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Comparison of Gait Parameters and Locomotor Capability Index in Transtibial Amputee using Two Different Types of Suspension System

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Abstract

Background: The main purpose of all suspension systems is prosthesis retention. Numerous means to suspend below-knee (BK) prostheses have been developed. Although suspension systems generally used for BK prostheses have similar functions, choices for prescription are not totally clear. Patellar tendon bearing (PTB) suspension principles are effective with many patients; however, those with short limbs may not achieve complication-free suspension. The fact that variations of BK suspensions continue to appear suggests that a universal suspension system is not yet available.

Objective: To find out the effect of two types of suspension system on gait parameters and locomotor capabilities index in subject with unilateral transtibial amputee.

Study design: Single study with post experimental design.

Methods and measures: Two different suspension systems such as supracondylar and cuff suspension for below knee prostheses were tested on 30 adults with unilateral transtibial amputees. All subjects walked with prosthesis. Data regarding gait parameters and Locomotor capabilities index were measured. Gait parameters such as velocity, cadence, step length, stride length were evaluated by CDG gait analyser and walking abilities of the subjects were evaluated by locomotor capabilities index (LCI).

Result: The results revealed that the statistical difference between two suspension systems is significant ($p<0.05$). Study suggested that using supracondylar suspension velocity, cadence, stride length and step length increased compared to cuff suspension. But value of Locomotor capability index was more in cuff suspension compared to supracondylar suspension which indicates use of cuff suspension reduces fear of falling and patients feels more secure.

Conclusion: The findings of the study thus support the hypothesis that there were significant difference with different suspension systems on gait parameters and locomotor capabilities index.

Keywords: Below-knee prostheses; Gait analysis; Residual limb; Suspension systems LCI; Unilateral amputees; Impact

Introduction

Limited use of prosthetic devices is concern for rehabilitation of amputees. Provision of good prosthesis is also the key element in the rehabilitation of persons with amputation. The amputee's functional needs and his/her satisfaction with the prosthesis should be taken into account when selecting particular prosthetics components [1-7]. Suspension systems and sockets are the most critical components of the prosthesis that are in direct contact with the amputee's residual limb. Suspension system is responsible for preventing excessive translation, rotation, and vertical movements between the residual limb and socket [1,8-11]. Various suspension systems have been developed to suspend below-knee (BK) prostheses [12] and this diversity is an attempt to fit individuals with different physical characteristics, life styles and job profile. Although suspension systems generally used for BK prostheses have similar functions, choices for prescription are not totally clear. Considering the factor of prosthesis retention, suspension systems have been designed; however, the effects of remaining aspects of limb-socket biomechanics are not obvious. Some factors, such as restriction of knee excursion, alter the gait pattern and efficiency [13].

In patients with lower limb amputation the primary aim of rehabilitation is to restore walking ability with prosthesis. Not all patients can receive prosthesis after amputation. Study was being done which reports the rate of prosthetic use following lower limb amputation related to peripheral arterial disease or diabetes has varied from 32% to 43% [14-17]. Factor for successful use of prosthesis may differ in how much they use the prosthesis and in the type of activities they can perform with their prosthesis [18]. Walking ability with a prosthesis depends on several factors including patient's physical and mental status [19], the surgical method used [20], postoperative care, nutrition and pain relief [21] as well as the rehabilitation and prosthetic fitting procedures [17]. The main goal of all suspension methods is to minimize the amount of motion that occurs between the residual limb and the prosthesis which known as pistoning. Excessive motion at this interface can lead to troubling issues for the prosthesis user including skin breakdown, loss of control, general discomfort, and compliance issues. If the prosthesis is causing discomfort and skin breakdown, this in turn limits the mobility of amputee and can have a negative impact on the quality of life [21].

The efficiency of the suspension systems can be evaluated both objectively and subjectively with the use of questionnaires. Researchers have developed numerous questionnaires as a means of assessing consumers' satisfaction with prosthetics and orthotics [21]. Clinical experience has shown that even small improvements in suspension of the prosthesis are well received by amputees, which helps explain the variety of alternatives that have been developed [11].

Previously different research has been conducted specifically examining the motion of the transtibial residual limb within prosthesis. Also different research on gait parameters, on different questionnaires by using different types of socket design and suspension had been conducted. Most of these studies analyzed the motion which occurred statically in positions of simulated gait. Based on the literature till date, no standard suspension system exists that satisfy the needs of all amputees. In developing country still cuff suspension and supracondylar suspension are being used as common suspension. For this study has been conducted to evaluate the effects of both suspension systems i.e supracondylar and cuff suspension in unilateral transtibial amputee on gait parameters and locomotor capabilities index. Aim of this study was to investigate the impact of suspension system on gait parameters and locomotor capabilities index with unilateral transtibial amputee.

