44</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.001</td>
<td>(p&lt;0.001), Highly Significant</td>
</tr>
</tbody>
</table>

Inference: Negative correlation

5. Table and graph of correlation of total score of DGI and eyes closed firm surface in mCTSIB test of posturography

<table>
<thead>
<tr>
<th>TOTAL SCORE OF DGI</th>
<th>FOAM EO</th>
<th>Spearman’s Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.317</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.013</td>
<td>(p&lt;0.05), Significant</td>
</tr>
</tbody>
</table>

Inference: Negative correlation

6. Correlation of total score of DGI and eyes open foam surface in mCTSIB test of posturography
DISCUSSION

The present study was conducted in order to investigate the correlation between postural sway and dynamic balance in dynamic neuropathy patients. All the participants were assessed for Postural sway and dynamic balance.

Table and graph no 4 describe the correlation between postural sway measured on firm surface(stable) with eyes open and the total score of DGI.

This showed a statistically significant negative correlation. But the correlation coefficient indicated a low negative correlation with r value of -0.312.

This conveyed that the postural sway velocity increases as the score of DGI decreases.

Due to the similarity between surfaces, the sensory systems which were acting during the test on balance master and on the ground while performing DGI were the same. Also in addition to this, the eyes were open during both the conditions. Due to this, the dynamic gait index score did not reduce even if the postural sway was increased.

There was a low negative correlation between postural sway and dynamic balance this may be due to the difference in the motor pattern recruitment during mCTSIB test and dynamic gait index. The components of DGI were similar to those which were performed during activities of daily life. Due to repeated practice and performance of similar task one gets adapted to these activities. So because of these adaptations the deviations while performing a dynamic gait index cannot be appreciated completely by naked eyes. But in balance master as the force plate is very sensitive, it detects the mild changes occurring in postural sway velocity in every direction.

Table and graph no 5 describe the correlation between postural sway measured on firm surface eyes closed and the total score of DGI.

This showed a statistically significant negative correlation. But the correlation coefficient indicated a low negative correlation with r value of -0.44.

When we stand on the balance master force plate and when we perform on the ground surface, the supporting surface remains similar that is both are firm surface this could be the reason for the correlation between postural sway and dynamic balance in this condition.

Normally the individual uses the vestibular and somatosensory system to maintain their balance in eyes closed condition because the visual system is eliminated. But as in diabetic peripheral neuropathy, the somatosensory system may be affected and in addition to that if the visual inputs are also blocked so, this may be the reason that the postural sway velocity was increased. This can be supported by an article, “postural sway in diabetic peripheral neuropathy among Indian elderly” stated that postural stability was affected in...
participants with diabetic neuropathy and was further worsened when vision was occluded. In addition to this, the motor pattern recruitment while performing DGI and performing mCTSIB test were different. So this may be the factors due to which the low negative correlation was found in postural sway and dynamic balance.

Table and graph no 6 describe the correlation of postural sway measured on foam surface eyes open and the total score of DGI.

This showed a statistically significant negative correlation. But the correlation coefficient indicated a low negative correlation with r value of -0.317.

In this condition, the vestibular and visual system were contributing for maintenance of the center of mass within the base of support. While performing DGI components at least any two systems from somatosensory, visual and vestibular were contributing for maintaining center of mass within base of support. Due to these factors there was a correlation between postural sway and dynamic balance.

In diabetic peripheral neuropathy, the proprioceptive and somatosensory input could be altered. The proprioceptive and somatosensory input which one gets on foam surface and ground surface were different. During mCTSIB test performed with eyes open on foam surface, proprioceptive and somatosensory input that were the movable surface and texture of the surface had already challenged in this condition so this may be the reason for postural sway to increased. Motor pattern recruitment on foam surface and ground surface, changing center of mass over the base of support while performing components of dynamic gait index was different which may cause a reduction in dynamic gait index score.

Table and graph no7 describe the correlation of postural sway measured on foam surface eyes closed and the total score of DGI.

In this condition, there was no statistical difference found between postural sway and dynamic balance. Because this situation was more complicated as compared to other conditions mentioned above (firm with eyes open and eyes closed, foam eyes open), in eyes open condition there were visual cues, vestibular inputs to maintain the postural stability but in this condition proprioception, somatosensory inputs were altered, and visual cues were blocked. In contrast to this while performing components of DGI minimum two systems were intact in each component. Also, the surface was familiar while performing DGI.

In this study, the correlation of following was done:
1. Total score of DGI versus postural sway velocity on firm surface with eyes open.
2. Total score of DGI versus postural sway velocity on firm surface with eyes closed.
3. Total score of DGI versus postural sway velocity on foam surface with eyes open.
4. Total score of DGI versus postural sway velocity on foam surface with eyes closed.

In the first three conditions, there were at least two systems acting among the visual, somatosensory, and vestibular due to which the low negative correlation was observed.

As compared to the first three conditions forth condition was maximally challenging. So, this may be the reason that there was no significant correlation between the postural sway and the dynamic balance.

Many studies done before concluded that an increase in postural sway has been shown to be associated with a reduction in balance ability which leads to an increased incidence of falls. In addition to this study, Niam et.al also reported a negative correlation of postural sway with dynamic balance (BBS) in stroke patients.

In contrast, the finding of the present study showed low negative correlation between postural sway measured on firm surface eyes open and eyes closed and foam surface eyes open and total score of DGI for dynamic balance in diabetic peripheral
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neuropathy patients. There was no significant correlation found in postural sway measured on foam surface with eyes closed and the total score of DGI for dynamic balance.

Also, there were some previous studies done to investigate the relationship between postural sway and dynamic balance which concluded that postural sway does not mean poor balance.\textsuperscript{26,27} The increase in postural sway may be due to maintain the postural stability and thus prevent falling.\textsuperscript{9} In diabetic peripheral neuropathy patients there may be the affection of either or both the small and large nerve fiber in limbs which may affects the proprioception and the somatosensory system.\textsuperscript{39,40,41} To prevent falls or to maintain the postural stability and to maintain the center of mass within the base of support there are movements made by the body which is known as postural sway.

Thus the result of the present study indicated it is not necessary that, an increase in postural sway indicates poor balance. To maintain the relation of the center of mass and base of support the postural sway occurred.\textsuperscript{9,10} Thus it can be said that a decrease in postural sway does not necessarily reflect an improvement in dynamic balance. Thus the finding of the study may be helpful in balance rehabilitation to prevent falls with the patient having diabetic peripheral neuropathy.

**CONCLUSION**

There is no correlation between postural sway and dynamic balance in diabetic neuropathy patients.

**Clinical implication**- Decrease in postural sway does not necessarily reflect improvement in dynamic balance in diabetic neuropathy patients.

**REFERENCES**

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