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Original Research

Functional Walking Speed in Transtibial Prosthesis Users: Insights from Prosthesis Use Duration

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ABSTRACT

Background: *Amputation of a lower limb has a detrimental effect on one's quality of life, psychological health, and physical health. Reduced physical capacity is one of the effects that contributes to physical health. As a result, the experience of using a prosthesis is essential for enhancing functional capacities to adjust to the social, professional, and family environments. The aim of this study was to determine the relationship between the length of prosthesis use and walking speed in transtibial prosthesis users.*

Methods: *This study used a cross-sectional analytical observational design. A two-minute walk test was used to measure walking speed, and an observation sheet was used to assess usage duration. Purposive sampling was employed to recruit a total of 15 participants, and hypothesis testing was conducted using Spearman's rank correlation.*

Results: *The results showed that there was no significant correlation between walking speed and the duration of prosthesis use among transtibial prosthesis users ($r = -0.314$, $p = 0.255$).*

Conclusion: *This study found no statistically significant relationship between the duration of prosthesis use and walking speed among transtibial prosthesis users. Walking speed is likely influenced by multiple factors, including age, stump length, muscle strength, and prosthesis condition. Therefore, rehabilitation strategies should adopt a comprehensive and individualized approach rather than relying solely on the duration of prosthesis use.*

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INTRODUCTION

Amputation is a medical surgery when a damaged or incurable limb is removed. Significant bodily changes result from this irreversible surgery. This procedure is carried out for a number of reasons, including those that cannot be healed or corrected with conventional methods. Lower limb amputation is one kind of amputation (Ss et al., 2020). Currently, lower limb amputations account for 85-90% of all amputations and transtibial amputation is the most frequently performed type of amputation surgery. Transtibial amputation is the loss of limb movement below the knee, along the tibia bone which

results in a person’s inability to carry out functional activities (Hagberg et al., 2023; Mahulkar et al., 2022; Ortega Bedoya et al., 2023).

Every year, 150.000 people in the US have their lower limbs amputated. Neuropathy, soft tissue sepsis, and peripheral artery occlusive disease are the causes of this condition. The higher prevalence of diabetes mellitus, which causes 82% of all amputations in the US, is another factor contributing to this correlation. Compared to other patients, those with diabetes mellitus have a higher risk of amputation. Twenty percent of instances involve trauma-related lower limb amputations, which are linked to serious wound contamination and substantial soft tissue loss. Ninety-three percent of amputations are the result of combat incidents (Walter et al., 2022).

People who have had amputations are likely to experience decreased walking abilities. Walking speed is one example of a temporal and spatial feature that can be used to track improvements in walking ability. Study found that transtibial amputees walk at a speed of 0.63 m/s. Gaining weight after transtibial amputation is a frequent phenomenon. This is because of the longer recovery period following amputation, which can result in a lack of energy for physical activity as well as difficulties adjusting the prosthesis (Paruchuri et al., 2025).

Amputation results in a person experiencing permanent disability, thereby bringing about dramatic changes in all aspects of a person's life in their daily activities. Even though amputation aims to save the patient's life and body, many still hurt the patient, namely psychological changes (Alluhydan et al., 2023). The impacts of higher amputation rates get worse. Additionally, older amputees are more negatively affected than younger ones. This is due to the fact that elderly people are less likely to return to their former professions due to physical limitations (Paruchuri et al., 2025).

After a lower limb amputation, patients are fitted with a transtibial prosthesis, which is an external device. The device can be used both physically and functionally to align the leg's shape (Alluhydan et al., 2023). A device that replaces a lost lower limb is called a transtibial prosthesis. For individuals who have had transtibial amputations, this prosthesis is intended to support lower limb function. According to Topuz (2022), the experience of using a prosthesis is the impression or achievement felt by an amputee while using the prosthesis. Therefore, the experience of using prosthesis is crucial for improving functional abilities to adapt to the surrounding environment, such as family, work, and social life (Alluhydan et al., 2023).

