EFFECT OF BALANCE EXERCISE ON BALANCE CONTROL IN UNILATERAL LOWER LIMB AMPUTEES

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Abstract:

OBJECTIVES: 1. To study the effect of balance exercise on balance control of unilateral lower limb amputees.
2. To study the difference in balance control in Trans Femoral and Trans Tibial amputees.

METHODOLOGY: Thirty unilateral Trans-femoral and Trans-tibial amputees were selected and divided into two groups of 15 each. Control group received conventional training and Experimental group received conventional training along with Phyaction balance exercise. Duration of treatment was 30 minutes, five days a week for four weeks. Pre and Post training evaluation of functional reach, and Global balance performance was done for both the groups. Statistical analysis was done by t test.

RESULT: Statistically significant improvement was seen in all the outcome measures in experimental group and no significant improvement was seen in case of control group which shows that balance exercise is effective in controlling balance in unilateral lower limb amputees.

CONCLUSION: Early phase balance exercise is effective in controlling balance of unilateral lower limb amputees. Area covered by the non-affected limb was more in comparison to the prosthetic limb, so strengthening of the non-affected limb should be incorporated in the rehabilitation of unilateral lower limb amputees.

Keywords: Balance training, Amputees, perturbation, Prosthesis.

INTRODUCTION:

Postural stability is essential to the performance of most daily activities and is necessary to lead an independent life. Gait and balance impairments may increase the risk of falls, the leading cause of accidental death. Fall related injuries constitute a serious public health problem associated with high costs for society as well as human suffering.

In able-bodied individuals the ankle joint and leg musculature play an important role in maintaining balance by appropriately shifting the center of pressure.

The reorganization of standing balance after a lower limb amputation is considered, with emphasis on persons with an acquired unilateral amputation above the ankle and below the hip joint. In the first section, three major peripheral motor and sensory impairments are discussed: (a) a lack of ankle torque generation to restore equilibrium in the sagittal plane, (b) a lack of weight-shifting capacity to control posture in the frontal plane and (c) a distorted somato-sensory input from the side of amputation.

Falling is an important clinical problem in amputee population. Balance confidence was the only factor associated with mobility capability and performance and social activity.

Miller WC et al 2001 in their study with 435 unilateral below knee and above knee lower limb amputees found that exactly 52.4% subjects reported falling in the past year, whereas 49.2% reported a fear of falling and concluded that Falling and fear of falling are pervasive among amputees.

Hof AL et al (2007) studied control of lateral balance in walking of Trans femoral amputees and their study found that amputees showed asymmetric gait with shorter stance (60%) at the prosthetic side versus 68% at the non-prosthetic side.

Backley JG et al (2002) studied balance performance of lower limb amputees during quiet standing and under dynamic conditions. They used a single axis stabilimeter to assess the center of pressure (COP) excursions in both the situations and found that Amputees had a greater problem controlling dynamic balance in the antero-posterior direction than mediolateral direction.
A.H. Vrieling et al (2008) in their study with unilateral trans femoral and trans tibial amputees studied that the ability to cope with balance perturbations is limited in prosthetic limb due to absence of ankle strategy.

Chiari, L.; et al 2005 in their study used prototype audio-biofeedback system for balance improvement through the sonification using trunk kinematic information and found that it is effective in controlling balance.

Nicholas et al 1997 in their study used force platform using audio and visual feedback for balance control in hemiplegic stroke patients and found that feedback can be used to improve balance.

Several studies have mentioned static balance tests and few studies mentioned regarding dynamic balance tests. Most of the studies have used weight-bearing training for unilateral lower limb amputees, which may not be sufficient for maintaining balance in daily activities since balance control is often required during ambulation which is a dynamic activity. Falls regularly occur when balance control is hindered by an external perturbation. So it is important to train balance by using perturbations. In this study an attempt has been made to see the effect of early phase balance training by support surface perturbations in unilateral lower limb amputees.

