Technical note

Weight bearing and velocity in trans-tibial and trans-femoral amputees

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Abstract

The purpose of this study was to review the clinical utility of static weight bearing (SWB) and maximal self-selected ambulatory velocity as objective quantifiable measures in an outpatient lower limb prosthetic clinic.

Seventy-three (n=73) consecutive trans-tibial (TTA) and trans-femoral amputees (TFA) attending an outpatient prosthetic clinic were studied. Prosthetic weight bearing was measured on a bathroom scale (mass in kg), normalised to body mass then expressed as a percentage and labelled static weight bearing (SWB). Maximum safe self-selected ambulatory velocity over a 10 metre level walkway (m/s) was measured with a stopwatch. The SWB mean for the TTA group was 94.93% (range 77 - 100%) and 88.36% for the TFA group (range 43 - 100%). The mean ambulatory velocity was 1.70 m/s (range 0.07 - 5.75) for the TTA group and 0.78 m/s (range 0.10 - 1.54) for the TFA group. A statistically significant relationship ($p<0.05$) was found between SWB and ambulatory velocity in trans-tibial and trans-femoral amputees in this study. A ceiling effect was noted in the trans-tibial group with 42% achieving 100% SWB through their prosthetic limb so it was concluded that ambulatory velocity was the more sensitive measure in established trans-tibial prosthetic limb users. SWB may be the more appropriate quantifiable measure for use in established trans-femoral prosthesis users. Prosthetic training programmes would benefit from the objective measurement of SWB. Once optimal SWB was achieved, ambulatory velocity would be the more sensitive measure of prosthetic use.

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Introduction

Quantitative measurement in clinical practice of prosthetic gait training allows review of progress, early identification of new patient or prosthetic abnormalities, evaluation of new techniques in prosthetic rehabilitation, and external review of clinical outcomes. For quantitative measures to be used routinely in outpatient clinics, they should be quick and easy to perform and require the use of minimally sophisticated technology,

Static weight bearing in amputees has been measured and shown to quantify pressure tolerance and reflect progress in gait training (Stolov *et ai,* 1971; Gapsis *et ai,* 1982). The authors in a previous study demonstrated that static weight bearing (measured with bathroom scales) correlated closely with forces through the prosthetic limb during walking measured by a force plate (Jones *et ai,* 1997). Ambulatory velocity provides not only a direct performance indicator but an index of functional status and a predictor of rehabilitation success (Alexander, 1996). The relationship of age, gender, strength, cognitive function, activity level and specific diseases to gait has been studied extensively and summarised by Alexander's literature review.

The purpose of this study was to review the clinical utility of static weight bearing (SWB) and maximal safe self-selected ambulatory velocity as objective, quantifiable measures in an outpatient lower limb prosthetic clinic.

Table 1. Etiology grouped by amputation level.

Etiology	Trans-tibial	Trans-femoral
Vascular	23	11
Traumatic	20	10
Infection	2	2
Congenital	3	0
Neoplastic	0	2

Method

Seventy-three (n=73) consecutive trans-tibial (TTA) and trans-femoral amputees (TFA) attending an outpatient prosthetic clinic were studied. Excluded from the study were partial foot, Symes, knee and hip disarticulation and hemipelvectomy amputees. Non-ambulant amputees were also excluded. Each amputee's age, gender, level of amputation, and type of walking aid customarily used indoors were recorded. Weight bearing on the prosthesis and ambulatory velocity were measured.

Data were collected and summarised, then divided into two groups corresponding to the trans-tibial amputees (TTA) and the trans-femoral amputees (TFA) respectively. Multiple regression techniques were used for data analysis using a level of significance $p<0.05$.

Results

Forty-eight (n=48) of the participants were TTA and twenty-five (n=25) were TFA. Age ranged from 11 to 94 years in the TTA group, mean age 59.0 years (TFA mean age 61.2 years, range 32-82). The TTA group had 38 males and 10 females (TFA 19 males, 6 females). Table 1 lists amputation etiologies and corresponding levels of amputation.

Some 60% of the TTA group used no walking aid (TFA 36%), 15% of the TTA used a cane (TFA 28%), 19% TTA used a quad stick (TFA 32%), and 6% of the TTA used a frame (TFA 4%).

Static weight bearing

SWB measures ranged from 77% to 100% with a mean of 94.93% TTA (TFA mean 88.36%, range 43 - 100%). Of the TTA 42% achieved 100%, but only 8% of the TFA were able to achieve this maximal level (Fig. 1).

Safe self-selected maximal ambulatory velocity

Ambulatory velocity for TTA ranged from 0.07 - 5.75m/s, mean 1.70m/s, (TFA mean 0.78m/s, range 0.10 - 1.54m/s) (Fig. 2). Of the TTA 31 % walked at a velocity of less than I m/s (TFA 60%). Some 40% of the TTA walked 1-2m/s (TFA 40%). There were 29% TTA with velocity of more than 2m/s (TFA 0).

