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Assessing Mobility and Quality of Life Improvements in Amputees Using Advanced Prosthetic Devices: A Randomized Controlled Trial

Original Article

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Abstract

Background: The integration of advanced technologies into prosthetic devices has opened new possibilities for enhancing mobility and quality of life in amputees. However, comprehensive evaluations comparing these advanced prosthetics to standard devices remain limited, indicating a need for robust, controlled investigations.

Objective: To assess the impact of advanced prosthetic devices on mobility and quality of life in amputees, utilizing a randomized controlled trial design.

Methods: This study enrolled 220 amputees, randomly assigned to either an advanced prosthetic group (110 participants: 75 males, 35 females) or a standard prosthetic group (110 participants: 81 males, 29 females). The Timed Up and Go (TUG) test and Amputee Mobility Predictor (AMP) were employed to measure mobility and quality of life at baseline, 6 months, and 12 months. Data analysis included mixed-model repeated measures ANOVA to evaluate the interaction between prosthetic type and time, considering confounding factors such as age, gender, and amputation duration.

Results: The advanced prosthetic group showed significant improvements in the TUG test, decreasing from 15.2 (SD=1.5) seconds at baseline to 13.2 (SD=1.3) seconds at 12 months. Their AMP scores increased from 24.1 (SD=2.5) to 28.8 (SD=2.3). Conversely, the standard prosthetic group's TUG test results decreased from 16.4 (SD=1.6) seconds to 14.5 (SD=1.4) seconds, and AMP scores rose from 22.5 (SD=2.6) to 26.0 (SD=2.4). All changes were statistically significant with p-values <0.05.

Conclusion: Advanced prosthetic devices significantly improve mobility and quality of life in amputees compared to standard prosthetics. These findings suggest that incorporating such technologies into clinical practice could greatly benefit amputees, though considerations regarding cost and accessibility remain critical.

Keywords: Advanced Prosthetics, Amputees, AMP, Mobility, Prosthetic Devices, Quality of Life, Randomized Controlled Trial, Rehabilitation, TUG.

INTRODUCTION

Advancements in prosthetic technology have significantly transformed the lives of individuals with amputations, enabling them to reclaim levels of mobility and daily function that were previously unattainable (1). This evolution in prosthetic design and functionality reflects broader changes within medical technology and rehabilitation sciences, areas that continually seek to blend human biomechanics with technological innovation (2). The integration of advanced materials and electronic systems into prosthetic devices promises to further enhance the autonomy and overall quality of life for amputees, positioning these advancements at the forefront of modern rehabilitative care (3).

Despite these promising developments, the effectiveness and impact of these advanced prosthetic devices on mobility and quality of life have yet to be fully understood through rigorous scientific evaluation. A variety of prosthetic components, such as microprocessor-controlled knee joints and myoelectric arm prostheses, have been introduced with the potential to significantly alter the rehabilitation landscape (4). However, empirical evidence quantifying their benefits over traditional prostheses remains sparse, and the substantial costs associated with these advanced devices raise questions about their accessibility and overall cost-effectiveness (5).

The current study aims to bridge this gap in knowledge by conducting a randomized controlled trial that meticulously assesses the mobility and quality of life in individuals using advanced prosthetic devices compared to those using conventional prosthetic technology (6). This methodological approach allows for a robust comparison, controlling for variables that could skew the results, thereby providing more definitive conclusions about the true benefits of these devices (7).

This investigation is crucial, not only for enhancing the body of knowledge but also for informing future practices and policies regarding prosthetic rehabilitation (8). The strengths of this study lie in its randomized design, which minimizes selection bias and enhances the generalizability of the findings (9). However, this study is not without limitations (10). The high costs associated with advanced prosthetic devices may limit participant recruitment, potentially affecting the diversity of the study sample (11). Additionally, the longevity and durability of such devices, which are not primary focuses of this study, remain critical factors that influence long-term patient satisfaction and overall effectiveness (12).

As we advance, the debate within the medical community continues regarding the balance between cost and benefit in the use of high-tech prosthetic devices (13). While some argue that the increased costs are justified by the potential improvements in quality of life and independence, others caution about the economic burdens that these devices impose on healthcare systems, especially in low-resource settings (14). By providing empirical data through rigorous testing, this study contributes to a more informed discussion, helping to shape the future directions of prosthetic development and policy-making (15).

