JPOST Journal of Prosthetics Orthotics Science Technology
Volume 3, Number 2 Year 2024
ISSN (online): 2962-8016
DOI: 10.36082/jpost.v3i2.1945

Differences in Walking Speed of SACH Foot And Single Axis Foot in Transtibial Prosthesis User

Dody Suprayogi[1*], Cica Tri Mandasari Ningsih[1]
[1]Prosthetics and Orthotics Department, Polytechnic of Health Sciences Surakarta, Indonesia

Correspondence*:
Address: Prosthetics and Orthotics Department, Polytechnic of Health Sciences Surakarta, Indonesia
e-mail: dodysupraa@gmail.com

Abstract

Background: Lower limb amputation causes disruption of limb function, one of which is the ability to walk. One of the walking aids that can be used is a transtibial prosthesis. A transtibial prosthesis consists of a socket, shank and foot components. The choice of foot type and the use of a transtibial prosthesis is one of the factors that influence walking speed. SACH foot and single axis foot are the types of foot that are often used by prosthesis users
Aims: To determine the difference in walking speed of SACH Foot and Single Axis Foot in transtibial prosthesis users.
Method and Subjects: Using quantitative research, observational method with cross sectional design. The subjects of this research were users of transtibial prosthesis type SACH foot and single axis foot. The sample for this study consisted of 28 people. The measuring instruments used in this research are 10 MWT (Meter Walk Test).
Results: Based on statistical tests, the results showed that there were differences in walking speed between SACH foot and single axis foot type transtibial prosthesis users. Where the p value <0.05 is 0.000 with an effect size of 0.81, which means it has a high or strong difference effect.
Conclusion: There is a difference in walking speed, namely the walking speed of users of single axis foot transtibial prosthesis is faster than SACH foot. So, it is recommended to prefer using a single axis foot in users of transtibial prosthesis, especially at moderate activity levels. The limitations of this research are that there are not many subjects and the foot types are less diverse. Future research can be developed with other types of foot prosthesis and measurement of gait parameters

Keywords: Walking Speed, Transtibial Prosthesis, SACH Foot, Single Axis Foot.

Article History

Received date: 22-08-2024
Revised date: 27-10-2024
Accepted date: 31-10-2024

Journal Prosthetics Orthotics and Science Technology (JPOST)
e-ISSN 2962-8016
Organized by Department of Prosthetics and Orthotics
Published by Poltekkes Kemenkes Jakarta I
email: jpost@poltekkesjakarta1.ac.id

Introduction

Lower limb amputation affects the ability to walk in humans (Ardesa et al., 2019). Reduced balance ability can result in shorter steps, which can also reduce walking speed (Nurhalimah & Munawarah, 2020). Walking speed is an important dimension of gait function and is known to decrease with age and several declining body functions (Redha et al., 2022). The prevalence of lower limb amputations reaches 85-90% of all amputations, as well as below-knee amputations or transtibial amputations in the United States currently, there are 43,000 amputations each year from a population of 280,562,489 people or approximately 0.02%. Meanwhile, according to other studies, there are approximately 158,000 lower limb amputations each year from a population of 307,212,123 or approximately 0.05%, an increase in the number and percentage of the total population (Hafner et al., 2022).

Young age group most cases of amputation are caused by trauma, in children 60% of amputations are caused by congenital and other surgical amputations are caused by trauma or cancer malignancy. Around 75% of amputations occur in men. The incidence of lower limb amputation in men has a higher figure of up to 85%. In 2007, cases of amputation in Indonesia reached 30%. Amputations in the lower limbs reach 85-90% of all amputations and below-knee amputations or transtibial amputations are the most common types of amputation surgery (Syaifuddin et al., 2016)

One of the mobility tools that can be used by amputee patients is a prosthesis. This prosthesis replaces the very complex function of the limbs. The main function of the prosthesis is to help the user walk again and do normal activities (Ardesa et al., 2019). In most cases, the limb that uses the prosthesis does not compensate for the amputated limb properly, this can affect walking speed, differences in spatiotemporal parameters and angles at the joints. Transtibial prosthesis affects energy expenditure when walking, because it is seen from various components, namely the foot, shank and socket which are different and have different weights and functions (Himmelberg & Buns, 2018). Foot prosthesis is a component that functions to distribute the load and maintain balance, besides the use of the foot can also add an aesthetic element to the prosthesis (Gardiner et al., 2016).

