Design of an individual lower limb orthosis with a knee joint mechanism

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An orthosis, also known as an orthopedic prosthesis, is an external device that stabilizes a selected joint or body segment used during the treatment of musculoskeletal injuries and in the rehabilitation process. These devices can also be defined as devices that affect the structure and functioning of the neuromuscular and skeletal systems in a planned manner.

The main feature of orthoses is that they allow for complete or partial immobilization of the joint, stabilization in a specific plane or limitation of the range of motion. Thanks to this, they are used during rehabilitation and convalescence of the patient after surgery. Additionally, these devices allow for relieving a specific body segment, thanks to which the patient can return to their everyday life faster.

The paper presents our own solution for a dynamic orthosis mechanism intended for people with temporary and permanent paresis of the knee joint. This is an original solution, the concept of which has been reported to the Polish Patent Office.

The developed mechanism, which is the main element of the device, allows for the implementation of blocking the mechanism and supporting the limb during walking. The lower limb orthosis mechanism is characterized by a three-degree range of flexion. The first one allows sitting, the second one allows blocking the limb while standing and the third one allows flexion of the limb while walking in the range of 20 degrees, whereby this angle can be adjusted individually to the patient. Based on the developed executive and technological documentation, a prototype of the mechanism was made, which was implemented in an individually adjusted orthosis. The entire orthosis was tested by the end user.

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Application of Eye Trackers in Combat Sports and Martial Arts

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Abstract

Introduction: The present study consists of a review of the literature in the field of combat sports in relation to perceptual-cognitive processes assessed with eye trackers. The goal of the study was to provide practical training guidelines based on the most recent research explaining the mechanisms of visual perception.
Research methods: Five combat sports and martial arts were selected for in-depth analysis of the control of visual processes: fencing, kendo, judo, karate, and boxing. Using two basic metrics of oculomotor functions: fixations and saccades, and the novice-expert research paradigm, practical conclusions were drawn.
Outcomes: Based on a meta-analysis of 12 selected research papers, it was concluded that in martial arts, experts generally showed longer fixations compared to novices. In addition, elite athletes selected those areas of interest (AOIs) that were most predictive of the opponent's fighting strategy.
Practical application: Analyses of eye movements (saccades), i.e. the ability to switch attention efficiently, revealed a significant superiority of the elite athletes. The speed of initiating fixations and saccadic movements was interpreted as decision-making efficiency. Speed metrics differentiated expert athletes from novices.

Keywords: perceptual skills, eye tracking, combat sports, fixations.

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Selected data mining methods for identifying burnout and PTSD risk in Uniformed Services

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PTSD is a critical concern in uniformed services, requiring adaptive and evidence-based interventions. This study applies Action Rule Discovery (ARD) to clinical data from veterans to identify effective PTSD treatment pathways. ARD enables the extraction of if–then action rules that support treatment modifications tailored to patient profiles. For example, switching from CBT to EMDR in non-responders under 40 results in measurable improvement. The use of ARD can help clinicians in Poland and internationally to improve diagnostic precision and therapy effectiveness. The analysis underscores ARD's potential for personalizing PTSD treatment in uniformed professions.

Patient Group	Recommended Action	Outcome Improvement
Under 30, combat-related PTSD, CBT non-responders	Switch to EMDR	50% symptom reduction
PTSD + comorbid depression	Add pharmacotherapy to CBT	45% dual symptom improvement
PTSD + substance use disorder	Integrated mental health support	50% recovery improvement

Table 1: Selected ARD rules extracted from veterans' dataset

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Determination of material constants of aortic tissue in tensile tests

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This study investigates the mechanical properties of porcine aortic tissue, serving as a model for human aortic tissue, based on a static tensile testing. The primary focus is on determining Young's modulus (E [MPa]), ultimate tensile strength (UTS [MPa]) and strain at UTS (ε_{UTS} [-]) which are critical for understanding the tissue's elastic behavior. The research incorporates digital image correlation to accurately measure Poisson's ratio (v [-]), providing a comprehensive analysis of the tissue's mechanical response. Specimens were dissected in two orientations: circumferential and axial, to assess directional differences in mechanical properties. The findings reveal that the porcine aorta exhibits anisotropic behavior, with variations in stiffness and strength between the two directions, aligning with previous studies on aortic tissue mechanics [1, 2, 3]. This research contributes to the broader understanding of aortic tissue mechanics, which is essential for applications in biomedical engineering and the development of aortic prostheses.

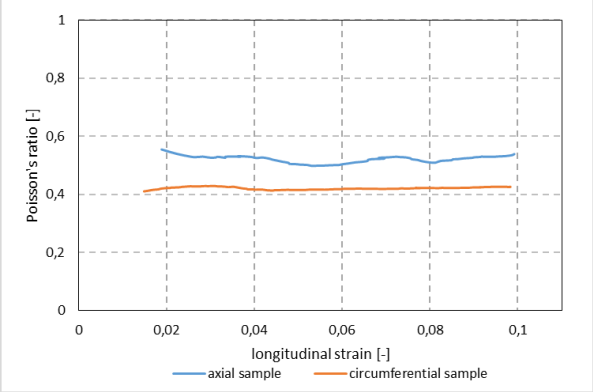

Figure 1: Poisson's ratio for aortic tissue considering two directions

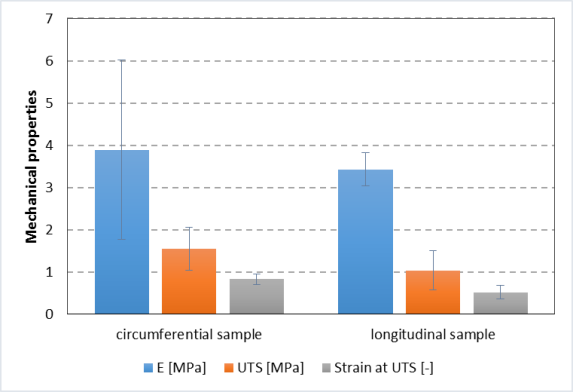

Figure 2: Mechanical properties of aorta tissue

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Flexible measurement platform - preliminary results

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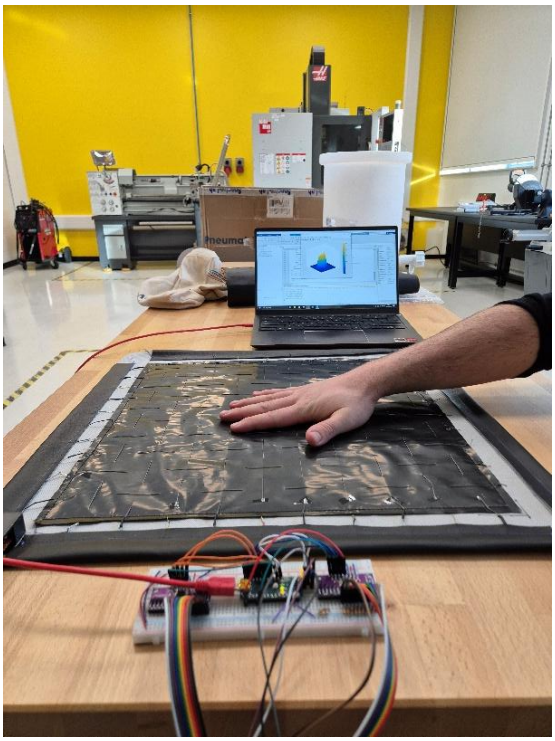
A flexible sensor mat based on piezopolymer technology has been designed for the measurement of plantar pressure during both static standing and dynamic motion. The sensing layer consists of a grid of intersecting conductive paths, with each crossing forming an independent pressure-sensitive point. This modular architecture enables easy customization of resolution based on application needs. Pressure data is collected and transmitted in real time via a USB interface. The entire structure is covered with a layer of eco-leather, ensuring comfort, durability, and hygienic usability. Preliminary tests confirmed effective detection of localized pressure changes. The mat offers promising capabilities for gait analysis, balance assessment, and patient weighing. Its low production cost and adaptability make it suitable for use in clinical, research, and rehabilitation settings.



Real-time pressure readings on a flexible pressure-sensitive mat

Flexible measurement platform

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Herb-Enhanced Polydimethylsiloxane: A Green Approach to Antibacterial Materials

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The development of eco-friendly biomaterials with antibacterial properties is essential for biomedical applications and reducing environmental impact. Polydimethylsiloxane (PDMS) is widely used due to its flexibility and biocompatibility, but its lack of inherent antibacterial activity limits its potential. In this study, PDMS was modified by incorporating 2.5 wt.% thyme powder to enhance its biological performance. Several properties were investigated, including density, water contact angle (WCA), hardness, tensile strength, FTIR analysis, antibacterial activity, and cell viability. The incorporation of thyme caused minimal changes in density and WCA, while hardness and tensile strength decreased, corresponding to the reduction of characteristic peaks in FTIR spectra. The biocomposites demonstrated antibacterial activity against *Staphylococcus aureus* and showed enhanced cell viability after 10 days of incubation, indicating a favorable impact on cell proliferation. Overall, the incorporation of natural additives like thyme into PDMS offers a sustainable strategy to develop advanced bioactive materials for healthcare and environmental applications.

