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Corresponding author:

Júlia Fátima Bertani Strelow

julia.strelow@universo.univates.br

Author Affiliation:

UNIVERSIDADE DO VALE DO
TAQUARI- UNIVATES.

Advanced Prosthetic Technologies in Individuals with Limb Amputation: A Systematic Review with Narrative Synthesis of Functional and Psychosocial Outcomes

Strelow, JFB; Da Cunha De Marchi, L; Scariot, AJV; Bortoluzzi, N; Santos, FS; Rempel, C.

ADMINISTRATIVE INFORMATION

Support - No financial support, grants, or external funding were received for this systematic review.

Review Stage at time of this submission - Formal screening of search results against eligibility criteria.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 26 July 2026 and was last updated on 26 July 2026.

INTRODUCTION

Review question / Objective To evaluate the available scientific evidence on the effects of advanced prosthetic technologies, including robotic prostheses, microprocessor-controlled prosthetic components, osseointegration systems, and sensory feedback technologies, on functional and psychosocial outcomes in individuals with upper- or lower-limb amputation.

Rationale Limb amputation is associated with substantial functional limitations, reduced mobility, impaired quality of life, and psychosocial challenges. In recent years, advanced prosthetic technologies, including microprocessor-controlled prosthetic components, powered prostheses, osseointegration systems, and sensory feedback devices, have been developed to improve functional performance and facilitate rehabilitation. Although an increasing number of clinical studies have evaluated these technologies, the available

evidence remains heterogeneous regarding patient populations, prosthetic interventions, and reported outcomes. A comprehensive synthesis of the current evidence is needed to clarify their effectiveness on functional and psychosocial outcomes and to support evidence-based clinical decision-making in prosthetic rehabilitation.

Condition being studied Upper- and lower-limb amputation is associated with significant functional impairment, reduced mobility, limitations in activities of daily living, and adverse psychosocial outcomes, including decreased quality of life and social participation. Advances in prosthetic technology have expanded rehabilitation options by incorporating microprocessor-controlled components, robotic prostheses, osseointegration systems, and sensory feedback technologies. This review will evaluate the impact of these advanced prosthetic technologies on functional and psychosocial outcomes in adults with limb amputation.

METHODS

Search strategy A comprehensive literature search will be conducted in PubMed/MEDLINE, SciELO, and the Cochrane Library. The search strategy will combine controlled vocabulary (e.g., MeSH terms) and free-text terms related to limb amputation, advanced prosthetic technologies, and rehabilitation outcomes using the Boolean operators ****AND**** and ****OR****. Search terms will include, but will not be limited to: **Amputation**, **Artificial Limbs**, **Prostheses and Implants**, **Microprocessor Knee**, **Microprocessor Foot**, **Powered Prosthesis**, **Robotic Prosthesis**, **Osseointegration**, **Bone-Anchored Prosthesis**, **Sensory Feedback**, **Haptic Feedback**, **Mobility**, **Gait**, **Walking**, **Balance**, **Activities of Daily Living**, **Quality of Life**, **Patient Satisfaction**, **Functional Recovery**, and **Rehabilitation**. The search strategy will be adapted to the indexing terms and syntax of each database. Reference lists of the included studies will also be screened to identify additional eligible publications.

Participant or population The review will include adults (≥ 18 years) with upper- or lower-limb amputation, regardless of the etiology (e.g., traumatic, vascular, neoplastic, congenital, infectious, or other causes). Studies involving individuals with unilateral or bilateral amputations at any amputation level who were evaluated using advanced prosthetic technologies will be considered.

Intervention Advanced prosthetic technologies, including microprocessor-controlled prosthetic knees and feet, robotic or powered prostheses, osseointegration systems, myoelectric prostheses, sensory feedback systems (e.g., vibrotactile or haptic feedback), and other advanced prosthetic devices designed to improve functional performance, mobility, and rehabilitation outcomes.

Comparator Conventional prosthetic devices, alternative prosthetic technologies, standard rehabilitation care, or no comparator, depending on the study design. Studies without a comparison group will also be considered if they evaluate the effects of advanced prosthetic technologies on the predefined outcomes.

Study designs to be included Randomized controlled trials, non-randomized clinical trials, prospective and retrospective cohort studies, case-control studies, cross-sectional studies, and other observational studies evaluating the effects

of advanced prosthetic technologies in adults with limb amputation. Case reports, case series, review articles, conference abstracts, editorials, letters, study protocols, biomechanical studies without clinical outcomes, and experimental engineering studies will be excluded.

Eligibility criteria Studies will be eligible if they include adults with upper- or lower-limb amputation who use or are evaluated with advanced prosthetic technologies and report clinical outcomes related to functional or psychosocial aspects. Studies published between 2016 and 2026 in English, Portuguese, or Spanish will be considered. Only primary studies involving human participants will be included.

Studies will be excluded if they involve pediatric populations, animal models, cadaveric studies, biomechanical or engineering studies without clinical outcomes, studies evaluating prosthetic components without advanced technology features, duplicate publications, reviews, meta-analyses, protocols, editorials, letters, conference abstracts, or studies without sufficient outcome data.