SACH foot and single axis foot are two of the types of feet that are often used by users of prostheses below the knee and above the knee. Solid-ankle-cushion-heel (SACH) foot is the simplest and simplest type of foot prosthesis consisting of an ankle block with a rigid forefoot. Single axis foot is a type of foot prosthesis that slightly imitates the movement mechanism of a normal human foot that has movement, namely being able to move plantar flexion and dorsi flexion. Single axis foot is more flexible than the sach foot type (Burger et al., 2018).

Patients who use prostheses are expected to be able to carry out their daily activities that are constrained by their limbs. One of the constrained activities is walking. A person needs a gait cycle to carry out the walking process to support their daily activities (Fukuchi et al., 2019). This study aims to determine the difference in walking speed in the use of SACH foot and single axis foot in transtibial prosthesis users by observing walking speed over a certain period.

Methods

This study of the Difference in Walking Speed of SACH Foot and Single Axis Foot in Transtibial Prosthesis Users uses a quantitative research type, analytical observational method with a cross-sectional design. The sample of this study was 28 respondents who used transtibial prosthesis, where in the selection of samples using the purposive sampling method, the inclusion criteria in this study were:

(1) Respondents were willing to participate in the study (2) Adult respondents (aged 19 - 55 years) (3) Unilateral transtibial amputation (4) Stump in a condition without wounds, (5) no contracture on the stump (6) Respondents can walk independently with their prosthesis The exclusion criteria for this study were: (1) Respondents had musculoskeletal disorders (2) Respondents were new users of transtibial prosthesis for less than 3 months. The instrument in this study used 10 MWT. The data normality test used Shapiro Wilk while the hypothesis test used Mann Whitney.

Results

1. Respondent characteristics

a. Respondent characteristics based on gender

Characteristics based on gender, it can be seen that the respondents involved come from 2 genders, namely male and female. This is shown in the following table:

Table 1 Distribution of respondents by gender

Gender	N	frequency (%)
Male	18	64,3
Female	10	35,7
Total	28	100

Source: Primary data processed, 2024

From the results of the frequency distribution table based on gender above, it can be concluded that there are more male subjects than female subjects, with a difference of 28.6%.

Table 2 Descriptive statistics of walking speed by gender

Walking speed	N	Min	Max	Mean
Male	18	0.87	1.28	0.9705
Female	10	0.83	1.22	0.9653

Source: Primary data processed, 2024

The descriptive statistical results above show that the average walking speed of men and women does not differ because there is only an average difference of 0.0052 m/s.

b. Respondent characteristics based on foot type

Based on the data obtained, it is known that there are two types of feet used by respondents. This can be seen in the following table:

Table 3 Distribution of respondents based on foot type

Foot Type	N	frequency (%)
SACH Foot	16	57,1
Single Axis Foot	12	42,9
Total	28	100

Source: Primary data processed, 2024

From the results of the frequency distribution of respondents based on the type of foot used from the 28 respondents studied, SACH foot users were 14.2% more than single axis foot users.

Table 4 Descriptive statistics of walking speed by foot type

Walking Speed	N	Min	Max	Mean
SACH foot	16	0.72	1.12	0.924
Single Axis Foot	12	0.97	1.23	1.142

Source: Primary data processed, 2024

The descriptive statistical results of walking speed based on the type of foot above showed that the use of a single axis foot produced a faster speed than the use of a SACH foot, with a difference in walking speed of 0.218 m/s.

2. Data normality

Data normality in this study is used to determine the type of statistics to be used. If the data is normally distributed ($p>0.05$) then use parametric statistics, namely the independent sample t-test. While for data that is not normally distributed ($p<0.05$) then use a non-parametric test, namely the Mann Whitney test. The normality test in this study uses

Shapiro Wilk which is used to test walking speed in both groups with small samples (<50) can be seen in the following table:

Table 5 Data Normality

Variabel	p value	Information
Foot type	0.325	Abnormal
Walking speed	0.256	Abnormal

Source: Primary data processed, 2024

The results of the normality test using Shapiro Wilk show that the data for both variables are not normally distributed, so nonparametric statistics are used, namely Mann Whitney.

3. Hypothesis testing

Hypothesis testing is used to test the difference in walking speed in patients using SACH foot transtibial prosthesis and patients using single axis foot transtibial prosthesis.

Table 6 Hypothesis testing

Walking Speed	n	Mean	p value	Effect size
SACH Foot	16	0.924	0.000	0.81
Single Axis Foot	12	1.142		

Source: Primary data processed, 2024

The results of the Mann Whitney test showed that there was a difference in the average walking speed between single axis foot users (1.142) and Sach foot users (0.924) with a p value = 0.000 where the p value <0.05 so it can be concluded that there is a statistically significant difference in walking speed in SACH foot transtibial prosthesis users and transtibial single axis foot users. Where for transtibial single axis foot users are faster than transtibial SACH foot users.