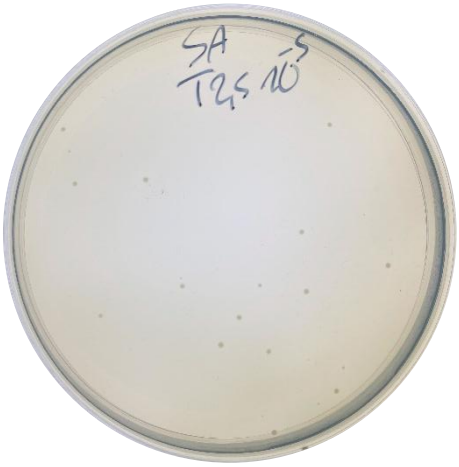

Figure 1: plate count for thyme biocomposite

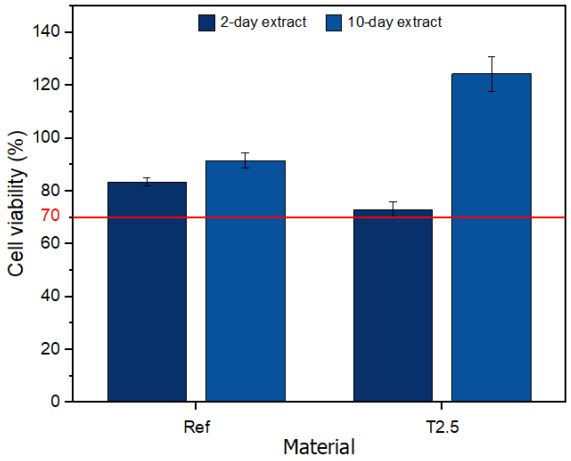

Figure 2: cell viability results

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Numerical analysis of selected lumbar spine stabilizations

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The aim of this study is to investigate the impact of selected interspinous stabilization methods on the effectiveness of treating intervertebral disc herniation at the L4–L5 level of the human spine and to propose alternative surgical treatment plans. Geometric models incorporating the proposed interspinous stabilizers were developed based on MRI scans and subsequently subjected to numerical analysis under identical boundary conditions. The study enabled an analysis of the stresses and strains occurring in individual components of the lumbar spine. The results indicated that the use of the 12 mm DIAM implant did not produce the desired therapeutic effect, whereas the "C" type implant demonstrated the most significant positive influence on the L4–L5 intervertebral disc herniation.

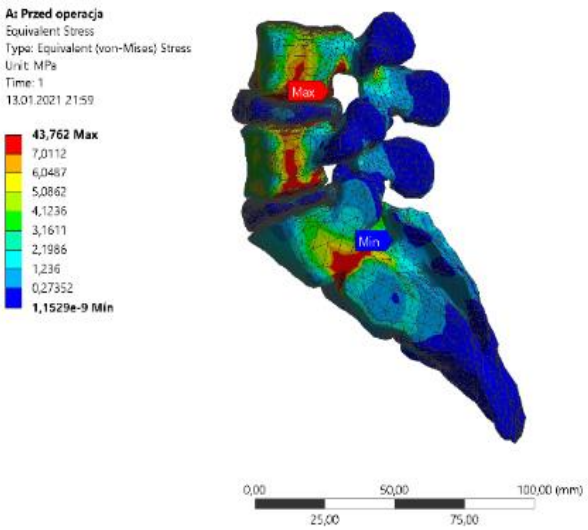

Figure 1: optional caption; style Heading 3; maximum 2 figures/charts/tables

Conclusions

The findings of this study highlight the importance of selecting an appropriate interspinous stabilization method tailored to the patient's anatomical and pathological conditions. The usefulness of modelling and simulation has been demonstrated, emphasizing the risk of making incorrect decisions when choosing the type of stabilization. Among the analysed options, the "C" type implant proved to be the most effective in reducing stress and strain in the L4–L5 segment, suggesting its potential superiority in clinical applications.

Biomechanical studies have been proposed to validate these clinical findings and support the treatment approach for lumbar disc herniation.

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Badania naukowe i rozwojowe ścieżką komercjalizacji i innowacji urządzeń dla osób niepełnosprawnych

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Projekt pt. „Badania naukowe i rozwojowe ścieżką komercjalizacji i innowacji urządzeń dla osób niepełnosprawnych" wpisuje się w obszar *Nauka dla innowacyjności* i realizuje cele programowe:

- poprawa efektywności współpracy nauki z otoczeniem gospodarczym,
- wspieranie procesów innowacyjności oraz komercjalizacji wyników badań naukowych i prac rozwojowych, w tym promowanie dobrych praktyk w zakresie innowacji,
- upowszechnianie wiedzy na temat związków między nauką i innowacyjnością a gospodarką.

Autorzy przedstawili metodologię opracowaną przez Design Council jako podstawowe podejście do projektowania. Głównym celem projektu jest przedstawienie konkretnych działań i prac projektowych w kontekście generowania innowacji przy użyciu podejścia Human-Centered Design (H-CD) na przykładzie urządzenia mobilnego (Rys. 1) dedykowanego osobom niepełnosprawnym, które jest jednocześnie łóżkiem i urządzeniem transportowym.

Rys. 1: Specjalne urządzenie jezdne przeznaczone dla osób niepełnosprawnych;

Projekt dofinansowany ze środków budżetu państwa, przyznanych przez Ministra Edukacji i Nauki w ramach Programu „Nauka dla Społeczeństwa II" nr NDS-II/SP/0506/2023/01.

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Numerical analysis of the effect of an external heat impulse on oxygen distribution in biological tissue with sensitivity analysis of oxygen-related parameters

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Biological tissue exposed to external heat undergoes complex thermophysical and biochemical changes, including variations in material properties, accumulation of thermal damage, and disrupted oxygen transport. Of particular importance is the perfusion coefficient, which reflects both blood flow and the extent of thermal injury. Since oxygen delivery occurs via capillaries, elevated tissue temperature can impair oxygen supply, potentially causing hypoxia.

This study presents a numerical model coupling bioheat transfer and oxygen transport in a 3D tissue domain subjected to thermal stimulation. The Pennes equation governs heat transfer, while the Arrhenius model quantifies thermal damage. Temperature- and damage-dependent tissue properties are included.

An axisymmetric Krogh cylinder model describes oxygen distribution, accounting for consumption in tissue and oxygen saturation in blood. Coupling between the thermal and oxygen models is achieved through the temperature-dependent perfusion coefficient linked to blood velocity in capillaries.

In the numerical stage, the finite difference method is primarily used to analyze the influence of thermal model parameters on temperature distribution and tissue damage. Additionally, a direct sensitivity analysis investigates how Krogh cylinder model parameters affect partial oxygen pressure distribution.

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Mechanical properties of polyurethane foam mimicking trabecular tissue in artificial femoral head bones of different producers and types—comparative study

Znaczko A., Żerdzicki K., P. Kłosowski

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Orthopedic implants intended for fracture fixation and joint replacement are commonly evaluated using artificial bone models. Among synthetic materials, polyurethane foam is widely used due to its ability to simulate the structure and mechanical behavior of human trabecular bone. This study aims to investigate the compressive and tensile properties of polyurethane foams used in artificial femurs and to assess their suitability for replicating osteoporotic trabecular bone tissue. Femur models from two major manufacturers—SAWBONES and SYNBONE—were examined. Foam samples were extracted from the femoral head in the coronal plane, and then cuboidal specimens were prepared along three orthogonal directions. Uniaxial compression and tension tests were performed to determine fundamental mechanical properties, including elastic modulus, Poisson's ratio, yield strength, and ultimate strength.

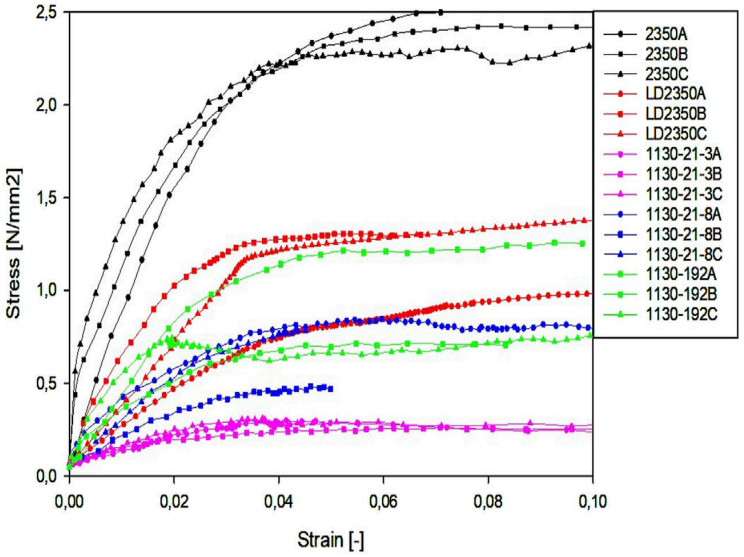

Figure 1: Representative stress–strain curves for compression tests.

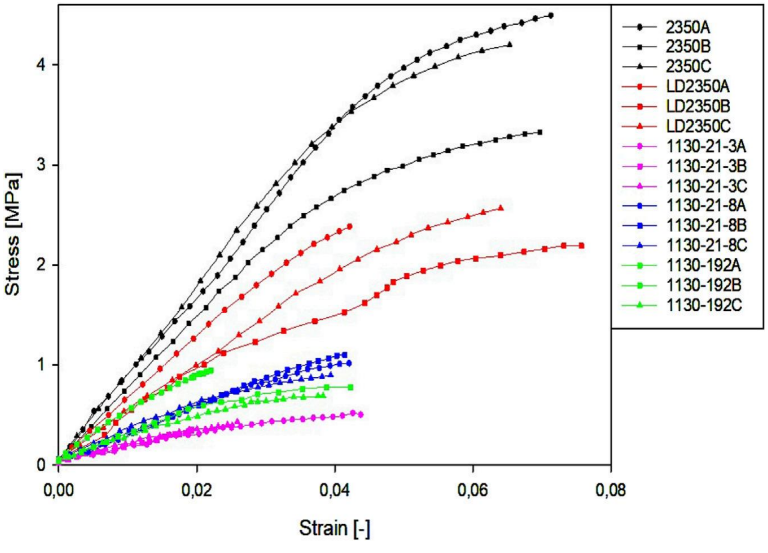

Figure 2: Representative stress–strain curves for tension tests.