Materials and Methods

Ethics statement

The study, a randomized trial, was conducted from May 2014-April 2015. Participants were allocated to groups that received transtibial prosthesis with supracondylar suspension and transtibial prosthesis with a cuff suspension. Ethics approval for the study was obtained from the Institutional ethical committee of National Institute for Locomotor Disabilities (Divyangjan). All participants provided written informed consent prior to recruitment.

Methods

Consecutive patients with transtibial amputation were invited to participate. The inclusion criteria for the study was unilateral traumatic transtibial amputee, had a stump with full ROM of hip and knee joints and strength not less than 4 in MMT, length of the stump 11 cm to 19 cm, free of contractures in the knee and hip joints and had no sign of phantom pain and phantom sensation. Both male and female subjects with an age range 25-50 yrs were recruited. All the subjects should be able to understand the given command. Subjects were excluded if they had any associated neurological or orthopedically condition, complicated stump (pain, wound, neuroma, etc) and had inadequate ROM and strength.

A total number of 30 participants (30 Transtibial amputees) were recruited for the study with age range from 25 to 50 years. There were 21 male and 9 female patients in the study. There was no drop out during the study. Participants were allocated to two groups by a random allocation sequence. One group (Group A) fitted with supracondylar suspension system and another group (Group B) fitted with cuff suspension system. Each group consists of 15 participants. The toe-out angle was similar for all subjects and that there was no gait deviation. Bench alignment and dynamic alignment during standing and walking was carried out. A four-week acclimation period was allocated for each group. The subjects used identical shoes during training and experiments.

Data collection

Temporospatial gait parameters like step length, stride length, cadence and velocity were evaluated by CDG gait analyser. Each participant was asked to wear transtibial prosthesis with shoes and then made to wrap the microcontroller called Ultraflex unit around the waist and a pair of CDG shoes of approximate size were put below the shoes. The cable of CDG shoes was connected to Ultraflex unit. The foot sensors data was digitally acquired at a sampling frequency of 100 Hz and stored in Memory stick of Ultraflex unit. The Ultraflex is a portable battery operated microcontroller unit storage facilities for off-line analysis. The gait data of all the subjects were evaluated in gait and biomechanics lab of National Institute for the Orthopaedically Handicapped, Kolkata, India. All the data were analyzed in CDG software and normalized with respect to the patients' physiological parameters. CDG shoes containing 8 pressure sensors of appropriate sizes were fitted to the patient at the sole of the normal shoe. Shoes were tied with the help of auxiliary straps. Stretch bandages were used once the shoes were connected properly to the cables along the legs of the patient and the cables were connected to the microcontroller which was tied to the trunk of the patient. Subjects were advised to walk on a level ground surface using transtibial prosthesis. Prior to test there was 5 min of resting period for accommodation of the system. Two trials were given for the participant to get acquainted to the machine. Once the instrument was applied to the patient he/she was asked to walk for 20 seconds. They were taught to walk with their self-selected walking speed with prosthesis.

Finally, to evaluate the effect of these two suspension systems on ability of the amputee to perform activities with the prosthesis Locomotor capability index (LCI) questionnaire were utilized. The LCI consists of 14 items that measure one general construct, the locomotor capabilities with the prosthesis. Two subscales emerge from this general construct; basic abilities (7 items) and advanced abilities (7 items). The items inquire about the ability to perform activities and the level of independence while performing these activities. Each of the 14 items is graded on a 4-point ordinal scale; 0 (not able to), 1 (yes, with help from other person), 2 (yes, with supervision) and 3 (yes, independently). The total LCI score is the sum of the item scores and can range from 0 (worst) to 42 (best). Similarly, subscale scores for basic and advanced capabilities with the prosthesis can range from 0 to 21.

Results

Statistical data was analyzed using SPSS 20.0 and p-values of 0.05 or less reflected statistical significance. Paired-samples t-test was employed to compare the effect of two suspension systems on gait variables (Figures 1-5).