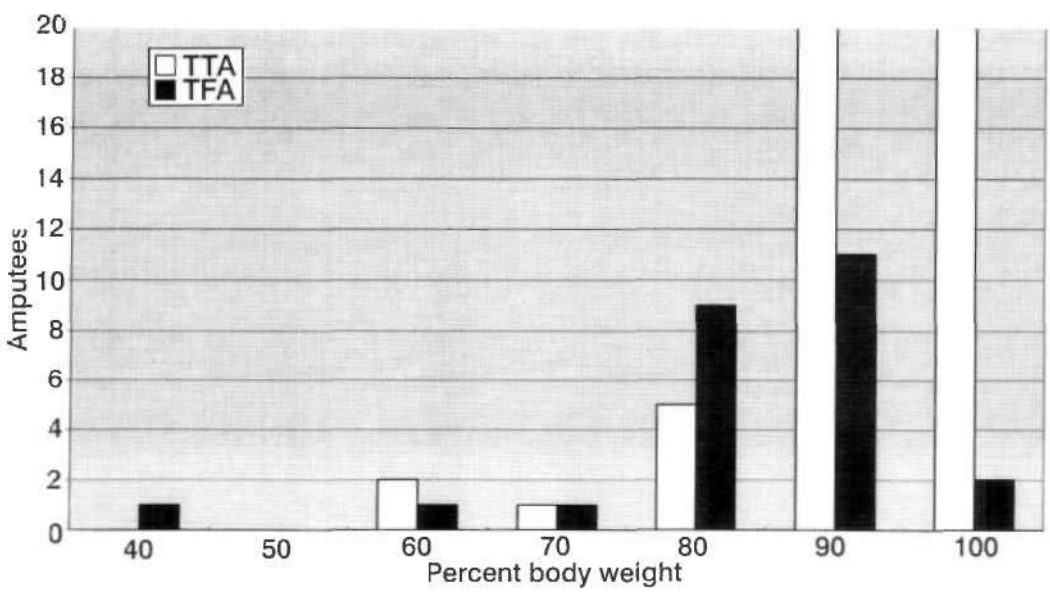

Fig. 1. Static weight bearing in TTA and TFA.

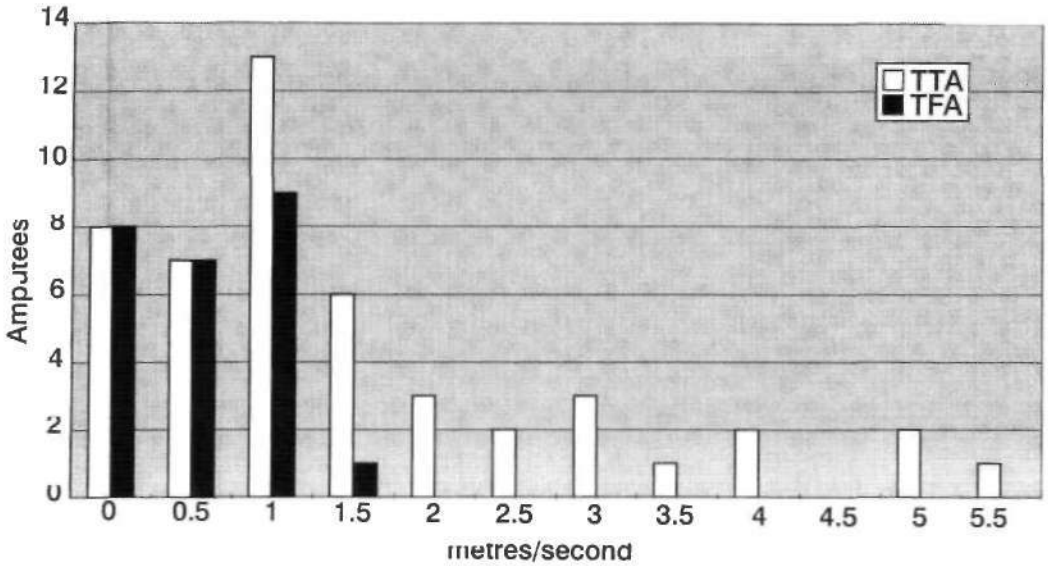

Fig. 2. Velocity in TTA and TFA,

Statistical relationships

There was a statistically significant relationship between SWB and velocity for the TTA (F=14.3, *p<0.05,* #=47) and TFA (F=11.0, p<0.05, df=24).

Discussion

In the context of an outpatient clinic reviewing established lower limb prosthetic users, the objective measures of static weight bearing and ambulatory velocity used are easily performed without interrupting the overall flow of the clinic.

The ceiling effect noted in SWB measurement in established TTAs limits its clinical usefulness. Once high level prosthetic users have reached 100% SWB, velocity becomes a more sensitive measure. Allowing the subjects to run, if this can be done safely, avoids a similar ceiling effect in high level users being measured for ambulatory velocity.

The SWB measure would appear to have particular potential for use in the clinical area of primary prosthetic training of both trans-tibial and trans-femoral amputees when weight transference through the new prosthesis is a major rehabilitation goal. A longitudinal study of weight bearing in this group would be recommended.

In terms of prosthetic training the provision of numerical feedback to the patients themselves is valuable as both an educational and motivational experience. In this study they took pride in their performance and gained self esteem when objective evidence of their performance in both ambulatory velocity and SWB was provided to them.

Conclusion

A statistically significant relationship was found between SWB and maximal safe self-selected ambulatory velocity in trans-tibial and trans-femoral amputees attending an outpatient prosthetic clinic. Some 42% of the established trans-tibial amputees in this study were able to statically bear 100% of their weight through their prosthetic limb. This ceiling effect made it an insensitive measure of clinical change in high level users. Ambulatory velocity would appear to be a more sensitive measure in the trans-tibial amputee group, as this group demonstrated a large range in walking velocity from 0.07m/s to 5.75m/s. However this effect was much less common for the trans-femoral amputee group. Maximal safe self-selected ambulatory velocity revealed that a large percentage of trans-femoral amputees (60%) were not able to exceed lm/s and none was able to exceed 2m/s. This study demonstrated that objective, quantifiable measures can be undertaken quickly and easily in an outpatient prosthetic clinic.

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