ADDITIONAL INFORMATION: Financial support of these studies from Gdansk University of Technology by the DEC-47/2020/IDUB/I.3.3 grant under the ARGENTUM TRIGGERING RESEARCH GRANTS – "Excellence Initiative - Research University"

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Mechanical properties of polyurethane foam mimicking trabecular tissue in artificial femoral head bones of different producers and types—comparative study

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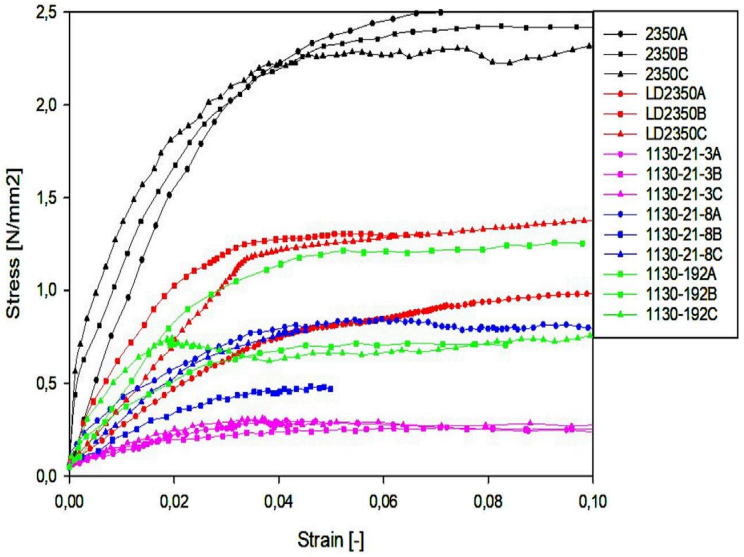

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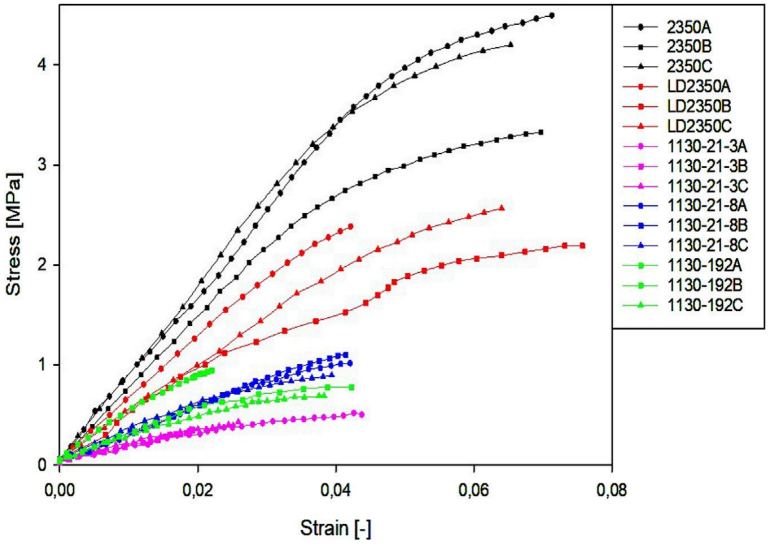

Figure 2: Representative stress–strain curves for tension tests.

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Analysis of Mechanics of Side Impact Test Defined in UN/ECE Regulation 129

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This article discusses differences between a side impact procedure described in UN/ECE Regulation 129 and scenarios observed in real world cases. In the simulations, the authors use a validated finite element model of real world CRS together with a fully deformable numerical model of the Q3 anthropomorphic test device (ATD) by Humanetics Innovative Solution, Inc. The comparison of five selected cases is based on the head injury criterion index. It is shown that the presence of oblique velocity components or the way in which the CRS is mounted to the test bench seat fixture is among the significant factors influencing ATD kinematics. The results show that the side impact test procedure is very sensitive to these parameters. The conditions of Regulation 129 may minimize the effects of the impact since it does not account for a rotation of the CRS, which should appear in the case of a realistic anchorage. Therefore, the adopted procedure generates the smallest HIC value, which is at the level of the far side impact scenario where there are no obstacles.

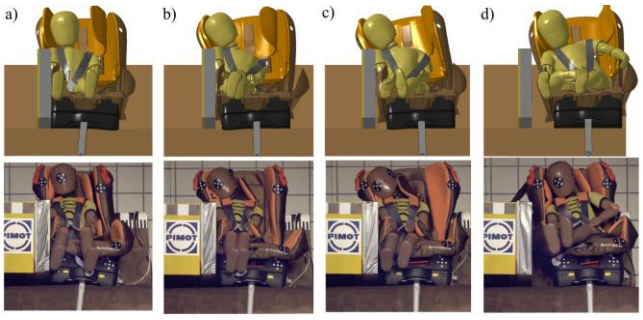

Figure 1: Dummy behavior during side impact test according to Regulation 129: FEA and experiment; a) t1 = 42 ms, b) t2 = 52 ms, c) t3 = 62 ms, d) t4 = 112 ms

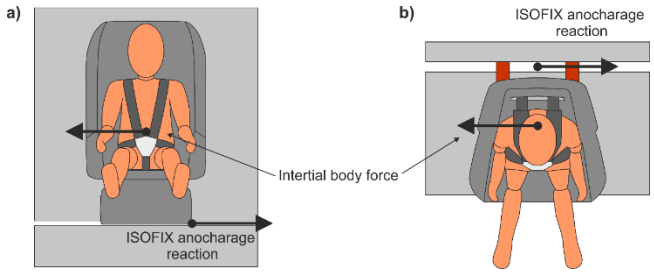

Figure 2: Force triggering rotations in CRS, a) front view, b) top view

This work was performed with the financial support from Grant no. RPMA.01.02.00-14-5640/16-00 granted within the Mazowieckie Voivodeship ROP 7 "Smart Growth" PA 1.2 and the support of the Interdisciplinary Centre for Mathematical and Computational Modeling (ICM) University of Warsaw under grant no GB65-19. The work was written as part of the implementation of the university research grant supported by Military University of Technology (No. UGB 000014-W100-22)

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Introduction to ballistic combat helmets

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In this paper, the author analyzes the evolution of combat helmets as a key element of individual ballistic protection for soldiers. Structural changes are examined, from steel helmets of the First World War, protecting only the upper part of the skull against artillery fragments, to modern, technologically advanced composite helmets. The origins of helmet use are discussed based on data from military operations in Afghanistan, Iraq, and Ukraine, highlighting the need to reduce fatal head injuries and minimize the risk of traumatic brain injury (TBI) and behind-helmet blunt trauma (BHBT). The paper reviews developments in design, materials, and functionality, focusing on the transition from heavy steel models to composite helmets such as MICH(ACH) and FAST, integrating advanced communication systems and modular protection. Ergonomics and user comfort, along with growing ballistic requirements, are emphasized as key design factors. The aim of the study is to show how technological advances and new battlefield challenges drive the evolution of modern combat helmets (Fig. 1).

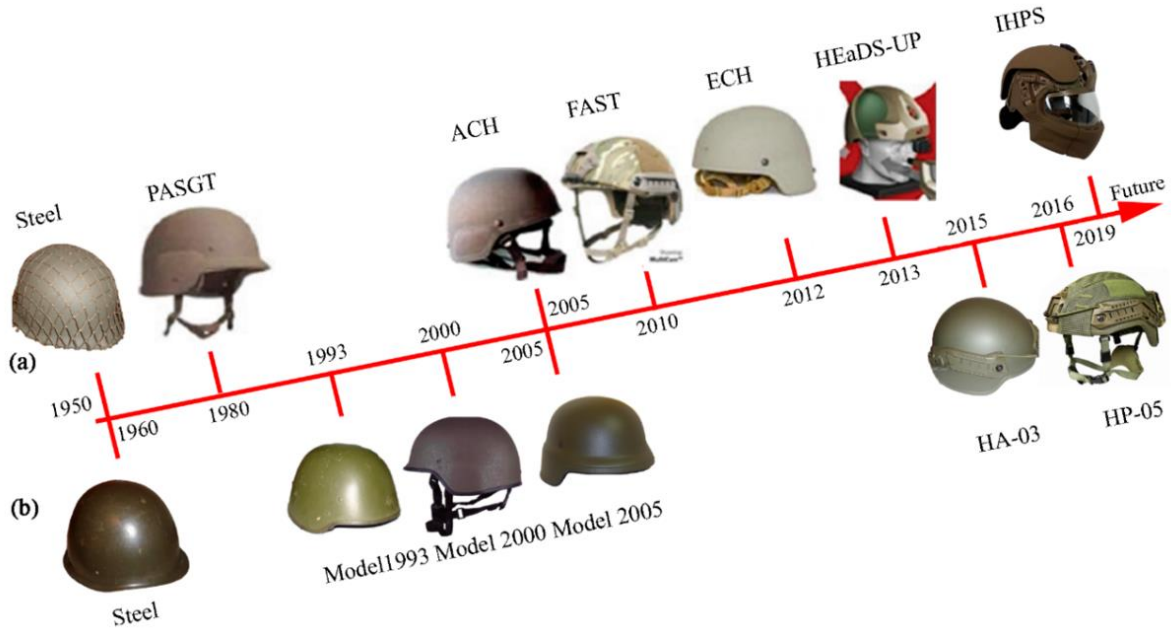

Figure 1: Evolution of helmets from World War II to today: a) US Army, b) Polish Army

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Swarm optimisation for the mechanical compatibility of the surgical mesh used for hernia repair with the abdominal wall.

Szymon Kalinowski, Katarzyna Szepietowska, Eric Florentin, Izabela Lubowiecka

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The study presents an approach to optimisation of the thickness field of surgical implants used in the treatment of abdominal hernia in humans. The primary objective is to achieve reduced and uniformly distributed forces in tissue-implant connections and the implant better reflecting the mechanical behaviour of the healthy abdominal wall. We also propose to extend the objective function by minimisation of implant deflection caused by intraabdominal pressure to avoid the implant bulging when the thickness is being reduced. In the optimisation we use material properties of three existing implants, BARD, DynaMesh and Dualmesh Gore, two orthotropic and one isotropic, respectively. For orthotropic implants we consider two orientations 0° and 90° to the spine line. The model of optimised implant, defined by means of finite element method and shown in Fig. 1-2 allows better distribution of forces in fasteners comparing to flat implants keeping its maximum deflection on a reasonable level.