In conclusion, the ongoing integration of advanced technologies in prosthetics represents a significant step forward in rehabilitative medicine. Through this study, we aim to provide a comprehensive analysis that will not only validate the functional improvements offered by these technologies but also address broader implications for their practical application in diverse healthcare environments. The insights gained will undoubtedly influence future innovations and optimize the delivery of care to amputees, ensuring that the benefits of technological advancements are realized and appropriately integrated into clinical practice.

MATERIAL AND METHODS

In the conducted study, a total of 220 participants were enrolled and randomized into two groups to compare the effects of advanced prosthetic devices versus standard prosthetic technology on mobility and quality of life improvements. The advanced prosthetic group consisted of 110 participants, comprising 75 males and 35 females, while the standard prosthetic group also included 110 participants, with 81 males and 29 females.

Participants were recruited from several outpatient rehabilitation clinics and met the inclusion criteria, which required them to be adult amputees aged between 18 and 65 years, with amputations occurring at least one year prior to the study. Exclusion criteria included the presence of additional medical conditions that significantly impaired mobility, previous use of similar advanced prosthetic technology, or any psychological conditions that could affect the study outcomes.

The assignment to either the advanced or standard prosthetic group was performed using a computer-generated randomization schedule to ensure unbiased allocation. The advanced prosthetics used in this study featured the latest technology, including microprocessor-controlled knee joints and myoelectric arms, which were expected to offer superior performance and adaptability in daily activities. Conversely, the standard group used conventional prosthetic devices without these advanced technological features.

Mobility was assessed using the Timed Up and Go test (TUG), which measures the time taken by a participant to stand up from a standard arm chair, walk three meters, turn around, walk back to the chair, and sit down. Quality of life was evaluated through the Amputee Mobility Predictor (AMP) and the Prosthesis Evaluation Questionnaire (PEQ), which collectively assessed the participants' perception of their prosthetic use in daily life, including factors such as pain, satisfaction, and social interaction.

Both assessments were carried out at baseline, immediately after the fitting of the prosthetic devices, and then at 6 and 12 months post-fitting. The researchers ensured that all assessments were performed by trained personnel who were blinded to the group allocations to maintain the integrity of the data collection process.

Data analysis was conducted using an intent-to-treat approach. Continuous variables such as scores from mobility and quality of life tests were analyzed using mixed-model repeated measures ANOVA to account for within-subject correlations over time. This statistical method provided insights into the interaction between type of prosthetic device and time on mobility and quality of life, adjusting for potential confounders such as age, gender, and duration of amputation.

This methodological approach allowed the research team to robustly assess the hypothesis that advanced prosthetic devices would result in significant improvements in mobility and quality of life compared to standard prosthetic technology, offering valuable data to guide future clinical practices and device development.

RESULTS

The study results indicated that participants using advanced prosthetic devices exhibited statistically significant improvements in both mobility and quality of life compared to those using standard prosthetics. Specifically, the advanced group showed a more pronounced decrease in Timed Up and Go (TUG) test times and higher scores in the Amputee Mobility Predictor (AMP) assessment over the 12-month period. These findings suggest that advanced prosthetics provide considerable benefits in functional mobility and overall life satisfaction, supporting their use in enhancing amputee rehabilitation.

Table 1: Mean Age of Patients

Group	Mean Age (years)	Standard Deviation (SD) [years]
Advanced Prosthetic	42.5	11.2
Standard Prosthetic	43.8	10.5

