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DESIGN OF MULTIFUNCTIONAL PROSTHESIS FOR TRANSTIBIAL AMPUTATION

Oana Andreea CHIRIAC, Elena-Theodora OANCEA

Abstract: *This study presents the development of a transtibial prosthesis adapted for recreational swimming through additive manufacturing. Conventional prostheses are not optimized for aquatic environments, and commercial alternatives remain costly and limited in accessibility. Two configurations were designed using CAD and fabricated from TPU 95A via FDM 3D printing: a fully integrated model replacing the distal segment and a modular variant replacing only the prosthetic foot. Mechanical and functional assessments indicate adequate buoyancy, flexibility, propulsion efficiency, and compatibility with standard coupling systems. The proposed solution demonstrates technical feasibility and cost-effectiveness, supporting accessible, patient-specific aquatic prosthetic applications.*
Key words: *lower limb amputation, swim prostheses, CAD and rapid prototyping*

1. INTRODUCTION

Lower limb prostheses are medical devices designed to replace lost anatomical segments and to restore, to the greatest extent possible, weight-bearing and locomotor functions. Lower extremity amputations may result from traumatic injuries, peripheral vascular disease, diabetes mellitus, or congenital disorders. The primary objective of a prosthetic device is to provide the patient with functional mobility, autonomy in daily activities, and a quality of life comparable to that of an individual without disability [1].

The present study aims to design and implement a multifunctional, customized prosthetic solution dedicated to recreational use, with a primary focus on aquatic activities, particularly swimming. The research seeks to improve the quality of life of individuals with lower limb amputations by optimizing and functionally adapting a conventional transtibial prosthesis to the specific biomechanical demands and physicochemical conditions characteristic of the aquatic environment.

For the development of a multifunctional, patient-specific prosthesis intended for recreational applications, the design strategy was grounded in a conventional device routinely employed for activities of daily living. The baseline transtibial configuration was structurally re-engineered through the substitution of key components—namely the pylon and the prosthetic foot—with elements specifically optimized in terms of hydrodynamic performance and functional compatibility with aquatic environments.

The proposed modifications were conceived not only to enhance buoyancy and reduce the overall structural mass, but also to establish a morphological configuration capable of improving propulsive efficiency and kinematic performance during swimming.

2. EXPERIMENTAL STUDIES

The swim fin design was developed using AutoCAD software, enabling the precise modeling of the swim fin geometry and its fixation components in compliance with the mechanical and dimensional standards applicable to existing prosthetic systems. Two adaptation strategies were proposed: (i) a configuration involving the complete replacement of both the prosthetic foot and pylon, and (ii) a modular solution allowing the attachment of a swim fin element in place of the

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standard prosthetic foot, thereby providing functional flexibility according to the user's specific requirements and activity profile.

The design concept was biomimetically inspired by the morphology of natural fins, as well as by commercially available swimming fins engineered to enhance aquatic propulsion through hydrodynamically optimized geometries. The resulting configuration integrates streamlined contours intended to minimize drag forces while maximizing thrust generation during the propulsive phase of the swimming cycle.

Elastic structural elements incorporated within the assembly allow controlled plantarflexion and dorsiflexion movements, thereby facilitating a physiological kinematic pattern during swimming. These compliant features contribute to a more natural and energy-efficient motion, while maintaining adequate structural stability and alignment of the prosthetic assembly under dynamic loading conditions in the aquatic environment.

Additive manufacturing (3D printing) technology was employed for component fabrication, offering advantages in terms of cost reduction, shortened production timelines, and rapid prototyping for iterative design optimization. The selected material for the fin was thermoplastic polyurethane (TPU), due to its favorable mechanical properties, including high elasticity, water resistance, abrasion resistance, and enhanced comfort at the skin–device interface. These characteristics are particularly critical for applications in aquatic environments, where prolonged exposure to moisture and repetitive dynamic loading conditions must be considered.