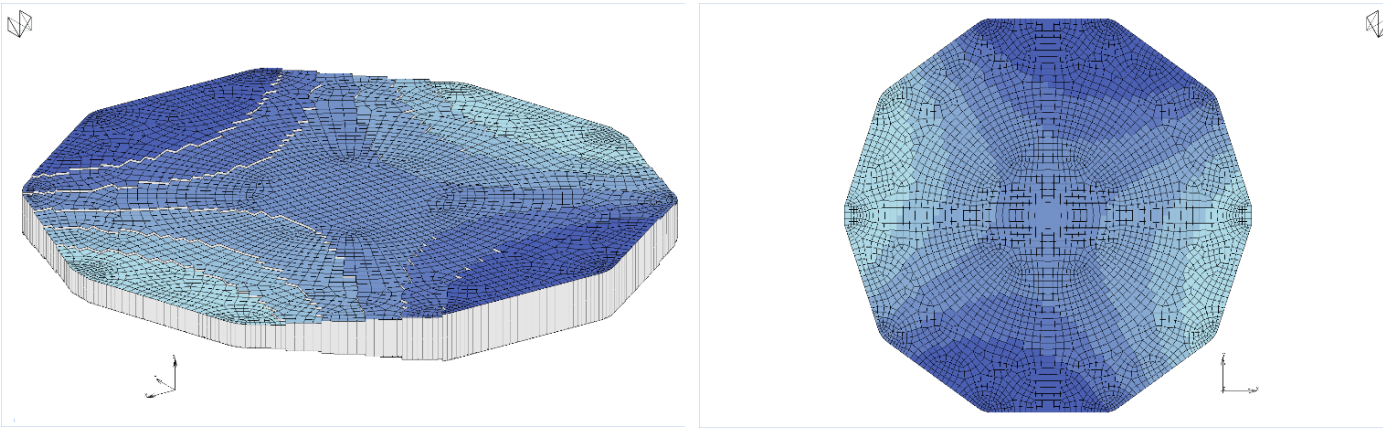

Figure 1: Optimised implant model for patient D2 with orientation 0° and thickness scaled 10 times to better show topology. On the left we have 3D view showing difference between thickness zones and on the right we have view from top better showing different thickness zones.

This work was supported by the National Science Centre (Poland) [grant No. UMO-2017/27/B/ST8/02518].

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Comparison of the abdominal wall mechanical behaviour before and after botulinum toxin application in hernia treatment – a numerical study

Aleksandra KONDRUSIK*, Katarzyna SZEPIETOWSKA, Zuzanna IWICKA, Wiktoria KORBUT, Mateusz ZAMKOWSKI, Maciej ŚMIETAŃSKI

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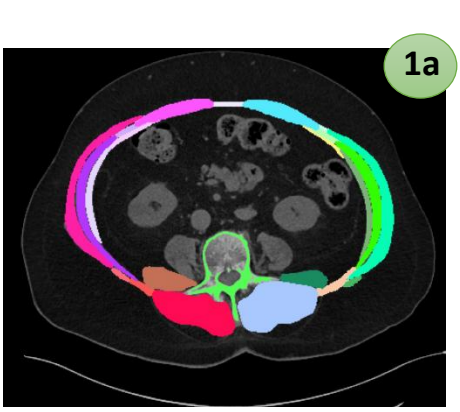
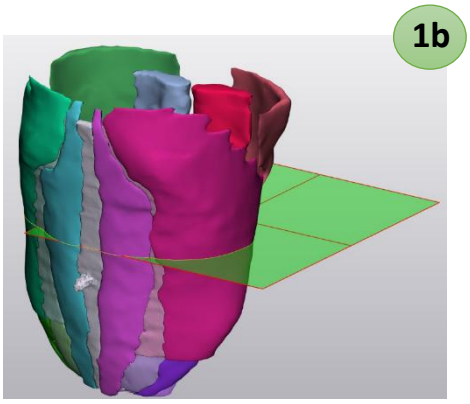
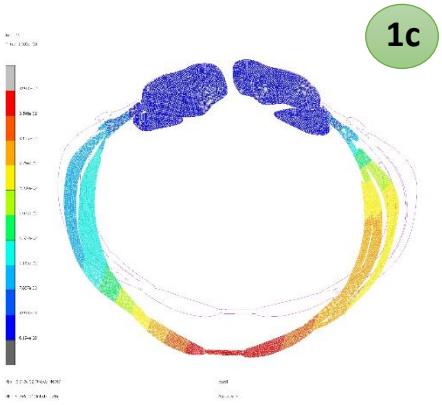
This study presents a comparative analysis of abdominal wall mechanical response , before and after app botulinum toxin application used in hernia treatment. Numerical models were developed based on geometry derived from computed tomography (CT) scans taken from the same patient before and after the procedure (Figure 1). The 2D finite element models in plane strain reflect the actual geometry of the abdominal wall cross-section. To replicate physiological conditions, the model was subjected to intra-abdominal pressure of 10 cmH_2O. The main objective of the analysis was to compare deformations and identify changes in the mechanical response of the muscle-fascial system following toxin injection. The results highlight the need for further research to accurately plan subsequent surgical interventions and evaluate the effectiveness of the method. The presented methodology marks a step toward using CT-based numerical modeling for the hernia repair.



a) CT scan image with highlighted muscle



b) 3D model with a marked cutting plane for performing numerical analysis in the plane strain



c) displacement map

Figure 1. Process and Numerical Analysis for a Patient Before Botulinum Toxin Injection (An identical procedure was applied to the model after botulinum toxin injecti on)

ADDITIONAL INFORMATION: The authors would like to thank the National Science Centre (Poland) (Grant no: UMO-2022/47/D/ST8/02433) for providing financial support to this project. Calculations were carried out partially at the Academic Computer Centre in Gdańsk.

1. Gdańsk University of Technology 2. Medical University of Gdańsk

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Various approaches to FEM modeling of the human abdominal wall

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This study compares 3D and 2D FEM models of the human abdominal wall. The geometries were created based on computed tomography (CT) images in Mimics, refined and discretized in 3-matic software. Numerical simulation were performed in MarcMentat. Both models use isotropic linear elastic material properties, the contact type used was glued (**Figure 1**) and are subjected to intra-abdominal pressure of 1000 Pa. The analysis focuses on comparing displacements (**Figure 2**) and strains obtained from both modeling approaches. The results revealed relatively small differences between the models, suggesting that the simplified 2D approach can offer a faster and computationally efficient alternative to full 3D modeling—especially in applications where quick results are required and computational resources are limited. The discrepancies are mainly due to the simplifications introduced in the plane strain model.The findings can help in choosing the right modeling strategies in biomechanical research for hernia repair application.

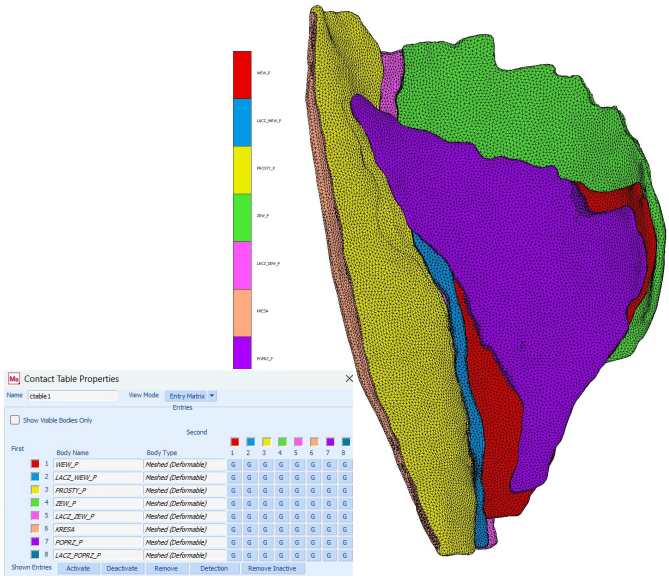

Figure 1: Contact bodies for 3D model of human abdominal wall in Marc Mentat

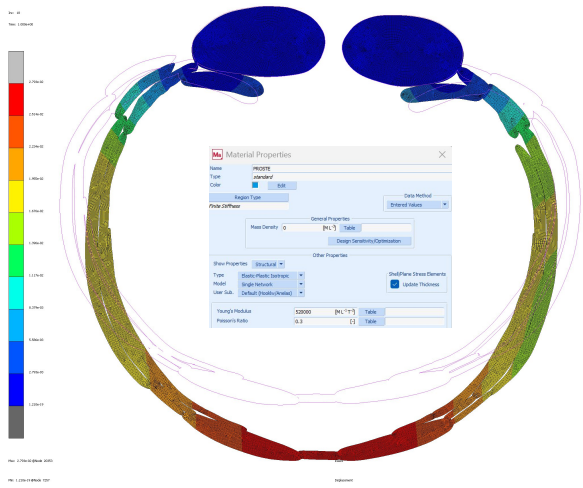

Figure 2: Displacement result for plane strain FEM model in Marc Mentat

Acknowledgment: The authors would like to thank the National Science Centre (Poland) [grant No. UMO2022/47/D/ST8/02433]. Calculations were carried out partially at the Academic Computer Centre in Gdańsk

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Design of a mechatronic mobile platform with a verticalization function for people with disabilities

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The study presents the design process and construction of an innovative mobile platform with a standing-up function, dedicated to individuals with tetraplegia. The device aims to increase user independence and reduce reliance on external assistance. An omnidirectional wheel drive system was implemented, along with a dedicated local and global control system. The prototype was developed based on an analysis of existing market solutions and was later improved following functional testing. The project exemplifies the integration of mobility technology with a rehabilitative function. Figure 1 presents the control system diagram, while Figure 2 shows the device prototype.