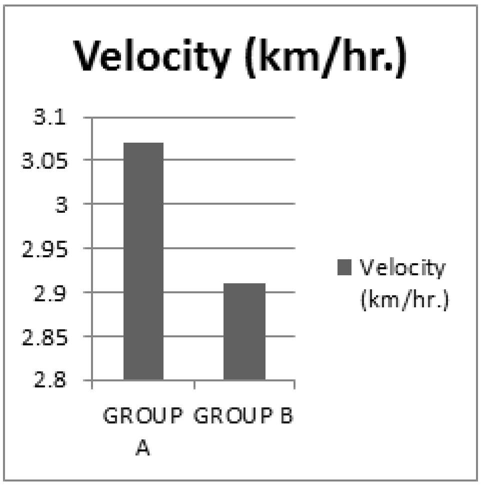

Figure 1: Showing velocity between groups.

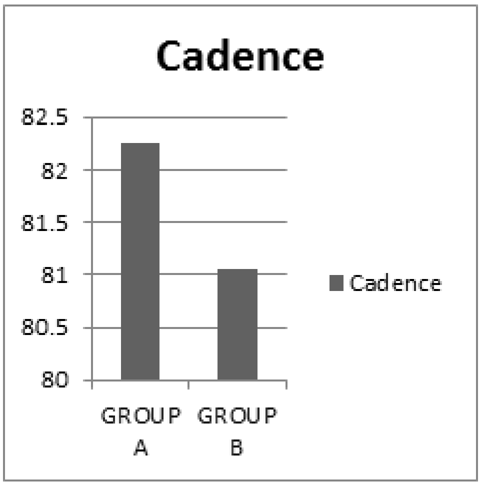

Figure 2: Showing cadence between groups.

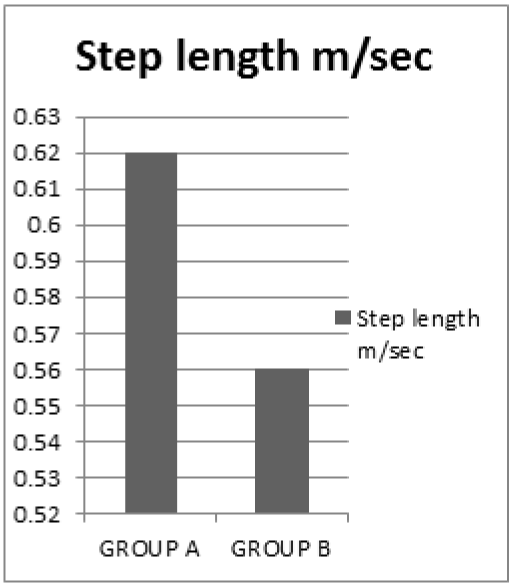

Figure 3: Showing step length between groups.

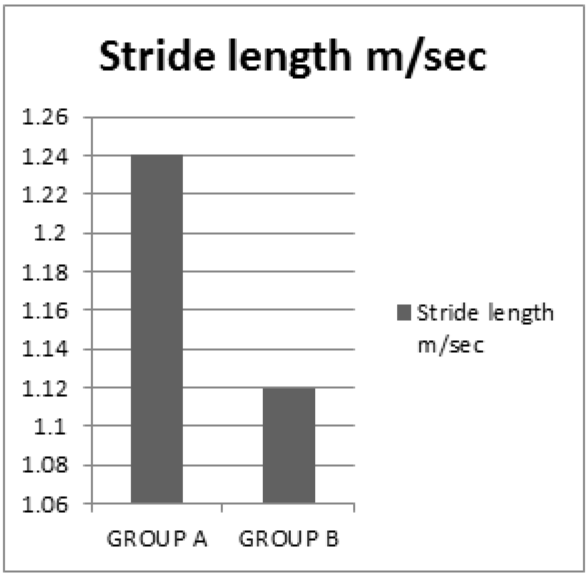

Figure 4: Showing stride length between groups.

The statistical tests were applied to all gait variables and LCI independently for both suspension systems. The average of obtained three successful trials each gait parameter was calculated for both suspension systems. Lastly, the overall average of gait parameters was calculated for all the participants to compare the suspension systems (Tables 1-3).

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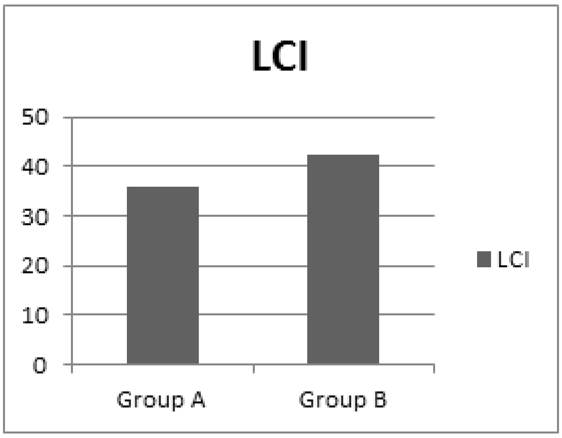

Figure 5: Showing Locomotor capability index.

