IJPMR April 2006; 17 (1): 14-17

Comparison of Static Weight-Bearing and Static Sway in Below Knee Amputees Trained by Conventional Verses Visual Biofeedback Techniques Using Dynamic Posturography

Dr. Ajay Gupta, MBBS, DPMR, DNB (PMR), MNAMS, Senior Resident

Dr. Rajendra Sharma, MBBS, MD (PMR), Assoc. Prof. & Sr. Specialist

Dept. of Rehabilitation, Safdarjang Hospital & V.M.M.C., New Delhi - 110029

Abstract

The purpose of this investigation was to compare the results in weight distribution between the two lower extremities of a group of unilateral below-knee (BK) amputee adults trained by conventional methods and another group trained by using visual feedback techniques through dynamic posturography imparted using a dual force plate system. Two sets of BK amputees were taken. One set of fifteen old BK amputees (>1 yr) using the PTB prosthesis and trained conventionally with parallel bars and mirror. Second set of fifteen recent amputees (3 months to 1 year) fitted with prostheses recently and they were given weight bearing training for equalized weight distribution by dynamic posturography using force plate systems. They were further sent to the parallel bar system for gait training. The results of our study indicated that weight bearing was more on the normal foot. The discrepancy was to the order of 65:35 percentage of Total Body Weight (%TBW). This data was then compared with normal individuals for the dominant and non-dominant phenomenon where the difference was 52:48%TBW. The difference in the second test group after training was much less, to the order of 55:45%TBW. This difference is believed to significantly improve the gait, reduce the static sway of the patient and thereby increase the overall acceptability of the prosthesis.

Keywords: **Amputees; Artificial limbs; Weight bearing; Posturography; Sway**

Introduction

Ambulation is a very basic activity required for all functions of normal life – ADL and vocational. Humans are ambulant on two lower limbs, which provide for the normal gait. Equal weight bearing is a prerequisite for proper stance and swing. In patients with unilateral below knee amputations, retraining for weight bearing thus becomes very important. To this end we tried to study the methodology and results for the significance of our training.

In addition to mobility, standing in upright posture is also a feature that is unique to humans. This happens to be an unstable position requiring dynamic control and constant muscular activity. Thus enters the concept of sway in the 3-D cone of stability. In order to maintain a stable position it is very important to keep the sway of the body in the cone of stability[1,2]. It was also thought that proper weight distribution on bilateral lower limbs should be an important prerequisite for reducing the sway.

Address for Correspondence: Dr. Ajay Gupta J-32, Sarita Vihar, New Delhi - 110076, Email: ajaygupta@touchtelindia.net

To these two effects we thought it was significant to study the weight distribution in below knee amputees on prosthetic limbs and to see if better training can achieve better results. It is also appreciated that any rehabilitation program should also focus on dynamic weight bearing but there are countable numbers of gait labs in our country and not every patient can be trained on such expensive equipment. We therefore focused on static weight bearing and the ease of training patients for such activity. Very cheap equipment can be designed to give feedback training in static weight bearing. There is also extensive literature that says that static weight bearing is also an important indicator for gait training[3,4,5] and we wish to focus on these findings.

This study aimed to compare symmetrical weight distribution and static sway in two groups of fifteen, unilateral, below-knee amputees using conventional (Exo-skeletal) prosthesis. It was observed that even after regular training of the below-knee amputees, these patients continued to have poorer balance than normal individuals.

Material and Methods

Subjects: We enrolled thirty below-knee amputees in our study with proper consent. Five, old, follow up patients were included who served as part of the control group. The criteria for the control group were those patients who were using the prosthesis for more than six months, thus the follow up patients could be included in this group. The average age of the patients in the control group was 42 years and the male to female ratio was 4:1. The patients included in the study group were those who were recently amputated (3 months to 1 year) and were being imparted training for the prosthesis for the first time. The average age in this group was 37 years and the male to female ratio was 11:4. The exclusion criterion included all patients with complicated stumps, patients above the age of 60 years, patient with other known co-morbidities likely to affect the balance and stability.