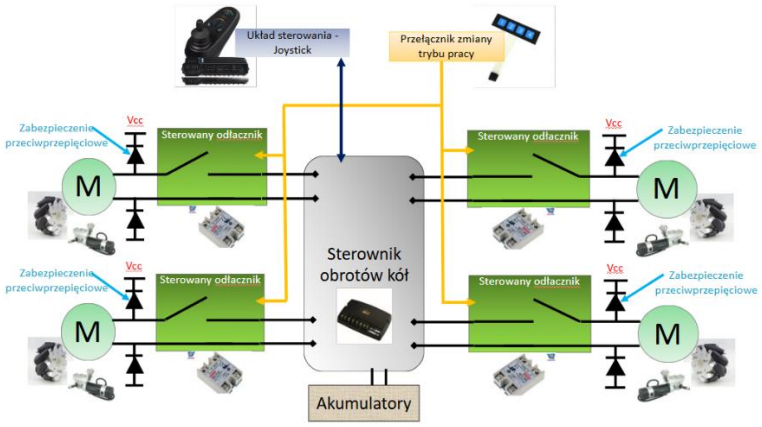

Figure 1: Control system diagram.

Figure 2: Device prototype.

The APC was funded by 1.2 Research, Development, and Innovation in Enterprises under the Regional Operational Program of the Silesian Voivodeship for 2014–2020, co-financed by the European Regional Development Fund. Project name “Mobilne mechatroniczne urządzenie z funkcją pionizacji dla osób niepełnosprawnych”, UDA-RPSL.01.02.00-24-00AA/19.

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TBI estimation for ballistic impacts using a military helmet as an example

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In this study, the authors focused on estimating the risk of traumatic brain injury (TBI) from ballistic impacts using combat helmet models. An analysis of existing ballistic standards for head protection, including PN-V-87001:2011 and NIJ 0101.06, was conducted to define acceptable deformation and transmitted acceleration requirements. The paper examines the characteristics of ballistic phenomena, such as the relationship between kinetic energy and helmet shell deformation, the duration of the impact pulse, and the translational and rotational accelerations experienced by the head. Additionally, the results of deformation tests on helmets impacted by 9x19 mm FMJ Parabellum (Fig. 1) and .44 Magnum rounds are presented, analyzing shell deflection as a function of the projectile's kinetic energy. The obtained deformation values were compared against craniocerebral injury criteria, allowing for a preliminary assessment of TBI risk across different helmet types and threat levels. The aim of this research is to identify critical design parameters influencing the ballistic performance of combat helmets, with a focus on minimizing the risk of severe head injuries.

a) b) c)

Figure 1. MICH-type helmet after 9x19 mm FMJ Parabellum projectile shot: a) X-ray, b) XCT front view, c) XCT side view

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Shaping Surface Properties of Highly Porous Additively Manufactured Implants

Ada ORŁOWSKA, Barbara RYNKUS, Wojciech KAJZER, Janusz SZEWCZENKO

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Additive technologies are increasingly finding applications in medicine, enabling the development of implants that are better tailored to the individual needs of patients. Additively manufactured implants can exhibit improved functionality by replacing solid material with highly porous structures, allowing for the formation of a durable bond between a permanent orthopedic implant and bone. Despite the growing interest in such implants, there is still a need to develop modification methods to ensure the highest possible biocompatibility and to create optimal conditions for osseointegration. While the highly porous structure of printed implants positively affects their properties, it also poses challenges in terms of surface modification. The aim of this work is to discuss the possibilities of shaping the surface properties of implants, including their central regions, and to present the challenges faced by surface engineering of printed biomaterials.

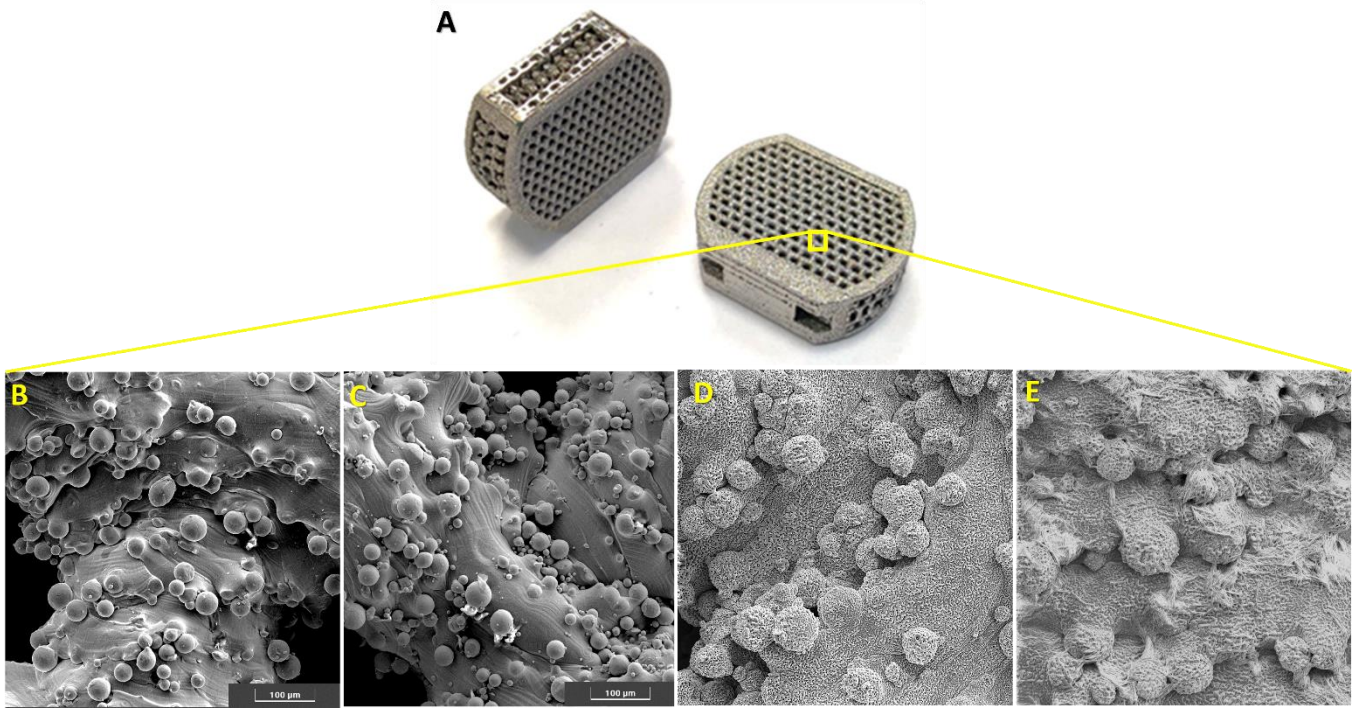

Figure 1: (A) High-porous implant made of Ti6Al4V using SLM technology. (B-E) Surface morphology of the additively manufactured implant B – in the initial state, C –after anodic oxidation, D –after plasma electrolytic oxidation, E –after plasma electrolytic oxidation with a chitosan coating applied by the immersion method

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Modelling and numerical analysis of flow in a fogging nozzle

Authors

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This study presents a numerical analysis of multiphase flow in a conical pressure-swirl nozzle using Computational Fluid Dynamics (CFD). The nozzle geometry was precisely reconstructed via 3D scanning and microscopy to capture intricate internal features. Simulations were performed in ANSYS Fluent using the Volume of Fluid (VOF) method coupled with the k-ω SST turbulence model, replicating realistic experimental conditions. Mesh refinement techniques, including boundary layer and localized grid enhancements, were implemented to ensure accurate resolution of velocity gradients and phase interfaces. The results revealed a sharp velocity peak at the nozzle outlet, followed by rapid jet expansion and intense turbulence. The model accurately captured critical flow phenomena such as vortex formation and downstream velocity decay. Validation against experimental mass flow rate data confirmed the simulation's reliability, supporting its applicability in analyzing and optimizing nozzle-based multiphase systems.

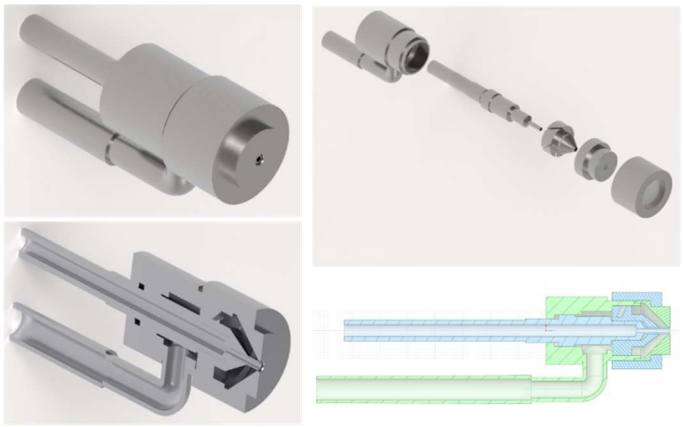

Figure 1: Geometric model of the nozzle, cross-section view, disassembled into components

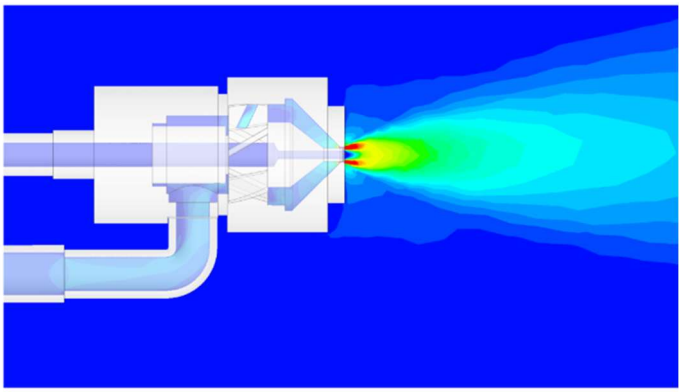

Figure 2: Velocity distribution map (scale up to 72 m/s)

Acknowledgements: The research was conducted as part of the SZAFIR project DOB-SZAFIR/02/A/002/02/2021 - type: National Defence and Security (DOB)—SZAFIR 2, Mobile disinfection system for medical protection of the Polish Armed Forces in counteracting SARS-CoV-2. The calculations were performed using the Ansys Fluent package and the HyperWorks package. The analyses presented in the study were carried out with the support of the Interdisciplinary Centre for Mathematical and Computational Modelling at the University of Warsaw (ICM UW) under computational grant no. GB84-21, as well as with the support of the National ANSYS License coordinated by the Interdisciplinary Centre for Mathematical and Computational Modelling at the University of Warsaw (ICM UW).