Several factors influence the experience of prosthesis use, such as the length of time the prosthesis is used and its duration. Transtibial prosthesis users reported being able to walk with the prosthesis within 4 months, with an average usage time of 3 to 4 hours per day. This period resulted in the achievement of functional independence. Mobility while using a prosthesis has become a single, most important contributing factor to the experience of using a prosthesis (Smith & Guerra, 2021).

The walking phase with a transtibial prosthesis is an intriguing one for those who have had lower limb amputations. When the sound side is raised off the ground during the initial contact phase, the prosthetic foot makes complete contact with the floor and transmits all of the load to the prosthesis. Pressure is distributed throughout the stump in the socket as a result of this phase. The loading response, middle support, final support, and final balance stages will all follow. Body weight is known to put pressure on the socket and stump. Amputees' increased knee flexion during the stance phase is the main cause of the pressure that results in gait (Ibarra Aguila et al., 2020).

Gait speed is a biomechanical characteristic of a person's gait and an important clinical tool for evaluating normal movement patterns. Several researchers have shown that gait speed is useful for assessing or predicting a person's functional health. Gait speed has been used in decision-making to obtain a biomechanical quantification of an individual's gait. A person's gait speed influences biomechanical variables such as joint kinematics, ground reaction force (GRF), joint strength, and muscle activity (Wu & Zhao, 2021).

Although previous studies have examined various factors influencing prosthesis use and mobility, there remains a limited number of studies that specifically analyze the relationship between the duration of prosthesis use and functional walking speed in transtibial prosthesis users, particularly using simple clinical measurements such as the two-minute walk test. Therefore, this study aims to analyze this relationship and provide scientific evidence regarding whether the duration of prosthesis use can be a determining factor in functional walking ability, while also serving as a basis for the development of clinical rehabilitation strategies to optimize patient mobility.

MATERIALS AND METHOD

The researchers performed an observational analytical study with a cross-sectional design in this study, which required continuous data collection. This research is important to be carried out as material for evaluating the use of prostheses on walking speed by measuring walking speed over time, this study aimed to examine the correlation between the duration of prosthesis usage and walking speed in transtibial prosthesis users (Dahlan, 2020). The Ipoed Prosthetic Leg Clinic in Langenharjo, Grogol District, Sukoharjo Regency, Central Java, is where this study took place out. The research was done between July and December of 2025.

All transtibial prosthesis users at the Ipoed Prosthetic Leg Clinic between 2020 and 2025 made up the study's sample. A purposive sampling technique was employed to select participants based on specific inclusion and exclusion criteria. The inclusion criteria were: (1) individuals who had used a transtibial prosthesis for at least 4 months; (2) had unilateral transtibial amputation; (3) aged between 20–60 years; (4) had no balance disorders; (5) and were willing to participate in the study. The exclusion criteria included individuals with a history of heart disease and those with muscle contractures. A total of 15 participants were included in this study, considering the limited availability of eligible subjects and the strict selection criteria, as well as the exploration nature of the study to identify the relationship between prosthesis use duration and walking speed.

The independent variable in this study was the duration of prosthesis use, while the dependent variable was walking speed. Walking speed was measured using the two-minute walk test (2MWT), which has been reported as a valid instrument for assessing functional walking performance in prosthesis users. The procedure of this study involved recruiting eligible participants, obtaining informed consent, and recording baseline characteristics, including the duration of prosthesis use. Participants were then instructed to perform the 2MWT by walking at a comfortable and safe pace for two minutes along a predetermined walking track. The total distance covered during the test was recorded and used to calculate walking speed. All measurements were conducted under standardized conditions to ensure consistency and reliability of the data.

A hypothesis test was conducted to determine whether there was a relationship between the duration of prosthesis use and walking speed in transtibial prosthesis users. Based on the results of the normality test, which showed a normal distribution, the

Spearman rank test was used. The Spearman rank correlation test was used to assess the strength of the relationship between variables using a non-parametric approach.