For the fabrication of the swim fin component, a Formbot Raptor 2.0 3D printer was employed, a semi-industrial FDM (Fused Deposition Modeling) system. This equipment was selected based on its generous build volume, compatibility with technical polymers such as TPU, and its high dimensional accuracy in reproducing the geometric features defined within the AutoCAD design environment.

The FDM technology enabled controlled layer-by-layer deposition, ensuring adequate interlayer adhesion and structural integrity of the elastomeric component, while maintaining the geometric fidelity required for proper integration with standardized prosthetic interfaces.

3. DESIGN METHODOLOGY

The design methodology adopted in this study followed a structured engineering workflow integrating biomechanical analysis, computer-aided design (CAD), material selection, and rapid prototyping.

Initially, the functional requirements of the prosthetic system were defined based on the biomechanical demands of swimming, including buoyancy optimization, drag reduction, controlled ankle-like motion (plantarflexion and dorsiflexion), and structural stability under cyclic loading in an aquatic environment. Particular attention was given to the interface compatibility with standard transtibial prosthetic components to ensure mechanical safety and modular adaptability.

Subsequently, the geometric modeling phase was performed using CAD tools, allowing the development of a hydrodynamically optimized fin profile inspired by biomimetic principles. Parametric design strategies were employed to enable iterative refinement of curvature, thickness distribution, and flexibility zones, thereby balancing propulsion efficiency with mechanical resistance.

Material selection was conducted based on mechanical performance criteria (elastic modulus, fatigue resistance, water resistance, abrasion resistance) and biocompatibility considerations at the skin–device interface. Thermoplastic polyurethane (TPU) was identified as an optimal solution due to its elastomeric behavior and suitability for additive manufacturing processes.

The fabrication stage utilized FDM-based additive manufacturing to produce functional prototypes. This approach enabled rapid design validation, dimensional verification, and mechanical testing under simulated aquatic conditions. Iterative adjustments were implemented following prototype evaluation to optimize performance parameters and ensure structural reliability.

The overall methodology ensured an integrated approach combining biomechanical principles, digital design technologies, and advanced manufacturing techniques to develop a multifunctional prosthetic solution tailored for aquatic recreational activities.

A conventional transtibial prosthesis (Figure 2.4) consists of a prosthetic socket, a connecting structural element (typically an aluminum or titanium pylon), fixation components (such as distal locking pins and modular adapters), and a prosthetic foot manufactured from materials including carbon fiber composites, polyurethane, or hybrid composite structures.

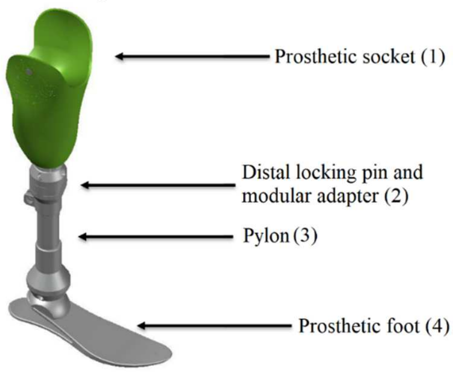

Fig. 1. 3D visualization of transtibial prosthetic components.

This modular architecture ensures mechanical load transfer from the residual limb to the ground, facilitates alignment adjustments in the sagittal, frontal, and transverse planes, and allows functional customization according to the patient's anthropometric parameters and activity level.

Among these components, the pylon and the prosthetic foot undergo functional limitations when exposed to aquatic environments. The pylon is typically manufactured from lightweight metallic alloys; however, in the absence of appropriate surface treatment or corrosion-resistant coatings, prolonged exposure to water may predispose the material to corrosion or oxidation phenomena. The prosthetic foot, generally designed as a rigid structure optimized for terrestrial ambulation, lacks intrinsic buoyancy or propulsive characteristics suitable for swimming.

In an aquatic setting, these elements not only contribute additional weight and structural stiffness but may also raise safety concerns by compromising stability and restricting the user's range of motion in water.

To address the heterogeneous functional requirements of patients, two distinct prosthetic configurations adapted for swimming were designed, each targeting a specific usage scenario and level of aquatic engagement.