AIMS & OBJECTIVES:
1. To study the effect of balance training on balance control of unilateral lower limb amputees in their early phase of rehabilitation.
2. To find out the difference in the improvement of balance in unilateral Trans- Femoral and Trans-Tibial amputees.

MATERIAL & METHOD

SUBJECTS:
Thirty patients with unilateral lower limb amputees both Trans-femoral(TF) and Trans-tibial(TB) attending outpatient Occupational Therapy department, outpatient Prosthetic and Orthotic department and Inpatient Rehabilitation ward, NIOH were selected for the study and divided into two groups of fifteen each. Group A was the Experimental group and Group-B was the control group. Evaluation of the entire outcome measures, both pre and post training were done by an Occupational therapist unaware of the study results.

INCLUSION CRITERIA-
- Age-18-55 years
- Amputation at least two months earlier
- Early phase of prosthetic training
- Ability to stand with a prosthesis without walking aids for at least 30 minutes
- Ability to perform Balance exercise level -2 in the balance exercise equipment.

EXCLUSION CRITERIA
- Impaired hearing and vision
- Having medical conditions that could affect their ability or balance
- Reduced sensation of the non-affected limb.
- Pain at the stump and fitting problems of the prosthesis

APPARATUS:
Phyaction balance exercise is an apparatus having a balance exercise soft ware installed in the personal computer/Laptop and a hard ware (Proprioceptive board/tablet) attached to it with a connecting cable. The apparatus is fitted with an internal electrical supply. The Board is of moving fulcrum type. The fulcrum changes with the changes in the board position. The board rolls on the balancing shapes that have a suitable diameter. Three pairs of interchangeable shapes are available. The board is attached with an encoder that detects its position. The encoder is operated through a lever that is in contact with the floor. The encoder is connected to an electronic card that reads the angle of the board top surface with respect to the floor on which the board rests and sends the reading to the PC through a USB port. The interface graphics of the tablet were designed by using the interactive graphic controls that are typical of the Windows operating systems.

- Dimensions: 420x430x65mm
- Weight 2.5Kg
- Maximum patient’s weight: 100Kg
- Movement range:- -15, +15 degrees

The equipment provides perturbation along with auditory and visual feedback.

MATERIALS:
Measuring tape for functional reach measurement.
Laptop and connecting cables.

OUTCOME MEASURES:-
Functional reach, Balance exercise parameter (Total area covered by both the feet) and the Global performance of balance.
DURATION OF BALANCE TRAINING:
30 minutes a day, five times a week for four weeks

PROCEDURE:
The amputee patients who fit the inclusion criteria were allotted to two groups by convenient sampling method after getting informed consent. All the amputees were using conventional TF and TT prosthesis. A general history was taken from the patient and individual patient demographics along with date of accident were saved in the data sheet provided by the balance exercise software. Baseline measurement of Functional Reach, and balance exercise performance, total area covered by both prosthetic limb and the non-affected limb, Global for both antero-posterior(AP) stability control and medio-lateral(ML) stability control for both trans-femoral and trans-tibial amputees were taken. Global performance is weighed average (a number from 0 to 100) of the 8 calculated parameters. The parameters are total area covered within the profile, Extra area outside the profile, Extra time taken and Recovery time. A score of 100 is the worst case and zero is the best. Experimental group received Phyaction balance exercise with conventional training and control group received conventional training only, which consisted of parallel bar training in front of a full-length mirror.