Equipment: For the training of the conventional group a routine parallel bar system with level ground and full length plane mirror on one side is used. For the training of the visual feedback group, dynamic posturography was used. This was imparted using a system consisting of two force plates for each foot. The load taken on each limb is displayed on the screen as a bar graph that is easily comprehensible by most patients. All patients were using the conventional exoskeletal PTB prosthesis with SACH foot.

Method: These patients were divided in two groups – study and control. The control group included five old and ten new patients. These were given below knee prosthesis and were trained for gait and weight bearing using the standard departmental protocol. This was based on using the parallel bars with a full length plane mirror on one side in which the patient sees his gait and posture and given intermittent feedback by the therapist. This training was given five days in a week for five weeks and each session lasted about half an hour.

The study group was also consisted of fifteen patients, which were amputated during the past six months to one year. They were given definitive prosthesis after proper care of the stump. They were trained using dynamic posturography. They were trained to achieve as equal a weight distribution as possible in five days a week for five weeks with each session lasting about twenty minutes. They were then sent to the parallel bars for the usual gait training.

At the end of five weeks training period all these patients were assessed for static weight bearing with eyes closed and also their sway parameters were recorded using a dynamic posturography unit. Three sets of readings were taken and averaged. The findings are reported in this paper.

Results

The observations made in the two groups in our study have been tabulated. Table 1 gives the averages of the percentage of total body weight borne by each limb in the group trained by conventional methods. It may be seen from Table 1 that the mean weight borne on the amputated limb (AL) was 36% TBW and that on the normal limb (NL) was 64% TBW. The range of variation on the AL was from 22-45% TBW with the median as 37% TBW and the mode as 37% TBW. The range on the NL was from 78-55% TBW with the median and mode as 63% TBW.

Table 1 : *Percentage Body Weight borne on each limb in the conventionally trained control group*

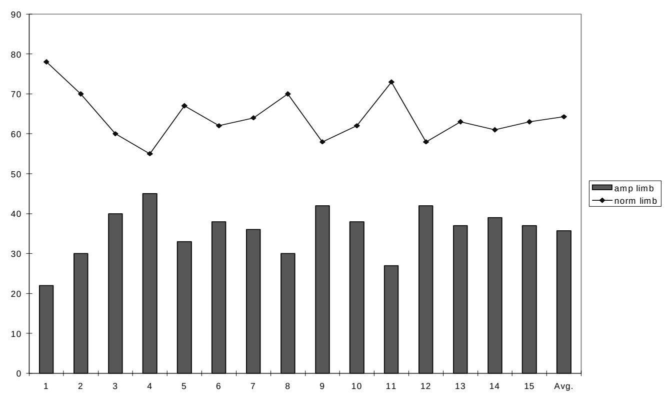
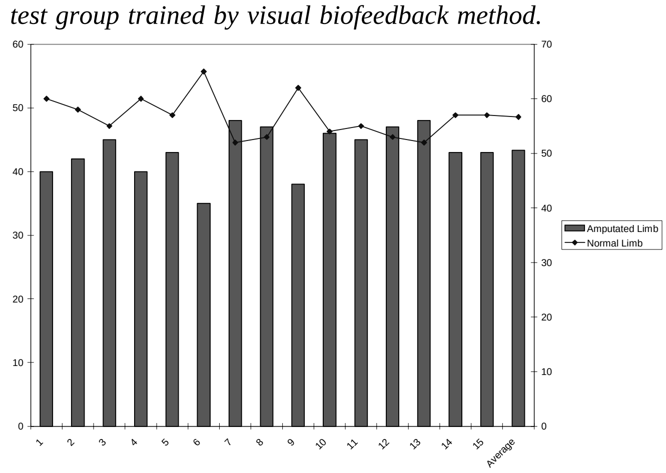


Table 2 shows the percentage of total body weight borne by the normal and amputated limb in the test group (i.e. the group trained by visual biofeedback). It gives the recordings of the individual group members and the group mean. The maximum load taken on the AL in this group was as high as 48% TBW while the minimum was 35% TBW. The mean, median and the mode on the AL in this group was 43% TBW while that on the NL was 57% TBW

Table 2 : *Percentage Body Weight bome on each limb in the test group trained by visual biofeedback method.*



The overall study group average has been compared with the test group average in table 3. There is a 21% increase in weight bearing in the visual biofeedback trained group.