This research has received ethical clearance from the Health Research Ethics Commission of 'Aisyiyah University of Surakarta with letter number: No. 524/VII/AUEC/2025. This study has adhered to the principles of research ethics, including respect for the rights and safety of the respondents. All participants were provided with an explanation of the study's objectives and procedures and signed an informed consent form prior to the study's implementation. The confidentiality of the respondents' data was also maintained, and the data was used solely for research purposes.

RESULTS

Table 1. Characteristics of Respondents Based on Gender (n = 15)

Variable	Frequency (n)	Percentage (%)
Gender		
Men	8	53.3
Women	7	46.7
Total	**15**	**100**

Fifteen transtibial prosthesis users were included as study participants. The characteristics of the participants are presented in Table 1. Table 1 shows that male participants constituted the majority, with 8 individuals (53.3%), while the remaining participants were female.

Table 2. Characteristics of Respondents Based on Age, Body Mass Index (BMI), Walking Speed, and Duration of Prosthesis Use (n = 15)

Variable	Minimum	Maximum	Mean
Age (years)	22	59	41.3
BMI	15.6	26.9	21.8
Walking Speed (m/s)	0.36	0.82	0.56
Spending Time Wearing a Prosthesis (years)	0.42	13	2.7

According to Table 2, the average age of the participants was 41.33 years. The respondents had an average walking speed of 0.56 m/s and a normal average body mass index of 21.8. The mean duration of prosthesis use among participants was 2.7 years.

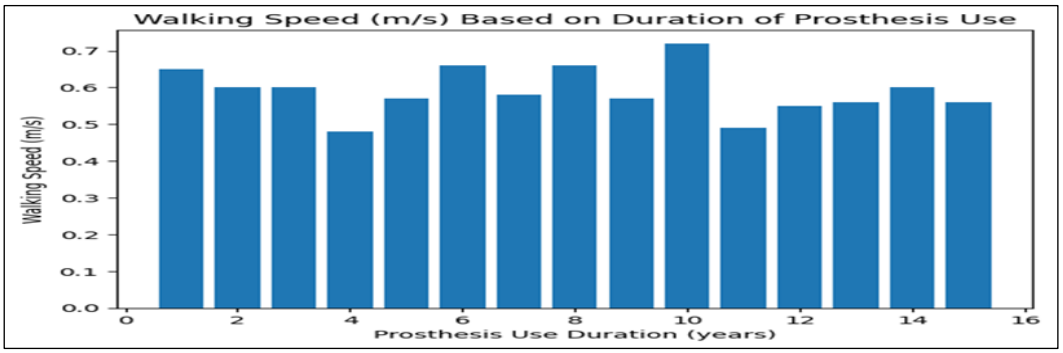


Chart 1. Walking Speed and Prosthesis Using Time

Table 3. Spearman Rank Correlation Between Duration of Prosthesis Use and Walking Speed (n = 15)

Variable	Correlation Coefficient (r)	p-value
Duration of Prosthesis Use vs Walking Speed	−0.314	0.255

Table 3 presents the results of the Spearman rank correlation test between the duration of prosthesis use and walking speed. The analysis showed a correlation coefficient of −0.314 with a p-value of 0.255. These findings indicate that there is no statistically significant relationship between the two variables ($p > 0.05$).

DISCUSSION

The average length of use was 5.03 years, according to research titled "The Relationship between Length of Prosthesis Use and Walking Speed in Transtibial Prosthesis Users" that measured prosthesis usage using observation sheets and interviews with transtibial prosthesis users. This shows that every participant in the research has completed the time of adjustment to using a prosthesis. The adaptation period for using a transtibial prosthesis is six months, according to research by (Bosman et al., 2023; Kim et al., 2025).

The average walking pace of the participants in this research was 0.5607 m/s. the study found that transtibial amputees walk at a pace of 0.63 m/s. This suggests that the research participants' average walking pace remained modest. The results of the analytical test revealed a p-value (>0.05) of 0.255. This indicates that transtibial prosthesis users' walking speed and prosthesis use duration are unrelated. This is due to the fact that gait speed is influenced by several factors. (Suprayogi et al., 2024), found that body mass index (BMI), stump length (amputation level), muscular strength, age, and prosthesis condition all had an impact on walking speed following amputation.