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Numerical analyses of the helmet outer shell for different material configurations

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This paper presents numerical analyses of a combat helmet outer shell for various material configurations. Modal analysis and dynamic penetration studies under impact from a 9x19 mm FMJ Parabellum projectile were carried out. Different types of materials were considered, including aramid fibers, ultra-high molecular weight polyethylene (UHMWPE) and new material systems. Modal analysis enabled the determination of the natural frequencies and vibration modes of the helmet shell, which are critical for assessing its behavior under dynamic loading conditions. In the dynamic penetration studies, mechanisms of deformation, energy absorption, and structural failure for different material configurations were analyzed. Comparative results are presented, highlighting differences in ballistic resistance, deflection profiles, and the protective effectiveness of helmet structures made from aramid and polyethylene-based materials (Fig. 1 and 2). The aim of the study is to identify material and structural factors that enhance the protective properties of helmets while minimizing deformation and the risk of traumatic brain injuries (TBI).

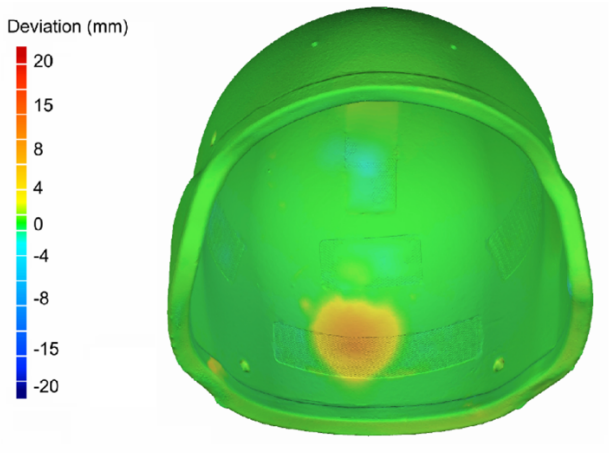

Figure 1: CT image of the geometry deviation between the helmet before and after the 9x19 mm FMJ Parabellum ammunitions shot as a colour map.

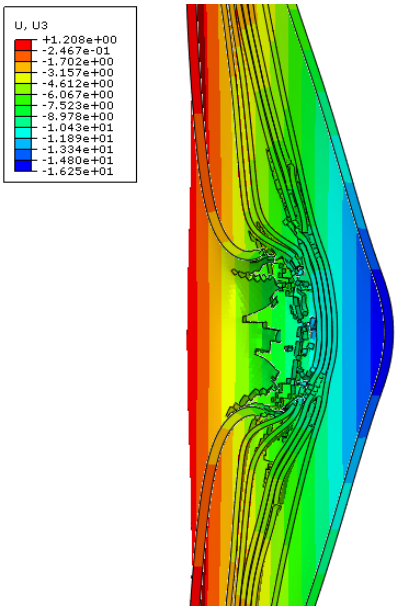

Figure 2: Numerical simulation results for a metal/aramid/metal sample.

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Silica-based coating applied via EPD as a strategy to improve the surface properties of NiTi alloys used for cardiac implants

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NiTi shape memory alloys are widely used in cardiovascular implants due to their exceptional mechanical properties and favorable biocompatibility. However, their high nickel content remains a concern, potentially compromising their compatibility with biological environments.

In this study, SiO_2 coatings were applied by EPD to improve the corrosion resistance and biological properties of the NiTi alloy. The process parameters were optimized to ensure stable deposition of SiO_2 particles. Microscopic observations revealed that the deposited coating was characterized by a heterogeneous structure and lack of continuity. Corrosion tests revealed susceptibility to corrosion despite applied coating. Bioassessment showed strong cell adhesion and promising cytocompatibility. The results highlight the potential for the use of SiO_2 coatings for use in cardiovascular medical devices. However, there is a need for further improvements in terms of their long-term stability in biological environments.

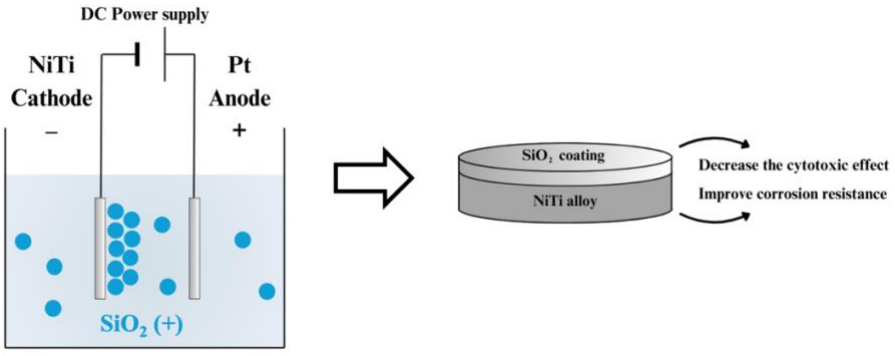

Figure 1: Scheme of application of SiO_2 coating by EPD method

The project was funded by the National Science Centre, Poland, allocated based on decision No. 2023/49/B/ST11/03301

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Selected aspects of spinal modeling

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Corresponding Author: Szymon Saternus, szymon.saternus@wat.edu.pl

This paper presents a multivariate modeling process of the human spine, which is a key tool for analyzing its biomechanics. The goal of the study was to create an accurate model of the spine in the AnyBody Modeling System environment, using the geometry of the patient's entire spine reconstructed from the resulting CT imaging, experimental data and the biomechanics of the structures interacting with the spine. The paper presents the successive stages of model construction, from image data processing, to reconstruction of anatomical geometry, to implementation of biomechanical properties of individual structures. Preliminary simulations are also presented, illustrating the possibilities of analyzing dynamic interactions within the spine. The combination of medical imaging, modeling methods and computer simulation has provided a tool for a more accurate assessment of the influence of various factors on the mechanics of the spine and a deeper understanding of its functionality.

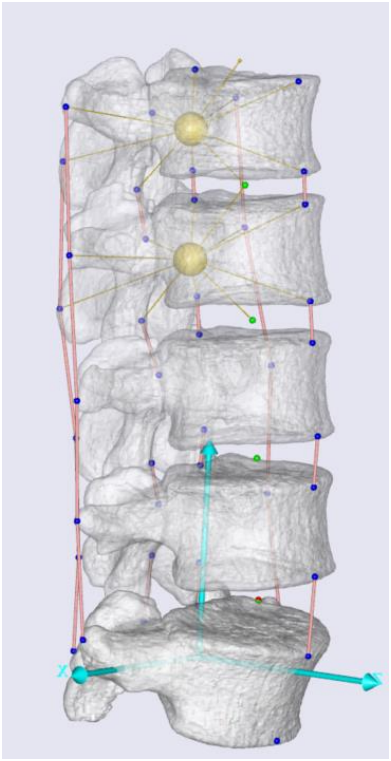

Figure 1: Lumbar spine model

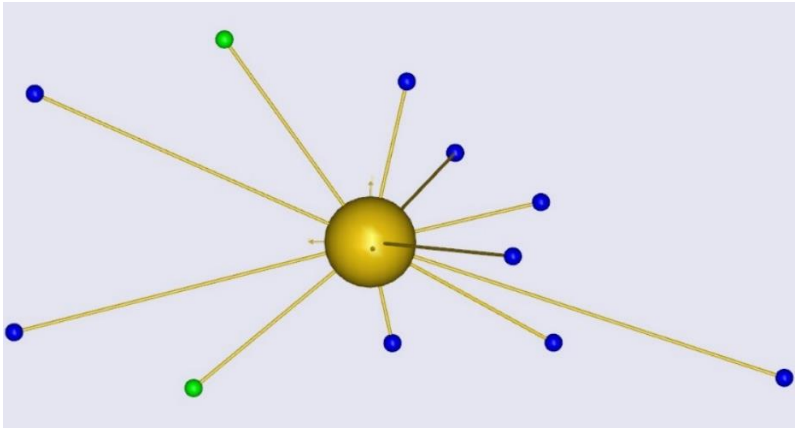

Figure 2: A single segment of the spinal vertebra in the AnyBody Modeling System

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Parametric design of a combined implant for maxillofacial reconstruction after resection caused by bone tumor - a case study

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The craniofacial area is particularly important for humans, both for functional and aesthetic reasons, which translate into psychological comfort. As a result of injuries or progressive lesions, there are cases in which bone reconstruction is required to restore the functions of this system. The presented research includes a case study of a patient with bone tissue neoplasm within the mandible, for whom an implant design was made to replace resected fragment. The aim of our research was to virtually plan the operation, design a personalised mandible implant and cutting guides. The geometry of the implant has been developed in such a way as to provide support for the fragments of the fibula, which are the place for dental implants, while reconstructing the outline of the mandible. The result of the project is a 3D model of the implant adapted to the patient's anthropometric characteristics along with a numerical model that was used to optimize the implant.