Table 3 : *Comparison of average percentage body weight borne by each limb in the control and the study group.*

Group	***Av. % TBW on AL***	***Av. % TBW on NL***
Conventional	35.5	64.5
Visual feedback	43.1	56.9

The static sway parameters were also recorded for both the groups at the end of the training period before discharge from the study. The purpose was only to observe the difference in static sway if any. The observations have been presented in Tables 4&5 for the control and the study group respectively. These values for the individual members of the group have then been averaged and compared. The average static sway has been shown as the percentage of the limits of stability (% LOS) transcribed by the person standing during the test period of twenty seconds.

Table 4 : *Static Sway as observed after training in the conventional control group.*

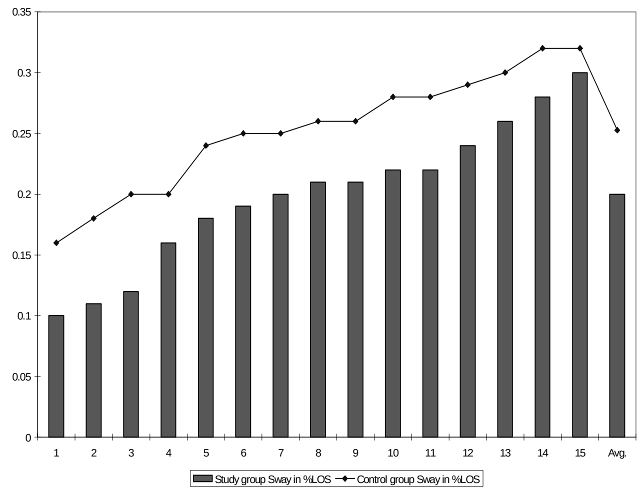
S.No.	Sway in % LOS	S.No.	Sway in % LOS
1	0.26	9.	0.32
2	0.28	10	0.16
3	0.20	11	0.25
4	0.30	12	0.25
5	0.32	13	0.26
6	0.24	14	0.28
7	0.20	15	0.29
8	0.18	**Avg**	**0.253**

Table 5 : *Static Sway as observed after training in the visual feedback study group.*

S.No.	Sway in % LOS	S.No.	Sway in % LOS
1	0.12	9.	0.19
2	0.30	10	0.24
3	0.20	11	0.16
4	0.22	12	0.26
5	0.18	13	0.11
6	0.28	14	0.21
7	0.10	15	0.22
8	0.21	**Avg**	**0.216**

The data in these tables has been diagrammatically shown in Figure 1. For the purpose of clarity the data shown in Figure 1 has been rearranged in ascending order for comparison and the serial numbers have been arbitrarily assigned. It may be seen that value to value each reading has a higher static sway in the control group as compared to the study group.

Figure 1 : *Static Sway in study group compared with the control group after re-arranging it in an ascending order.*



Discussion

In our study it was found that weight bearing on each limb was more towards equal after visual feedback training as compared to conventional training, and the difference was significant. The static sway observed in the two groups was not significantly different yet the average stability was apparently more in the visual feedback trained group.

The above findings suggest the importance of appropriate biofeedback. The main difference in our study group was that the feedback was in a mathematical and quantifiable form. In the conventional group also feedback was there in the form of the mirror and the therapist but that was only a subjective feedback

Tiberwala et al[6] have done a study and shown that even in normal individuals there was some difference in the weight borne by each limb. They also correlated that more weight was borne by the dominant side extremity and this gave the concept of dominant lower limb. Keeping this in mind it would be impractical to achieve absolute symmetry but the results obtained by us were very close to it. Hence any further training was unlikely to cause much improvement.