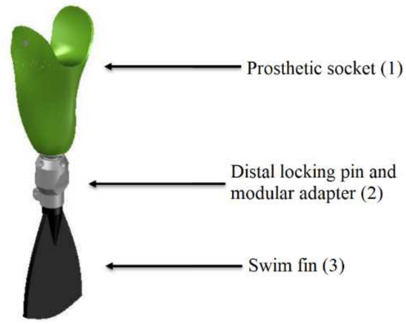

Fig. 2. 3D visualization of transtibial prosthetic components – swim fin replacing the pylon (3 from the fig. 1) and the prosthetic foot (4 from the fig. 1).

The first model developed (Figure 2.5) consists of a fully integrated structure that replaces both the pylon and the prosthetic foot. This solution involves the removal of the distal components of the standard prosthesis and the attachment of a fin specifically designed in AutoCAD to connect directly to the prosthetic socket. The fin geometry was inspired by the morphology of natural fins and is fabricated from thermoplastic polyurethane (TPU) to ensure adequate flexibility, buoyancy, and efficient propulsion in the aquatic environment.

The advantages of this configuration include optimized weight distribution, achieved through the use of a lightweight polymeric material significantly less dense than conventional metallic or composite prosthetic components. The structural design enables active propulsion and efficient kinematic performance in water, supported by the hydrodynamically contoured shape and the elastic behavior of the material. Additionally, the model allows secure and straightforward attachment to the socket, as it incorporates an adapter compatible with the existing suspension and fixation system.

This configuration is recommended for individuals seeking full functional support during swimming activities, as it entails the complete replacement of the distal prosthetic assembly with a solution exclusively adapted for aquatic use.

The second proposed configuration represents a modular adaptation in which only the prosthetic foot is replaced, while preserving the standard pylon of the transtibial prosthesis.

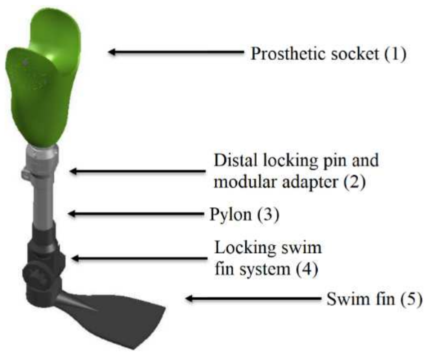

Fig. 3. 3D visualization of transtibial prosthetic components – swim fin replacing only the prosthetic foot (4 from the fig. 1).

This design is primarily intended for users who require a rapid and practical transition between terrestrial ambulation and recreational swimming activities. It is particularly suitable for individuals who utilize a conventional swimming fin on the contralateral limb and require improved bilateral balance, symmetry, and mechanical support at the level of the prosthetized segment.

The modular swim fin incorporates a fixation interface fully compatible with standard distal adapters, enabling straightforward mounting and demounting without specialized instrumentation. Compared to the fully integrated model, the reduced geometric dimensions of this solution ensure minimal alteration of the prosthesis' overall mass and inertial characteristics, thereby preserving functional versatility.

Key advantages of this configuration include reduced installation time, high compatibility with existing prosthetic assemblies, and suitability for repeated or short-duration aquatic sessions. The fin mechanism allows angular adjustment to accommodate individual biomechanical preferences and swimming techniques. Once positioned, the selected orientation is secured using a pivot-and-pin locking system, which ensures stable fixation and prevents undesired displacement under hydrodynamic loading.

Both prosthetic configurations were conceived to ensure dimensional adaptability to various socket geometries, allowing customization according to the patient's anthropometric parameters and residual limb characteristics. The connection interfaces were engineered to maintain compatibility with standardized modular coupling systems commonly employed in transtibial prosthetic assemblies, thereby facilitating integration into existing clinical configurations without extensive structural modifications.