From the results of the research data analysis, the value (d = 0.81) is known, so it can be concluded that the magnitude of the difference in walking speed in users of SACH foot and single axis foot transtibial prosthesis is classified as a high effect.

Discussion

Based on the research conducted, the results of the respondent characteristics data based on gender from 28 respondents studied, there were 18 respondents (64.3%) male and 10 respondents (35.7%) female. According to (Stotz et al., 2023) men have a faster walking speed than women, because generally men have been trained since childhood with movements such as running, kicking, jumping, or spinning which increase motor skills, one of which is walking speed.

The results of this study showed that there was no difference in walking speed, even though the number of male subjects was more than female. in male and female subjects who used transtibial prostheses, because there was only an average difference of 0.0052 m / s. The thing that caused the absence of a difference in walking speed in male and female subjects was due to the use of prostheses. Based on the research conducted, it was found that users of SACH foot and single axis foot transtibial prostheses had an age range of 19 - 55 years.

According to (Liu et al., 2022), as a person ages, they will experience several changes in body structure and function. As age increases, musculoskeletal function will decrease, such as muscle flexibility, joints, cartilage function, decreased bone density and decreased muscle strength, especially in the lower extremities, which will result in impaired balance function and walking speed in humans. So this study did not use subjects who were included in the elderly category.

The results of the research data analysis showed a p value = 0.000 (p <0.05) with an average walking speed value on the SACH foot of 0.924 m / s and an average speed on the single axis foot of 1.142 m / s. This shows that there is a difference in walking speed between users of SACH foot transtibial prosthesis and single axis foot. Users of transtibial prosthesis with Single axis foot have better walking speed because there are differences in the mechanism

of the ankle joint mechanism. In SACH foot, the ankle joint has no movement, while the single axis foot has dorsi flexion and plantar flexion movements, so that in terms of function it is closer to a normal ankle joint. However, the walking speed on both types of feet is below the average walking speed in general. Below-knee amputation causes decreased speed and asymmetry of gait. There are several factors that cause transtibial prosthesis users to have slower walking speeds, namely user factors such as age, weight, leg length, confidence when walking, and there are factors from the prosthesis, namely the weight of the prosthesis, the comfort of the prosthesis and the design of the foot used (Gouteron et al., 2021)

The results of this study indicate a difference in the walking speed of transtibial prosthesis users according to the foot design used. These results are in accordance with the results of a study conducted by (Abbas et al., 2020) which concluded that the design or type of foot used in unilateral transtibial prosthesis users affects spatiotemporal gait parameters, especially at the K-1 activity level, and body weight affects gait parameters. Single axis foot is a type of foot that has a movement mechanism such as ankle plantar flexion and dorsi flexion movements. The walking pattern formed in transtibial prosthesis users with a single axis foot can approach a normal walking pattern, so it will affect walking speed.

The results showed that transtibial prosthesis users with a single-axis foot achieved better walking speeds. These findings align with previous research (Louessard et al., 2022), which indicated that for transtibial prosthesis users, the choice of foot type impacts balance, an essential factor in walking speed. In normal walking conditions, the ankle joint performs plantar flexion and dorsiflexion movements. Therefore, to achieve a gait pattern close to normal, a foot prosthesis that enables these movements is essential. A single-axis foot is a type of prosthetic foot that allows for both plantar flexion and dorsiflexion during walking.

The study results further demonstrated that transtibial prosthesis users with single-axis feet walked faster than those using SACH feet, consistent with findings from Hashimoto et al. (2021), which concluded that alignment and motion of the prosthetic foot—specifically, 10 degrees of plantar flexion and dorsiflexion—can impact socket reaction moments. This suggests that achieving a gait pattern close to normal in terms of speed requires a prosthetic foot capable of plantar flexion and dorsiflexion throughout the gait cycle, from initial contact to terminal swing.

Conclusion and Recommendation

There is a notable difference in walking speed, with transtibial prosthesis users utilizing single-axis feet walking faster than those using SACH feet. Therefore, it is recommended to prioritize single-axis feet in transtibial prosthesis users, particularly for individuals with moderate activity levels. The limitations of this study include a small sample size and limited variety in prosthetic foot types. Future research could expand by incorporating different types of prosthetic feet and additional measurement parameters.