Information sources The electronic databases PubMed/MEDLINE, SciELO, and Cochrane Library will be searched from January 2016 to July 2026. The search will include controlled vocabulary and free-text terms related to amputation, advanced prosthetic technologies, rehabilitation, mobility, functional outcomes, and psychosocial outcomes. Reference lists of included studies will be manually screened to identify additional eligible studies. No contact with study authors, clinical trial registries, or grey literature sources will be performed.

Main outcome(s) The primary outcomes will be the functional and psychosocial effects of advanced prosthetic technologies in adults with limb amputation. Functional outcomes will include mobility, gait performance, walking speed, balance, functional capacity, independence in activities of daily living, prosthesis use, and safety during locomotion (including falls and complications). Psychosocial outcomes will include quality of life, patient satisfaction, confidence, and perceived benefits related to prosthetic use. Outcomes will be extracted according to the measurement instruments reported in each included study, such as mobility scales, gait assessments, functional performance tests, quality-of-life questionnaires, satisfaction measures, and adverse event reports. The review will consider outcomes assessed after the

implementation or use of advanced prosthetic technologies, regardless of follow-up duration.

Additional outcome(s) Additional outcomes will include energy expenditure during walking, gait symmetry, rehabilitation outcomes, return to daily activities, prosthetic adaptation, and user preference regarding advanced prosthetic devices. Device-related adverse events and complications associated with specific technologies, such as osseointegration-related complications, will also be considered when reported.

Data management All retrieved references will be managed using the Rayyan platform, which will be used for duplicate removal, study screening, and selection. Data from included studies will be extracted using a standardized data extraction form developed by the reviewers. Extracted information will include study characteristics, participant demographics, amputation level, prosthetic technology evaluated, comparator, outcome measures, follow-up period, and main results. Data extraction will be performed independently by reviewers, and any discrepancies will be resolved through discussion and consensus. The collected data will be organized in structured databases to support qualitative synthesis and evidence assessment.

Quality assessment / Risk of bias analysis The methodological quality and risk of bias of the included studies will be assessed according to study design. Randomized controlled trials will be evaluated using the Cochrane Risk of Bias 2 tool (RoB 2), while non-randomized studies will be assessed using the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool. The certainty of evidence for the main outcomes will be evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. The assessments will be performed independently by reviewers, with disagreements resolved through consensus.

Strategy of data synthesis A narrative synthesis will be performed due to the expected heterogeneity among the included studies regarding participant characteristics, types of advanced prosthetic technologies, study designs, and outcome measures. Extracted data will be summarized in descriptive tables, including study characteristics, interventions, comparators, outcome measures, and main findings. The effects of advanced prosthetic technologies will be synthesized according to outcome domains, including functional outcomes (mobility, gait performance, balance, independence, and safety)

and psychosocial outcomes (quality of life, satisfaction, and perceived benefits). When possible, comparisons will be made between advanced prosthetic technologies and conventional prosthetic devices. A meta-analysis will only be considered if sufficient methodological and clinical homogeneity is identified among studies.

Subgroup analysis When sufficient data are available, subgroup analyses will be performed according to relevant clinical and technological characteristics, including amputation level (upper versus lower limb), type of advanced prosthetic technology (microprocessor-controlled components, robotic or powered prostheses, osseointegration systems, and sensory feedback technologies), and study population characteristics. These analyses will be exploratory and will aim to identify potential differences in outcomes associated with specific technologies or patient groups.

Sensitivity analysis A sensitivity analysis will be conducted, when applicable, to evaluate the robustness of the findings. This analysis may include the exclusion of studies considered at high risk of bias, studies with limited methodological quality, or studies with substantial differences in intervention characteristics or outcome assessment. The impact of these exclusions on the overall interpretation of the results will be assessed.

Language restriction Studies published in English, Portuguese, and Spanish will be included.

Country(ies) involved Brazil.

Other relevant information This systematic review will be conducted according to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020). The review protocol will be registered in the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY). The review will include clinical evidence regarding advanced prosthetic technologies and their effects on functional and psychosocial outcomes in adults with limb amputation. Due to expected heterogeneity among interventions, populations, and outcome measures, findings will be synthesized narratively.

Keywords Amputation; Advanced prosthetic technology; Microprocessor prosthesis; Osseointegration; Rehabilitation; Mobility; Quality of life.

Dissemination plans The findings of this systematic review will be submitted for publication in a peer-reviewed scientific journal and may be presented at national and international scientific conferences related to orthopedics, rehabilitation, prosthetics, and assistive technologies.

Contributions of each author

Author 1 - Julia Fátima Bertani Strelow.

Email: julia.strelow@universo.univates.br

Author 2 - Luiza da Cunha De Marchi.

Email: luiza.marchi@universo.univates.br

Author 3 - Ana Julia Viapiana Scariot.

Email: ana.scariot3@universo.univates.br

Author 4 - Nathália Bortoluzzi.

Email: nathalia.bortoluzzi@universo.univates.br

Author 5 - Francisco De Souza Santos.

Email: francisco.santos5@univates.br

Author 6 - Claudete Rempel.

Email: crempel@univates.br