The selection between the two models is determined by the intended activity profile and the functional objectives of the user. In clinical rehabilitation settings or structured aquatic training programs, the fully integrated configuration (pylon–fin assembly) demonstrates superior hydrodynamic performance, optimized mass distribution, and improved propulsive efficiency. In contrast, the modular solution—entailing replacement of the prosthetic foot only—offers enhanced functional versatility, simplified transition between environments, and increased practicality for routine or short-duration recreational swimming sessions.

4. DEVELOPMENT OF THE SWIM FIN MODELS IN AUTOCAD

The fin models were developed using computer-aided design (CAD) techniques within the AutoCAD environment, enabling precise geometric definition and parametric control of the structural components. The modeling process began with the establishment of reference dimensions derived from the mechanical interfaces of standard transtibial prosthetic systems, ensuring compatibility with existing socket and adapter configurations.

A three-dimensional solid modeling approach was employed to define the hydrodynamic contour of the fin, incorporating curvature profiles optimized to reduce drag and enhance thrust generation.

Attention was given to thickness gradients and flexible zones, strategically distributed to permit controlled plantarflexion and dorsiflexion under hydrodynamic loading.

The attachment interface was modeled according to standardized prosthetic coupling geometries, including alignment features and mechanical tolerances necessary for secure fixation. Parametric constraints were applied to allow rapid dimensional adjustments for different socket sizes and user-specific requirements.

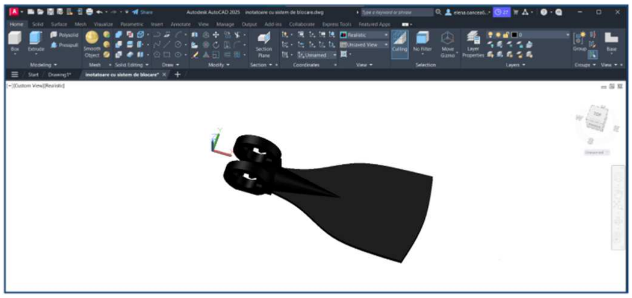

Fig. 4. Final autocad rendering of the slightly curved swim fin design

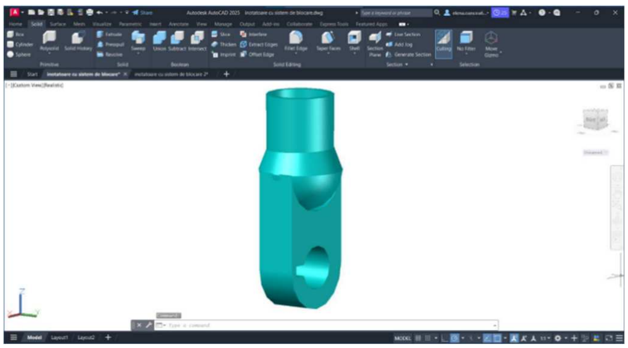

Fig. 5. Component for attaching the fin to the prosthesis

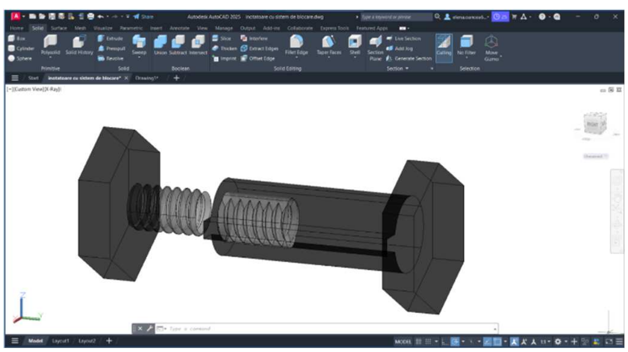

Fig. 6. Pivot and screw for securing the swim fin

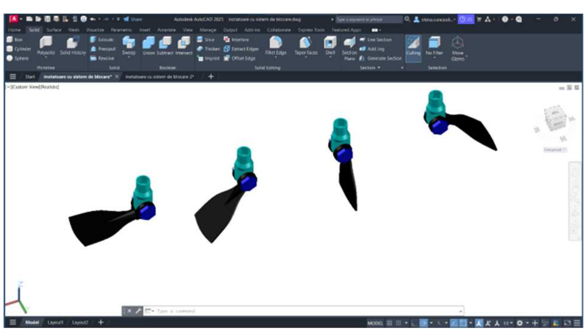

Fig. 7. Fin Fixation Variants: A – Neutral Position, B – 45°, C – 90°, D – 135°.