References

Abbas, H., Hamandi, S., Abdulsattar, M., & Sabeeh, Y. (2020). The effect of prosthetic foot type on spatio- temporal parameters of unilateral below-knee amputees Source: Primary data processed, 2024

A case study. Proceedings - 2020 International Conference on Assistive and Rehabilitation Technologies, ICareTech 2020, 51–56. https://doi.org/10.1109/iCareTech49914.2020.00017

Ardesa, Y., Ningsih, C., & Syaifuddinn, M. (2019). PERBEDAAN PENGARUH ANTARA PENGGUNAAN ABM KRUK DENGAN PROSTESIS TERHADAP MOBILITAS PASIEN PASCA AMPUTASI TRANSTIBIAL.

Burger, H., Vidmar, G., Zdovc, B., Erzar, D., & Zalar, M. (2018). The influence of prosthetic foot stiffness on energy expenditure in unilateral below-knee amputees. National Journal of Clinical Orthopaedics, 2(3), 66–75. www.orthoresearchjournal.com

Fukuchi, C. A., Fukuchi, R. K., & Duarte, M. (2019). Effects of walking speed on gait biomechanics in healthy participants: A systematic review and meta-analysis. In Systematic Reviews (Vol. 8, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s13643-019-1063-z

Gardiner, J., Bari, A. Z., Howard, D., & Kenney, L. (2016). Transtibial amputee gait efficiency: Energy storage and return versus solid ankle cushioned heel prosthetic feet. Journal of Rehabilitation Research and Development, 53(6), 1133–1138. https://doi.org/10.1682/JRRD.2015.04.0066

Gouteron, A., Casillas, J.-M., Calistri, L., Morisset, C., Laroche, D., & Gueugnon, M. (2021). CASE REPORT Assessing Gait After Changing Prosthetic Foot: Contribution of Subjective and Objective Measurements. A Pilot Study. http://journals.lww.com/jpojournal

Hafner, B. J., Halsne, E. G., Morgan, S. J., Morgenroth, D. C., & Humbert, A. T. (2022). Effects of prosthetic feet on metabolic energy expenditure in people with transtibial amputation: A systematic review and meta-analysis. In PM and R (Vol. 14, Issue 9, pp. 1099–1115). John Wiley and Sons Inc. https://doi.org/10.1002/pmrj.12693

Hashimoto, H., Kobayashi, T., Kataoka, M., & Okuda, K. (2021). Influence of coronal and sagittal prosthetic foot alignment on socket reaction moments in transtibial prostheses during walking. Gait and Posture, 90, 252–260. https://doi.org/10.1016/j.gaitpost.2021.08.011

Himmelberg, N., & Buns, M. (2018). The influence of prosthetic foot stiffness on energy expenditure in unilateral below-knee amputees. National Journal of Clinical Orthopaedics, 2(3), 66–75. www.orthoresearchjournal.com

Liu, J., Cui, K., Chen, Q., Li, Z., Fu, J., Gong, X., & Xu, H. (2022). Association of walking speed with cognitive function in Chinese older adults: A nationally representative cohort study. Frontiers in Aging Neuroscience, 14. https://doi.org/10.3389/fnagi.2022.1003896

Louessard, A., Bonnet, X., Catapano, A., & Pillet, H. (2022). Quantification of the Influence of Prosthetic Ankle Stiffness on Static Balance Using Lower Limb Prosthetic Simulators. Prosthesis, 4(4), 636–647. https://doi.org/10.3390/prosthesis4040051

Nurhalimah, & Munawarah, M. (2020). HUBUNGAN ANTARA PANJANG LANGKAH DENGAN KESEIMBANGAN DINAMIS PADA PASIEN LANJUT USIA DENGAN KONDISI KNEE OSTEOARTHRITIS (OA) GRADE II. Jurnal Ilmiah Fisioterapi, 20(1), 30–39.

Redha, A. H., Adnindya, M. R., Septadina, I. S., Suciati, T., & Wardiansah, W. (2022). ANALISIS HUBUNGAN USIA, INDEKS MASA TUBUH, KECEPATAN BERJALAN DAN RIWAYAT JATUH DENGAN KESEIMBANGAN BERJALAN LANSIA MAJELIS TAKLIM ASMAUL HUSNA PALEMBANG. Jurnal Kedokteran Dan Kesehatan : Publikasi Ilmiah Fakultas Kedokteran Universitas Sriwijaya, 9(2), 191–198. https://doi.org/10.32539/jkk.v9i2.17491

Stotz, A., Hamacher, D., & Zech, A. (2023). Relationship between Muscle Strength and Gait Parameters in Healthy Older Women and Men. International Journal of Environmental Research and Public Health, 20(7). https://doi.org/10.3390/ijerph20075362

Syaifuddin, M., Murti, B., & Probandari, A. (2016). HUBUNGAN PANJANG PUNTUNG (STUMP) INDEKS MASSA TUBUH (IMT).