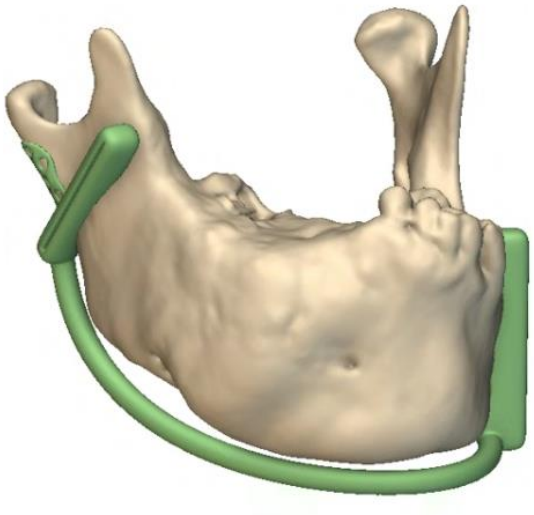

Figure 1: A model of the diseased mandible with a resection template marked in green

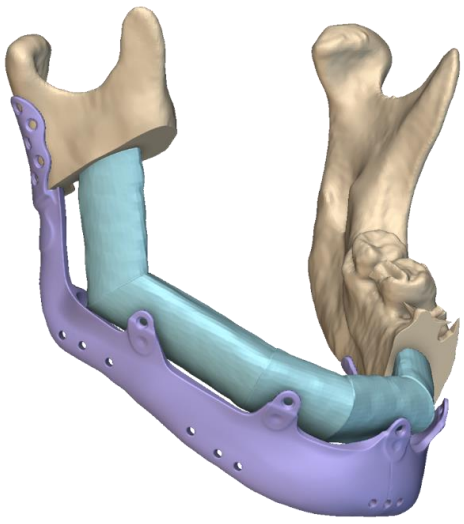

Figure 2: Final version of the patient specific implant geometry: yellow color – bone after resection, purple color – titanium PSI, blue color – fibula fragments

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New Insights into Finite Element Modelling of a Female Cervical Spine

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This study focuses on improving the accuracy of a previous developed finite element model of the female cervical spine by testing various modelling techniques. Given the higher risk of whiplash-associated disorders in women, a female-specific model was developed. Enhancements included the addition of annulus fibrosus fibers, modelling the vertebrae as rigid, and testing a novel fluid-like nucleus pulposus. Cervical spine segments were analyzed under flexion, extension, lateral bending, and axial rotation to assess range of motion. Validation against in vitro and previous model data confirmed the model's reliability. The inclusion of fibers significantly restricted spinal motion, enhancing realism. Modeling vertebrae as rigid bodies reduced computational time by about 80% without major performance loss. The fluid cavity approach for the nucleus pulposus showed potential to simulate disc behavior more accurately. Overall, the study provides new insights into sex-specific spine modeling and biomechanical behavior.

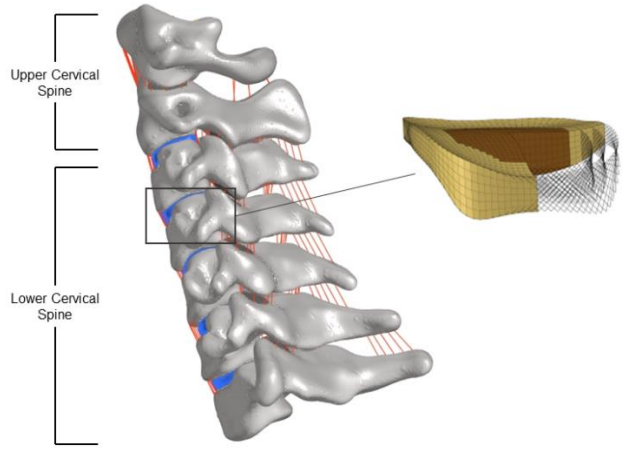

Figure 1: Developed FE model of the female cervical spine.

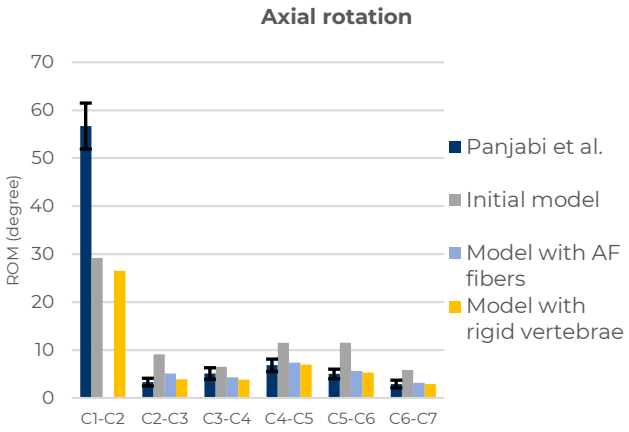

Figure 2: Comparison between simulation results and in vitro data for axial rotation, which exhibited the most significant changes following the model modifications.

Acknowledgments: This work is supported by Portuguese Science Foundation under grants PTDC/EME - EME/1239/2021, UIDB/00481/2020, UIDP/00481/2020 and 2024.00600.BDANA.

TEMA - Centre for Mechanical Technology and Automation, Department of Mechanical Engineering, University of Aveiro, Portugal; LASI - Intelligent Systems Associate Laboratory, Guimarães, Portugal; Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Poland.

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Energy Absorption Properties of Cellular Structures Produced by SLA Technology

Authors

Konrad SIWEK, Karolina SPYCHEL, Michał KUCEWICZ, Paweł BARANOWSKI

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Cellular structures are being investigated for use in protective footwear to reduce loads transferred to the lower limb during blast exposure. The objective is to develop energy-absorbing boot soles capable of mitigating shock wave propagation. As a first step, the deformation behavior and energy absorption efficiency of various topologies were evaluated under controlled loading conditions. The study was focused on two-dimensional structures fabricated from resin-based materials and tested under quasi-static compression. Numerical simulations using the LS-DYNA solver enabled analysis of deformation mechanisms, force histories and EA properties capacity of cellular structures. Furthermore, the parametric study of different methods of structure representation and boundary conditions was also conducted. The main goal of this task was to shorten the simulation time while maintaining numerical accuracy and proper representation of the cellular structures' deformation behavior.

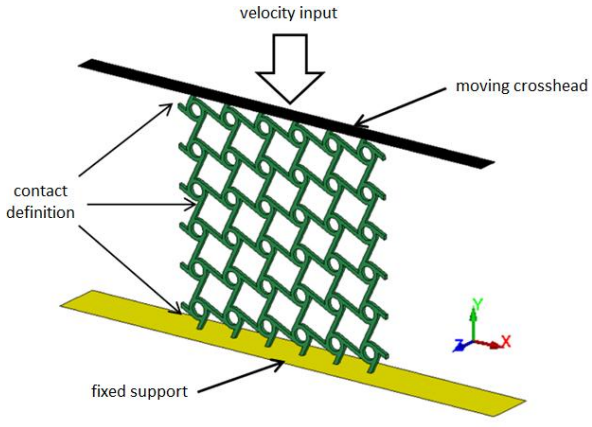

Figure 1: Numerical model

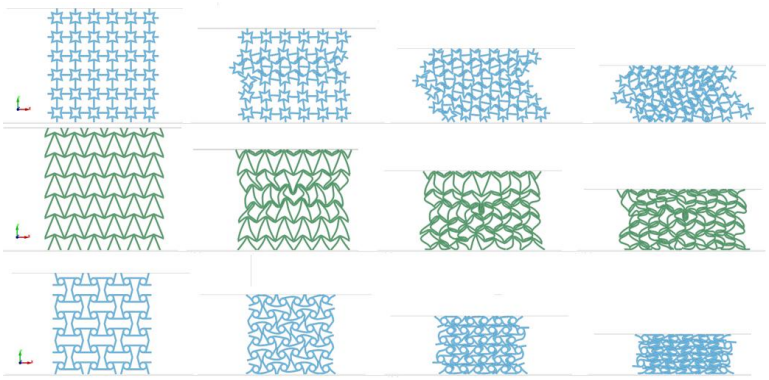

Figure 2: Stages of quasi-static compression

Conference fee paid from the budget of the PhD Research Club Of Mechanics And Computational Engineering of the Military University Of Technology.

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Analysis of the energy absorption of combat helmet linings for market available design solutions

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In this paper, the authors present an analysis of the energy absorption performance of helmet liner systems used in military helmets, currently available on the market in various structural configurations. The study discusses the construction of liners, highlighting differences in materials, geometries, and energy dissipation technologies, including multilayer systems, foams of varying densities, and configurations integrated with suspension and retention systems. The ability of different liner designs to attenuate forces transmitted to the user's head during dynamic impacts was assessed.

Compression tests were conducted at multiple strain rates to evaluate the energy absorption efficiency as a function of deformation velocity. The analysis of test results enabled an assessment of liner behavior under both low- and high-velocity impact conditions, representative of realistic ballistic and blunt impact scenarios.

The findings indicate significant differences in damping characteristics across the examined systems and point to directions for further optimization of helmet liner designs, particularly in terms of minimizing the risk of traumatic brain injury (TBI) and improving user comfort.

Figure 1. Examples of analysed military helmet lining systems

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Kinematic relationship analysis between the rotation of selected body segments and the motion components of a prototype sling therapy device.

Michał STANKIEWICZ, Kamil SYBILSKI, Szymon SATERNUS, Jerzy MAŁACHOWSKI, Jerzy KWAŚNIEWSKI

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Suspension therapy is a rehabilitation method that aims to relieve stress on joints, muscles and tissues. This method is widely used by physiotherapists, because thanks to various types of suspension, as it allows for the achievement of traction and mobilisation, which is of great importance for many disease entities. This paper presents a kinematic analysis of body movements during suspension therapy using a prototype rehabilitation device. The aim of the study was to determine the relationship between the movements forced by the actuators and the actual movements of body segments, including the spine. A research method is described using an optoelectronic system that allowed precise measurement of movements in the supine position. The article also provides an overview of selected movement sequences and an analysis of their progression, which can be used to further optimise therapy.