The swim fin attachment system was engineered to allow multiple angular configurations, thereby accommodating different biomechanical and functional requirements during aquatic activities. Four discrete fixation positions were defined within the adjustment mechanism:

- A – Neutral position (0°): alignment in continuation of the longitudinal axis of the prosthetic assembly, recommended for streamlined positioning and reduced hydrodynamic resistance during floating or low-intensity propulsion.
- B – 45° position: moderate angular inclination, facilitating controlled propulsion and transitional movements between floating and active kicking phases.
- C – 90° position: perpendicular orientation relative to the prosthetic axis, enhancing thrust generation during active swimming strokes.
- D – 135° position: extended angular configuration, intended for specific propulsion techniques or compensatory biomechanical strategies depending on the user's swimming style.

The angular adjustment mechanism incorporates a pivot-based articulation combined with a mechanical locking system, ensuring stable fixation under hydrodynamic loading. This design enables reproducible positioning, mechanical reliability, and adaptability to individualized functional demands.

The finalized CAD assemblies enabled visualization of the complete prosthetic configuration, interference analysis between components, and preparation of STL files for additive manufacturing. This digital workflow ensured dimensional accuracy, repeatability, and efficient transition from conceptual design to physical prototyping.

For the purpose of 3D printing the fin, the configuration illustrated in figure 8 was selected. This version was dimensioned for a pediatric patient and is presented exclusively as a prototype. The prosthetic socket and the remaining structural components of the prosthesis were likewise fabricated using additive manufacturing technology.

The geometry developed in AutoCAD was exported in. STL (Stereolithography) format to ensure compatibility with the slicing software Simplify3D, thereby enabling appropriate processing of the digital model for FDM-based fabrication.

a) b) c)

Fig. 8. Prosthesis with prosthetic foot – conventional configuration (a); prosthesis with attached swim fin – complete replacement of the distal prosthetic segment (b); prosthesis with attached swim fin – replacement of the prosthetic foot only (c).

5. 3D PRINTING TECHNOLOGIES USED FOR MEDICAL DEVICES

Additive manufacturing has become an established fabrication approach in the field of medical devices, enabling patient-specific design, rapid prototyping, and cost-efficient production of complex geometries. In medical engineering, 3D printing technologies are primarily employed for prosthetic components, orthotic devices, surgical guides, anatomical models, and customized implants.

3D printers can be classified according to the printing technology employed and the types of materials they can process, as presented in the table below.

Fused Deposition Modeling (FDM) printers operate based on the controlled extrusion of a thermoplastic filament in a molten state, which is deposited sequentially in layers to generate the final three-dimensional structure. Commonly processed materials include polylactic acid (PLA), polyethylene terephthalate glycol-modified (PETG), acrylonitrile butadiene styrene (ABS), thermoplastic polyurethane (TPU), and, in certain applications, fiber-reinforced composite filaments. Although FDM technology does not achieve the highest dimensional resolution or surface finish compared to other additive manufacturing methods, it remains highly efficient and cost-effective for rapid prototyping, functional components, and educational applications [2].

Stereolithography Apparatus (SLA) printers are employed in applications requiring high geometric accuracy and superior surface quality. These systems utilize ultraviolet (UV) laser irradiation to selectively photopolymerize a liquid, photosensitive resin. Derived technologies, such as Digital Light Processing (DLP) and Masked Stereolithography (MSLA), enable increased printing speeds and are particularly suitable for the fabrication of small-scale models, jewelry, dental components, and high-fidelity aesthetic prototypes. Nevertheless, the use of photopolymeric resins necessitates additional post-processing steps, including solvent-based cleaning and UV post-curing, which may increase workflow complexity and processing time [3].