PHYACTION BALANCE EXERCISE:
On the first day of training level of balance exercise performance of the patients’ was evaluated. Patients stood erect on the moving Board with their hands alongside their bodies. Patients were instructed to stand with both feet on the floor as motionless as possible to maintain balance while the board sways over a diameter of 40 centimeter both in medio-lateral and antero-posterior direction. For safety purpose one therapist stood near by the patient. The movement of the board was set in the exercise program for individual patients. Feet position selected for the patient was bilateral, position of the patient was standing, Board heading was straight for medio-lateral balance control exercise and transversal for antero-posterior balance exercise. Graphic presentation of the exercise was set complete which will show the board and the graphic presentations on the screen. Each patient got both visual and auditory feedback from the screen. The amplitude and frequency of movement was set to be 3 degrees and 3 cycles/min respectively. Patient was asked to stand on the Proprioceptive board and the program was set starting from level one exercise. If the patient could do level-1 without any error then the next level of exercise was done. Initially most of the patients could do balance level two, so the exercise was set starting from balance level-3 and progressed to the next levels as the patient’s ability to control balance progressed without covering extra area. With the improvement of the patient’s ability the level of difficulty was increased. All the patients in the Experimental group received 15 minutes of medio-lateral balance control exercise and 15 minutes of antero-posterior balance control exercise. Each 15 minutes were divided into 5 sets of exercise of 3 minutes each set. After each three minutes of exercise patients received 1 minute rest. Each patient received antero-posterior balance control exercise after completing 15 minutes of medio-lateral exercise in the same manner. Exercise performance was noted on initial evaluation and after 4 weeks of training.

DATA ANALYSIS AND RESULTS
Paired t-test was used to analyze that data within each group and Un-paired t test was used to analyze the data between the two groups. Result was considered significant at p<0.05. Data was analyzed by using SPSS software version 10.0

Table 1
Comparing pre and post FUNCTIONAL REACH within each group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre Functional reach Mean (SD)</th>
<th>Post Functional reach Mean (SD)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>4.17 (2.09)</td>
<td>9.67 (3.17)</td>
<td>0.002</td>
</tr>
<tr>
<td>Control group</td>
<td>3.85 (3.71)</td>
<td>4.38 (2.60)</td>
<td>0.070</td>
</tr>
</tbody>
</table>

Graph 1

As seen in Table and Graph-1, there is a statistically significant improvement in functional reach post training in experimental group and no significant improvement in control group.
Table 2
Comparing Medio-lateral (ML) global balance performance within each group

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre M-L global balance performance Mean (SD)</th>
<th>Post M-L global balance performance Mean (SD)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>63.87 (9.02)</td>
<td>28.62 (12.39)</td>
<td>0.005</td>
</tr>
<tr>
<td>Control group</td>
<td>59.69 (11.37)</td>
<td>52.38 (13.82)</td>
<td>0.077</td>
</tr>
</tbody>
</table>

Graph 2

The Table and Graph-2 shows statistically significant improvement (p=0.005) in Medio-lateral global balance performance post training in experimental group and no significant improvement (p=0.077) in control group.

Table 3
Comparing Antero-Posterior (A-P) global balance performance within each group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre A-P global balance performance Mean (SD)</th>
<th>Post A-P global balance performance Mean (SD)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>71.44 (7.09)</td>
<td>33.26 (6.22)</td>
<td>0.002</td>
</tr>
<tr>
<td>Control group</td>
<td>62.69 (6.85)</td>
<td>55.38 (8.73)</td>
<td>0.065</td>
</tr>
</tbody>
</table>

Graph 3

The Table and Graph-3 shows statistically significant improvement (p=0.002) in Antero—Posterior global balance performance post training in experimental group and no significant improvement (p=0.065) in control group.

Table 4
Comparing Mean Differences between both the groups

<table>
<thead>
<tr>
<th>TEST</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional reach</td>
<td>3.193</td>
<td>0.005</td>
</tr>
<tr>
<td>A-P Balance performance</td>
<td>3.704</td>
<td>0.002</td>
</tr>
<tr>
<td>M-L Balance performance</td>
<td>5.068</td>
<td>0.000</td>
</tr>
<tr>
<td>2 Minute Walk Test</td>
<td>3.596</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Graph 4

The Table and Graph-4 shows statistically significant improvement in all the four-outcome measure in experimental group in comparison to control group.
Table 5
Comparing Area covered by prosthetic and non-affected limb in all patients.