Sl.no	Baseline characteristics	Group A	Group B
1	No of Subjects	15	15
2	Age range (years)	25-50	25-50
3	Mean age (SD)	39.13 (7.1)	39.33 (7.3)
4	Sex (Male/Female)	11/4	10/5

Table 1: Descriptive statistics of subject's characteristics.

Parameters	Mean ± SD(Group A)	Mean ± SD (Group B)	t value	P value
Velocity (km/hr)	3.07 ± 0.19	2.91 ± 0.23	2.13	0.025
Cadence	82.26 ± 4.71	81.05 ± 4.17	1.753	0.01
Step length m/sec	0.62 ± 0.015	0.56 ± 0.017	2.62	0.027
Stride length m/sec	1.24 ± 0.03	1.12 ± 0.034	2.89	0.039

Table 2: Comparison of Gait parameters for both Group A & Group B.

LCI	Mean ± SD	t value	P value
Group A	35.73 ± 4.1	4.08	0.001
Group B	42.26 ± 2.9		

Table 3: Comparison of Locomotor capabilities index for both Group A & Group B.

Discussion

The gait of lower limb amputees has long been studied to understand the kinematic and kinetic deviations resulting from the loss of ankle and foot (transtibial amputees). The effects of suspension system on the gait of individuals with transtibial amputation have been investigated. This study attempted to examine the effect of type of suspension system on gait parameters and locomotor capabilities index.

The transtibial amputees always want to earn the ability to maintain a steady gait without endangering their stability irrespective of their walking speed. That is why they should have some significant differences in their gait parameters as a compensation for maintaining their stability in different speeds. It is essential that normal ranges for gait parameters should be defined with reference to speed of walking. So as per the requirement, the aim of this study was to determine how selected gait parameters may change as a result of application of different types of suspension.

The result of the study showed that there is an increase in velocity, step length, stride length and cadence of supracondylar suspension group than the cuff suspension group. When comparing velocity in both the groups 5.87% increment found in supracondylar suspension (3.07+0.19) than in cuff suspension (2.9+0.20). This improvement is statistically significant (p=0.025). In cadence the improvement in supracondylar suspension is 1.43% higher than cuff. The percentage improvement is negligible but it shows statistically significant result (p=0.01). This tendency to walk with a higher velocity using supracondylar suspension is due to the fact patient feel more comfortable using supracondylar suspension. This study is supported by Gholizadeh et al. [21] When step lengths of both the group are compared 10.5% longer step length found in supracondylar (0.62+0.015) than cuff suspension (0.561+0.017) having p=0.039. Supracondylar (1.24+0.030) and cuff (1.12+0.034) when compared for stride length 10.7% longer stride length found in supracondylar than cuff (p=0.001). Therefore it can be interpreted that amputees adopt longer step length on prosthetic side, this might have happened due to the enhanced suspension and cosmesis of the prostheses using supracondylar suspension. This results is supported by the literature led by Cluitmans et al. [6] stated that the donning and doffing has an important effect on prosthetic use and donning doffing is more easy in supracondylar suspension than cuff suspension. This is compatible with the findings of Van de Weg and Van der.

The locomotor capabilities index of cuff suspension shows the greater value than that of supracondylar suspension group. The mean value of cuff suspension in LCI is (42.26+2.96) and in supracondylar group the mean value of LCI is (35.73+4.11).The cuff suspension shows

18.27% more improvement than supracondylar group. The above data reveals that the result of this study might be due to acceptance of suspension system by the participants may be due to reduction of fear factor during activities. This is also supported by the literature of Baars and Greetzen [8]. They emphasized that the enhanced suspension and cosmesis of the prostheses had a positive effect on prosthetic function and the participant's satisfaction.

The result of the present study support the hypothesis and shows statistically significant difference between the supracondylar suspension and the cuff suspension group.

Conclusion

The findings of the study thus support the hypothesis that there were significant difference with different suspension systems on gait parameters and locomotor capabilities index in subjects with unilateral transtibial amputee. Though supracondylar shows better result in gait parameters but the result is reverse in case of LCI. So, further study is required to get a better option of suspension system for below knee prosthesis.

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