A further important category of additive manufacturing systems is represented by Selective Laser Sintering (SLS) technology. These systems employ a high-energy laser source to selectively interfere with thermoplastic powders such as polyamide (nylon) or thermoplastic polyurethane (TPU) in a layer-by-layer process, eliminating the need for auxiliary support structures. A principal advantage of SLS resides in its capacity to generate complex geometrical configurations with enhanced mechanical performance and relatively homogeneous surface characteristics. Consequently, this technology is extensively applied in the automotive sector, in the prototyping of functional assemblies, and in advanced industrial design applications [2].

For high-performance industrial applications, including the fabrication of metallic components and load-bearing implants, advanced powder bed fusion technologies such as Direct Metal Laser Sintering (DMLS) and Electron Beam Melting (EBM) are utilized. These processes are based on the selective melting of metallic powders, commonly titanium alloys, stainless steel, or cobalt-chromium alloys, resulting in components that exhibit mechanical properties comparable to those achieved through conventional manufacturing techniques. Due to their substantial operational costs, stringent process control requirements, and specialized infrastructure, these technologies are predominantly implemented in the medical, aerospace, and defense industries [4].

A rapidly developing domain within additive manufacturing is bioprinting, which involves the controlled deposition of biological materials, including cell-laden hydrogels and stem cells, in order to engineer artificial tissues. Such technologies are increasingly investigated in regenerative medicine, pharmaceutical research, and the fabrication of patient-specific anatomical constructs. Although currently situated largely within the experimental and translational research stages, bioprinting holds significant promise for the advancement of organ transplantation, tissue engineering, and personalized therapeutic interventions [5].

For the fabrication of the fin component, a Formbot Raptor 2.0 3D printer was utilized, a semi-industrial system based on Fused Deposition Modeling (FDM) technology. This equipment was selected due to its large build volume, compatibility with technical polymers such as thermoplastic polyurethane (TPU), and its high dimensional accuracy in reproducing the geometric features defined within the AutoCAD design environment.

The use of an FDM platform enabled controlled layer-by-layer deposition of the elastomeric filament, ensuring structural integrity, adequate interlayer adhesion, and faithful replication of the CAD-generated geometry, which are essential parameters for the functional performance of the prosthetic component in an aquatic environment.

Fig. 9. Formbot Raptor 2.0 3D Printer [6]

The printing parameters selected for the fabrication process are presented in the figure below. A nozzle with a diameter of 0.4 mm was utilized, and the extrusion width was manually configured to 0.40 mm, ensuring precise control over filament deposition and dimensional fidelity. The extrusion multiplier was adjusted to 0.90 to mitigate the risk of over-extrusion, which could adversely affect surface finish quality and geometric accuracy.

Retraction settings were activated, with a retraction distance of 2 mm and a retraction speed of 1800 mm/min, to reduce material oozing and stringing during non-print travel movements. Furthermore, the internal infill density was set to 100%, thereby maximizing structural integrity and mechanical robustness of the printed component, which is critical for functional performance under loading conditions.

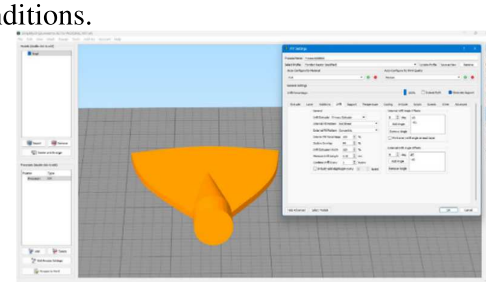

Fig. 10. Layering and Contour Parameter Settings

The extrusion temperature was set to 215°C and the build plate temperature to 60°C, values selected in accordance with the processing requirements of thermoplastic polyurethane (TPU), ensuring optimal layer adhesion and dimensional stability during fabrication.

a) b)

Fig. 11. Multifunctional transtibial prosthesis: a) walking prosthesis, b) swimming prosthesis

The additive manufacturing process had a total duration of approximately 4 hours, during which an estimated 18,000 mm of filament was consumed exclusively for the fabrication of the fin component. Continuous process supervision was essential to identify potential manufacturing deviations, including layer displacement, extrusion irregularities, or adhesion deficiencies. Such monitoring enables prompt corrective intervention, thereby reducing material waste and ensuring the structural integrity and dimensional accuracy of the final printed component.