It has been shown that prosthetic foot takes more weight on the forefoot as compared to the normal foot[7] . This is an important reason for increased sway in amputated patients. Another important reason is that in SACH foot the ankle is fixed. This results in the loss of ankle strategy for posture and balance[2]. Ankle and hip are the major joints involved in the maintenance of erect posture and stability. The increased instability leads to loss of confidence and fear of falling which is a major impediment to successful rehabilitation of amputated patients.

Fernie and Holling[8] have shown that postural sway in people with below knee amputations is increased while Vittas et al[9] showed that it was comparable to the control group. Thus we considered it appropriate to evaluate the static sway in our group of patients.

Eli Isakov et al[10] in 1992 studied the standing sway and weight bearing distribution in below knee amputees and concluded that these subjects were significantly less stable than able bodied persons during standing and the major contribution was due to loss of proprioceptive inputs from the amputated limb.

Standing is an unstable position which requires the constant use of muscular activity and joint mobility especially at the ankle and hip to maintain stability[11,12]. These functions are significantly expected to be compromised in below knee amputees with a SACH foot as the ankle strategy of balance is lost. This was confirmed in our findings indirectly as the extent of sway reduced in those patients trained to achieve better weight distribution.

Engsberg JR[13] et al pointed out in their study done on BK amputee children that the weight bearing pattern in children was more towards the normal children with the normal limb behaving as the dominant foot and taking a greater share of the total body weight. The significant difference was in the forefoot predominance in the prosthetic limb perhaps due to the basic design of the prosthetic foot piece (i.e. the keel of the foot-piece).

Conclusion

It can be concluded that better weight bearing leads to less static sway and is a positive factor for successful rehabilitation of amputees. For achieving better weight distribution over the amputated limb it is helpful to use some form of visual feedback training. Force plates are one of the options for feedback and it should be possible to device a system without much cost. The difference though not statistically significant yet is a fair indicator that better training is essential. It will thus be prudent, to extend this study to a wider group with stratified patient characteristics.

References

1. Brouwer B et al. Normal variability of postural measures; implications for the reliability of relative balance performance outcomes. Scan J Rehab Med 1998; 30:131-7.
2. Timothy L. Kauffman et al. Balance is a critical parameter in Orthopedic Rehabilitation. Orthop Phys Ther Clin N Am 1997; 6(1): 43-78.
3. Jones ME et al. Static versus dynamic prosthetic weight bearing in elderly trans-tibial amputees. Prosthet Orthot Int 1997 Aug; 21(2):100-6.
4. Engsberg JR et al. External loading comparisons between able bodied and below-knee amputee during walking. Arch Phys Med Rehabil 1991; 72(9):657-61.
5. Hurley GR et al. The role of the contralateral limb in below-knee amputee gait. Prosthet Orthot Int 1990;14(1): 33-42.
6. Tibarewala DN et al. Static weight-bearing patterns of below-knee amputees using patellar-tendon-bearing prosthesis. J Biomed Eng. 1982 Jul;4(3):233-40.
7. Summers GD et al. Foot loading characteristics of amputees and normal subjects. Prosthet Orthot Int 1987;11(1):33-9.
8. Fernie GR, Holling PJ. Postural sway in amputees and normal subjects. J Bone Joint Surg Am 1978;60:895-8.
9. Vittas D et al. Body sway in below-knee amputees. Prosthet Orthot Int 1986;10:139-41.
10. Isakov E et al. Standing sway and weight-bearing distribution in people with below-knee amputations. Arch Phys Med Rehabil. 1992;73(2):174-8.
11. Basmajian JV. Posture, In: Basmajian JV, ed. Muscles alive; their functions revealed by electromyography. Baltimore: Williams & Willkins; 1962: 83-96.
12. Murray MP et al. Normal posture stability and steadiness. Quantitative assessment. J Bone Joint Surg Am 1975; 57:510-6.
13. Engsberg JR et al. Weight distribution of below-knee amputee and able bodied children during standing. Prosthet Orthot Int 1992;16:200-2.