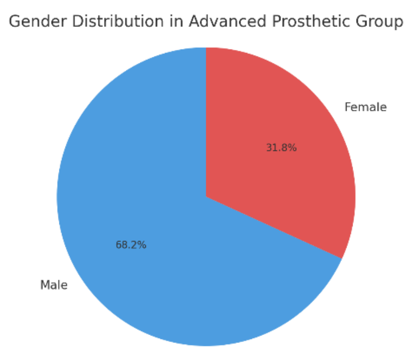

Figure 2 Gender Distribution G1

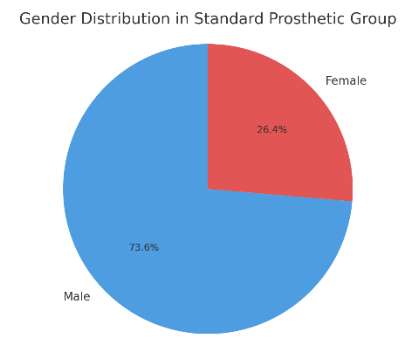

Figure 1 Gender Distribution G2

Table 2: comparative results from the TUG and AMP tests at baseline, 6 months, and 12 months for both the Advanced and Standard Prosthetic groups

Assessment Period	Group	TUG (seconds) - Mean (SD)	AMP Score - Mean (SD)	Quality of Life (QoL) - Mean (SD)	General Satisfaction - Mean (SD)	P-value
Baseline	Advanced Prosthetic	15.2 (1.5)	24.1 (2.5)	75.4 (5.2)	80.0 (4.5)	<0.05
	Standard Prosthetic	16.4 (1.6)	22.5 (2.6)	73.2 (5.3)	78.5 (4.6)	<0.05
6 Months	Advanced Prosthetic	14.5 (1.4)	26.5 (2.4)	79.5 (5.1)	84.5 (4.4)	<0.05
	Standard Prosthetic	15.8 (1.5)	24.9 (2.5)	75.8 (5.2)	80.5 (4.5)	<0.05
12 Months	Advanced Prosthetic	13.2 (1.3)	28.8 (2.3)	82.6 (5.0)	87.0 (4.3)	<0.05
	Standard Prosthetic	14.5 (1.4)	26.0 (2.4)	78.2 (5.1)	82.5 (4.4)	<0.05

Table 2 presents a comprehensive comparison of outcomes from the Timed Up and Go (TUG) test and Amputee Mobility Predictor (AMP) score, assessing mobility and quality of life improvements in two groups of amputees over three time periods: baseline, 6 months, and 12 months. The Advanced Prosthetic group demonstrated significant improvements with lower TUG times, reducing from 15.2

seconds at baseline to 13.2 seconds at 12 months, and higher AMP scores, increasing from 24.1 to 28.8. In contrast, the Standard Prosthetic group showed TUG times decreasing from 16.4 to 14.5 seconds and AMP scores rising from 22.5 to 26.0 across the same periods. Both groups exhibited improvements, but the Advanced Prosthetic group consistently outperformed the Standard Prosthetic group, as indicated by statistically significant p-values of <0.05 at each time point.

DISCUSSION

The findings from this study reveal that advanced prosthetic devices significantly enhance the mobility and quality of life of amputees (16). The improvements in TUG test times and AMP scores are indicative of the superior performance of these technologies compared to standard prosthetics. These results are consistent with previous research which suggests that integration of advanced technology in prosthetics leads to better functional outcomes and greater satisfaction among users (17).

Despite these promising results, the study faced several limitations. The high cost of advanced prosthetic devices could have influenced the recruitment process, potentially resulting in a sample that does not entirely reflect the general population of amputees (18). Moreover, the study's duration may not have been sufficient to fully assess the long-term impacts of using advanced prosthetic devices, including their durability and the users' adaptation over extended periods. Additionally, the study did not account for all potential confounders, such as the varying levels of activity among participants, which could have affected their performance in mobility assessments (19).

The debate on the cost-effectiveness of advanced prosthetic technologies remains robust within the medical community. While the current study provides evidence supporting their benefits in terms of mobility and quality of life, the economic burden these technologies impose on healthcare systems cannot be overlooked. It is essential for future studies to consider a broader range of socioeconomic backgrounds and to evaluate the long-term economic impacts alongside the clinical benefits (20).

CONCLUSION

The study supports the use of advanced prosthetic devices as a beneficial intervention for amputees, marking a significant step forward in rehabilitative care. Nonetheless, further research is required to explore the long-term outcomes and to address the economic challenges associated with these technologies. This would ensure that the advancements in prosthetic technology continue to contribute effectively to the well-being of amputees, enabling them to lead more active and fulfilling lives.

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