6. TESTING AND VALIDATION METHODS FOR THE SWIMMING PROSTHESIS AND TECHNO-ECONOMIC ANALYSIS OF THE PROTOTYPE

For the comprehensive functional and biomechanical evaluation of a swimming-adapted prosthetic device, current scientific literature advocates the integration of standardized assessment protocols with controlled experimental testing in aquatic environments. The validation process of such a prototype necessitates a dual approach, encompassing both laboratory-based mechanical characterization and user-centered functional trials conducted under controlled or real-life aquatic conditions.

The initial evaluation phase involves mechanical testing performed in a laboratory setting to determine the structural performance of both the material and the geometrical configuration produced through additive manufacturing. Standardized cyclic loading protocols, elastic deformation analyses, and quantitative assessments of stiffness and recovery behavior following compressive and tensile loading are particularly relevant, especially when elastomeric materials such as thermoplastic polyurethane (TPU) are employed. Moreover, in components fabricated via Fused Deposition Modeling (FDM), the assessment of interlayer adhesion is critical, given that the layered architecture may constitute a structural vulnerability when exposed to high humidity levels or repetitive mechanical stress. Such testing is essential to ensure durability, safety, and long-term functional reliability of the prosthetic system in aquatic applications [7].

For in-use assessment, functional biomechanical testing is performed, including kinematic and kinetic analyses of joint behavior during gait or swimming-specific movements. These evaluations may be conducted using force platforms, motion capture systems, or various sensor-based measurement devices. The primary parameters monitored include range of motion, trajectory symmetry, movement cycle duration, and force transmission characteristics [8].

A comprehensive validation protocol for a TPU-based, additively manufactured swimming prosthesis should therefore integrate multiple assessment domains: mechanical characterization (including tensile testing, fatigue resistance, and deformability analysis), functional biomechanical evaluation, subjective user feedback, structured clinical assessment, and in situ aquatic testing supported by video capture and sensor-based data acquisition. The convergence of these methodologies enables a rigorous, multidimensional evaluation of structural integrity, functional performance, safety, and user acceptability in aquatic conditions.

In the present study, two prosthetic configurations specifically adapted for recreational aquatic activities were conceptualized and engineered, as depicted in the figure below. Both designs are derived from a conventional transtibial prosthesis, modified through the replacement of the distal structural components with a fin manufactured from thermoplastic polyurethane (TPU). The fin was developed using AutoCAD-based modeling and subsequently fabricated through additive manufacturing techniques.

The primary objective of this analytical approach is to identify the most appropriate solution from both technical and economic standpoints. Furthermore, a comparative cost analysis was undertaken to evaluate the production expenses of the proposed prototypes relative to commercially available prosthetic systems with comparable aquatic functionality currently accessible on the market.

Following the comparative evaluation of the two proposed configurations, Model 1 (prosthesis with attached swim fin – complete replacement of the distal prosthetic segment) was selected, as it demonstrated a series of essential advantages from both technical and economic perspectives. Firstly, it is characterized by reduced mass and a simplified structural geometry, factors that contribute to improved handling and hydrodynamic performance. Secondly, the model exhibits enhanced adaptability, being compatible with multiple types of standard transtibial prosthetic systems without requiring substantial modifications to the existing configuration.

An additional significant advantage is the lower production cost, attributable to the reduced component dimensions, shorter printing duration, and simplified assembly process. Furthermore, this configuration is particularly suitable for occasional users who employ the prosthesis primarily for recreational activities such as swimming, providing an efficient, accessible, and easily attachable solution to a conventional prosthetic system.