<table>
<thead>
<tr>
<th>Area covered</th>
<th>Non-affected limb Mean (SD)</th>
<th>Prosthetic Limb</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre training Mean (SD)</td>
<td>396.45 (6.43)</td>
<td>47.43 (5.56)</td>
<td>0.002</td>
</tr>
<tr>
<td>Post training Mean (SD)</td>
<td>102.26 (7.22)</td>
<td>50.44 (2.61)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Graph 5
Comparing the area covered by non-affected limb and the prosthetic limb

As shown in Table and Graph-5, all the patients both pre and post balance training, covered more area by the non-affected limb in comparison to the prosthetic limb.

Table 6
Comparing Global Balance improvement in Trans-femoral and Trans-tibial amputees

<table>
<thead>
<tr>
<th>Type of amputee</th>
<th>Pre balance performance Mean (SD)</th>
<th>Post balance performance Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trans-Femoral</td>
<td>66.94 (4.09)</td>
<td>37.26 (5.22)</td>
</tr>
<tr>
<td>Trans-Tibial</td>
<td>70.69 (5.38)</td>
<td>32.38 (4.82)</td>
</tr>
</tbody>
</table>

Graph 6
Comparing the balance improvement in trans femoral and trans tibial amputees

The result shows that the Trans-tibial amputees improved better than the Trans femoral amputees.

DISCUSSION

The result of the study showed that there is a significant improvement in Functional Reach and the global balance performance in the experimental group and no significant improvement in these outcome measures in the control group. This suggests that post Phyaction Balance training, balance control improved in the unilateral lower limb amputees which is similar to the findings of a study by Laessoe et al 2008\textsuperscript{13} who concluded that both young and elderly use anticipatory postural control strategies to minimize the impact of predictable perturbations and perturbation training by using a moving board improves balance control. Along with perturbation, all the patients got both visual and auditory feedback during the training and thus experimental group showed improvement in balance control. The result of the study is supported by Van Ootegham et al 2008\textsuperscript{9}. In their study they used continuous variable amplitude oscillations evoked by translating platform and the result showed that with repeated trials participants reduced their magnitude of center of mass (COM) displacements. These findings provide important insight into the generalizability of improved compensatory balance control with training.

A study by A Gupta and R Sharma (2006)\textsuperscript{10} found that visual feedback is important in training symmetrical weight bearing in unilateral amputees and the result of their study showed significant improvement after training with visual feedback.

In our study amputees covered more area on the non-amputated limb than the prosthetic limb and the result corroborates with the study of A.H Veiring et al 2008\textsuperscript{8} which says that, compared to quiet standing, loading on non affected limb is more than the prosthetic limb when balance is perturbed. Various causes have been cited in many studies for the asymmetric weight bearing like a lack of ankle torque generation to restore equilibrium in the sagittal plane, a lack of weight-shifting capacity to control posture in the frontal plane and a distorted somato-sensory input from the side of amputation. In this study it was seen that improvement in Medio-lateral balance control is better than anterior-posterior balance control. The poor improvement in the anterior-posterior balance control may be attributed to lack of ankle strategy in both amputee groups which could not be used when balance was perturbed in antero-posterior direction. The better improvement in balance performance seen in Trans-tibial amputees than the trans femoral amputees may be attributed to the presence of hip abductors/adductors and knee extensors/flexors in the former group for the use of hip strategy when balance was perturbed and the absence of adequate strength and length of hip and knee muscles in the trans-femoral amputees.
CONCLUSION

The present study showed the effect of perturbation on balance control of unilateral lower limb amputees and thus gives evidence that during early prosthetic training, balance training should be incorporated in the rehabilitation program of amputees for their better participation in community life. As the amputees covered more area in the non-affected limb than the prosthetic limb, which suggests that amputees bear most of their body weight on the non affected side. The result suggests that strength training of the non affected limb is important in the rehabilitation of the unilateral lower limb amputees. Future studies can be conducted to see the effectiveness of Medio-lateral balance control and Antero-posterior balance control in amputees with respect to residual limb length.

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