The length of the stump, the state of the prosthesis, and the age of the respondents all had an impact on the study's findings. The study's respondents ranged in age range from 41.33 on average to 59 on average. A person's ability to walk will decrease beyond the age of 40, according to studies by Otadi & Malmir (2026). This indicates that age contributes to the study results, so in future research, age should be a factor that must be controlled.

Stump length is one factor affecting transtibial prosthesis users' walking speed. The 15 respondents in this study had different stump lengths, which affected the study's findings. Different stump lengths would still skew the study's findings even if the average time of prosthesis usage among study participants has passed the adaptation period. Walking speed is influenced by muscular strength, which varies depending on stump length (Butoya et al., 2025; Seethapathi et al., 2024). The two most important factors in predicting the distance walked in the Two-Minute Walk Test (2MWT) were the maximal isometric torque strength of the residual hip extensor muscles (mean torque), according to recent research by Sawers and Fatone (2025) of 13 transtibial prosthesis users.

The research participants' average duration of prosthesis usage was 5.03 years, indicating that they have been using prostheses for a considerable amount of time. The state of the prosthesis in terms of its parts, alignment, and deterioration is one of the elements that influences walking speed. Users of Single Axis type leg prostheses had an average walking speed of approximately 1.142 m/s, while users of Solid Ankle Cushion Heel (SACH) type prosthetic legs recorded an average of 0.924 m/s, according to an

observational study by Suprayogi et al. (2024) involving 28 people using transtibial prostheses. The outcomes of this study were also influenced by the respondents' prosthetic conditions. Modifications to the plantar-dorsiflexion and inversion-eversion angles of the prosthetic foot significantly affected the interaction moment between the socket and the residual limb, known as the Socket Reaction Moment (SRM), especially during the stance phase by 5%, 20%, and 75%, according to a large-scale study titled "Influence of coronal and sagittal prosthetic foot alignment on socket reaction moments in transtibial prostheses during walking" (DeGrasse et al., 2023; Hashimoto et al., 2021; Kooiman et al., 2023).

However, no discernible changes in spatiotemporal measures like cadence, stride length, or walking speed were detected in this investigation. According to these results, SRM is a biomechanical indication that is more sensitive than traditional spatiotemporal measures for identifying changes in prosthesis alignment. The conclusion from the results of this study is that there is no relationship between the length of use of the prosthesis and walking speed in transtibial prosthesis users due to the presence of several uncontrolled factors that influence the results of the study.

Based on the finding that there is no association between the duration of prosthesis use and walking speed among transtibial prosthesis users, this study suggests the need for further research to identify other factors that influence walking speed. These factors may include age, stump length, muscle strength, as well as the condition and fitness of the prosthesis. Thus, future research is expected to provide a more comprehensive understanding to support the development of more effective rehabilitation interventions.

This study has several limitations, including a relatively small sample size (n = 15), which may limit the generalizability of the findings. Additionally, the use of a cross-sectional design does not allow for the identification of causal relationships between variables, and the variables examined were limited to the duration of prosthesis use without considering other factors such as muscle strength, stump length, level of physical activity, and prosthesis quality. Therefore, future studies are advised to use a larger sample size, employ a longitudinal design, and consider various other factors that may influence walking speed to obtain more comprehensive and accurate results.

CONCLUSION

This study concludes that there is no significant correlation between the duration of prosthesis use and gait speed in transtibial prosthesis users, likely due to the influence of multiple uncontrolled factors. Walking speed appears to be affected by various parameters, including age, stump length, muscle strength, and prosthesis quality (e.g., alignment and component selection), rather than the duration of prosthesis use alone. These findings imply that rehabilitation strategies should adopt a comprehensive and individualized approach by addressing multiple contributing factors to optimize functional mobility. Future research is recommended to implement more rigorous control procedures and include a broader range of variables to minimize potential bias and provide more robust evidence.

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DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

AI tools were used solely for grammar and language editing. The authors take full responsibility for the content and integrity of the manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest, whether financial or non-financial, that could have affected the results of this study.

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