Table 4

Time and Material Requirements for Prosthesis Fabrication.

Component	Material	Printing Time [min]	Material Consumed [g]
Swim fin	TPU PolyFlex 95	240	51.96
Hexagonal connector (3 pieces)	PLA	30	0.28
Pyramid adapter for prosthetic foot fixation	PLA	50	8.22
Prosthetic foot	PLA	170	27.84
Adapter for foot connection	PLA	60	9.28
Adapter for pylon connection	PLA	70	12.09
Pyramid adapter for socket fixation	PLA	30	3.43
Prosthetic socket	TPU PolyFlex 95	360	57.51
Pylon	PLA	90	10.31
Short pylon adapter	PLA	75	10.46
10 Screws	PLA	20	1.04

From a materials engineering perspective, commercially available aquatic prosthetic devices predominantly employ rigid composite structures and high-performance polymers specifically engineered for long-term durability under demanding environmental conditions. However, these materials are typically processed through advanced industrial manufacturing techniques, which substantially increase production costs. In contrast, the proposed prototype utilizes accessible thermoplastic materials that can be processed locally within university laboratories or certified prosthetic workshops, without reliance on high-cost industrial infrastructure.

The implementation of additive manufacturing further enables decentralized production, allowing fabrication in academic laboratories, specialized workshops, or other non-industrial environments equipped with standard FDM systems. Moreover, the digital nature of the design workflow permits efficient distribution and rapid customization of CAD files, facilitating adaptation to patient-specific anatomical geometries derived from three-dimensional scanning. This approach supports scalable personalization, cost efficiency, and increased accessibility within the domain of customized aquatic prosthetic solutions.

7. CONCLUSION

The implementation of a transtibial prosthetic system adapted for swimming through additive manufacturing technologies has demonstrated feasibility and relevance from technical, economic, and social standpoints. Following the stages of conceptual design, mechanical evaluation, and functional analysis, the findings indicate that such a device can be produced at comparatively low cost while fulfilling essential performance criteria, including controlled buoyancy, adequate structural flexibility, biomechanical comfort, and compatibility with standardized prosthetic coupling systems. The proposed configuration addresses the needs of individuals with lower limb amputation seeking participation in recreational aquatic activities without the financial burden associated with high-cost specialized equipment.

The selection of TPU as the primary manufacturing material ensures appropriate elastic behavior for effective propulsion generation in water, while simultaneously providing favorable mechanical compliance at the skin–device interface. The adaptability of the model was confirmed through its seamless integration with an existing transtibial prosthetic assembly, without requiring substantial structural modification. Moreover, the biomimetic design strategy—derived from the morphological characteristics of natural fins—contributed to enhanced hydrodynamic performance and improved efficiency of aquatic locomotion.

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Proiectarea unei proteze multifuncționale pentru amputație transtibială

Articolul prezintă dezvoltarea unei proteze transtibiale adaptate pentru înot recreativ prin utilizarea tehnologiei de imprimare 3D. Protezele convenționale nu sunt optimizate pentru mediul acvatic, iar alternativele comerciale sunt costisitoare și inaccesibile. În cadrul cercetării au fost proiectate în CAD și fabricate din TPU 95A prin tehnologie FDM două configurații: un model integrat, care înlocuiește segmentul distal, și o variantă modulară, care înlocuiește doar piciorul protetic. Evaluările mecanice și funcționale au evidențiat flotabilitate adecvată, flexibilitate, eficiență propulsivă și compatibilitate cu sistemele standard de prindere, demonstrând fezabilitatea tehnică și economică a soluției propuse.

Oana-Andreea CHIRIAC, PhD Engineer, Professor, National University of Science & Technology POLITEHNICA Bucharest, Faculty of Medical Engineering, Bioengineering and Biotechnology Department, oana_andreea.chiriac@upb.ro, 0040758425407, Bucharest.

Elena-Theodora OANCEA, Engineer, X-Lab Solutions SRL, elena.oancea@stud.fim.upb.ro, 0040733535151, Bucharest.