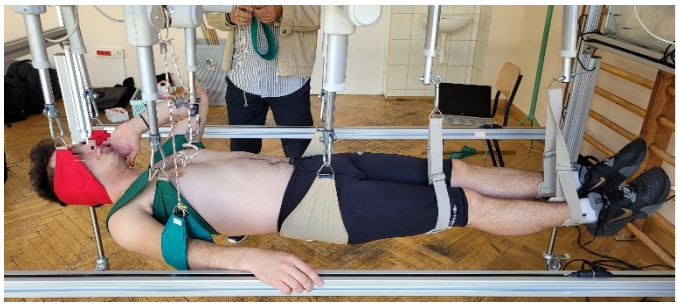

Figure 1: prototype device for suspension therapy

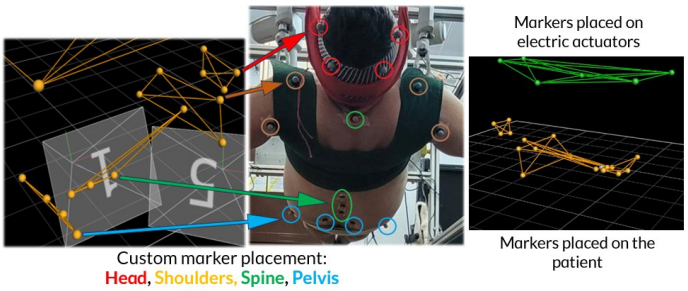

Figure 2: placement of measurement markers on the patient's body and preparation of a virtual model in Nexus software

ADDITIONAL INFORMATION: This work was financed by The National Centre for Research and Development under research project Rzeczy są dla ludzi/0080/2020

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Statistical shape modelling of the abdominal wall muscles

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Corresponding Author: Katarzyna Szepietowska e-mail; style: katszepi@pg.edu.pl

Computational models of the abdominal wall may be useful in improving the effectiveness of some medical treatment methods, for example a ventral hernia surgery, through *in silico* studies. Most of the existing finite element models of the abdominal wall are based on a single patient geometry. However, the human abdominal wall shape is characterized by high variability. The aim of this study is to investigate geometrical variability of the abdominal wall muscles. CT images of patients with healthy abdominal walls were processed in Mimics (Materialise). Rectus abdominis, external oblique, internal oblique and transverse abdominal muscles and connective tissues were segmented for each patient. Their 3D shapes were next postprocessed in 3-Matic. Statistical shape modelling is used to find mean shape and principal shape modes. Preliminary statistical shape models of each muscle (Figures 1-2) show geometry variation, that may be important to be included in the analysis of the mechanical biocompatibility of surgical meshes used in hernia repair.

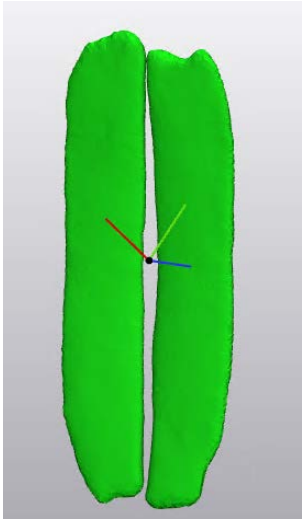

Figure 1: Mean shape of the rectus abdominis muscles

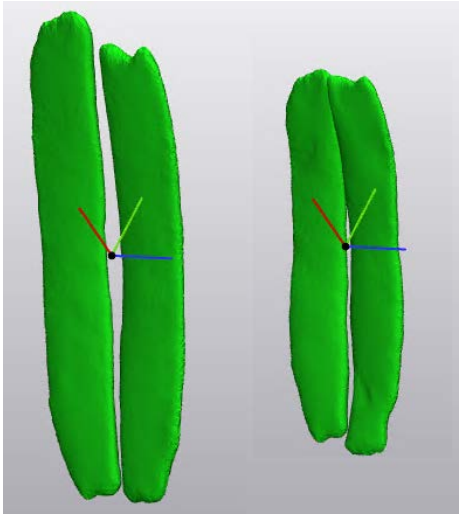

Figure 2: Shapes with different coefficients corresponding to the first mode.

ADDITIONAL INFORMATION: The authors would like to thank the National Science Centre (Poland) (Grant no: UMO-2022/47/D/ST8/02433) for providing financial support to this project. Calculations were carried out partially at the Academic Computer Centre in Gdańsk.

[1]Gdańsk University of Technology, [2] Medical University of Gdańsk

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Displacements of breast cancer lesions

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Corresponding Author: Adrianna Szumiejko, e-mail; style: adrianna.szumiejko@pwr.edu.pl

This research aims to develop and validate an innovative tool for preoperative localization of breast cancer by fusing multimodal diagnostic imaging (MMG, USG, MRI) with 3D photogrammetry. The system will generate personalized, AI-enhanced 3D breast models with tumor localization, physically reconstructed via 1:1 3D printing. The models will simulate breast deformation across patient positions, supporting surgical planning and potentially reducing reoperation rates in breast-conserving surgery (BCS). The project, carried out at a leading oncology center in collaboration with Wrocław University of Science and Technology, combines clinical validation with technological advancement. Potential outcomes include enhanced surgical precision, reduced treatment delays, improved patient understanding of the illness, marking a significant contribution to personalised oncologic care.

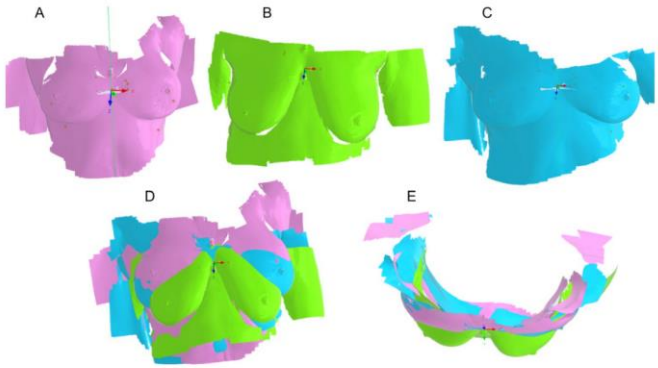

Figure 1: Patients breasts in different positions (A-C) fused together to one coordinate system (D-E)

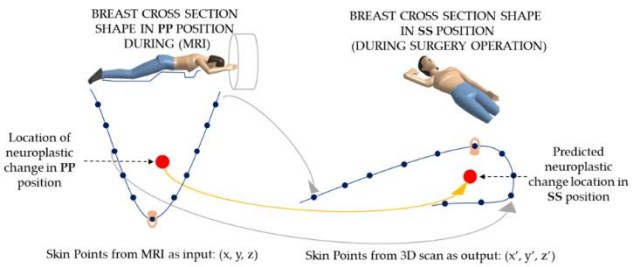

Figure 2: Conceptual deformation calculation with deep neural network model

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[2] Breast Unit, Department of Breast Imaging, Lower Silesian Oncology, Pulmonology and Hematology Center, Wroclaw, Poland

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PIV-based analysis of flow in atomizing nozzle

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High-resolution velocity fields of a turbulent jet emerging from a conical pressure-swirl nozzle were acquired using the Particle Image Velocimetry (PIV) technique. The measurements revealed peak velocities approaching 80 m/s, accompanied by pronounced turbulence intensity and the presence of well-defined vortex structures. The PIV method proved to be an effective tool for visualizing and analysing turbulent fogging flows, enabling the acquisition of both instantaneous distributions and time-averaged velocity fields within the analysed control volume. Although velocity measurements in the immediate vicinity of the nozzle outlet were limited due to the high concentration of particles, a complete and detailed picture of the jet propagation further downstream was successfully obtained. Overall, the findings confirm that PIV provides reliable experimental data for validating CFD models of multiphase nozzle flows, thereby establishing a robust methodology applicable to similar fluid systems characterized by complex turbulent and multiphase interactions.

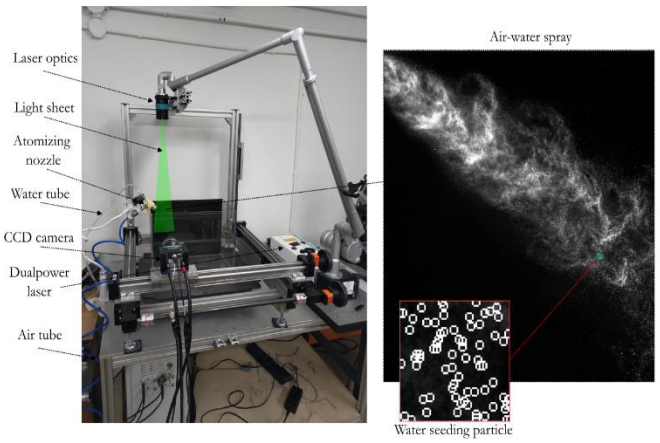

Figure 1: Experimental setup

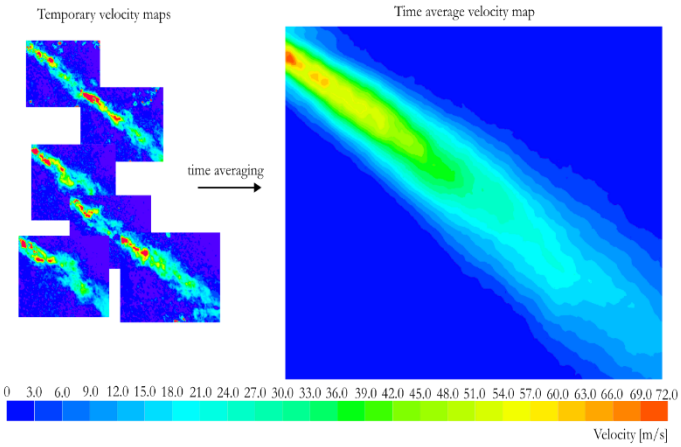

Figure 2: Time average velocity map

ADDITIONAL INFORMATION: The research was conducted as part of the SZAFIR project DOB-SZAFIR/02/A/002/02/2021 - type: National Defence and Security (DOB)—SZAFIR 2, Mobile disinfection system for medical protection of the Polish Armed Forces in counteracting SARS-CoV-2.

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Novel antibacterial and biocompatible PMMA composite with hybrid clay mineral nanofiller

Lenka KLECANDOVÁ, Magdalena ANTONOWICZ, Karolina WILK, Jana KUPKOVÁ, Gražyna SIMHA MARTYNKOVÁ, Zbygniev PASZENDA, Marcin BASIAGA

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In this study we prepared polymer composite material with hybrid organo-anorganic filler. The clay mineral - montmorillonite - was modified by chlorhexidine diacetate and subsequently Ca - deficient hydroxyapatite was prepared on clay mineral surface. This hybrid nanocomposite was used as filler for poly(methyl methacrylate) composites. The characterisation of created polymer-clay composite was achieved by Fourier transform infrared spectroscopy, scanning electron microscopy, X-ray powder diffraction, optical microscope and differential scanning calorimetry. The hardness of composites was also established and bacterial adhesion was also studied. The results show improvement of hardness of PMMA after addition of clay mineral filler. The fillers are evenly distributed in polymer matrix and improve mechanical and antimicrobial properties.

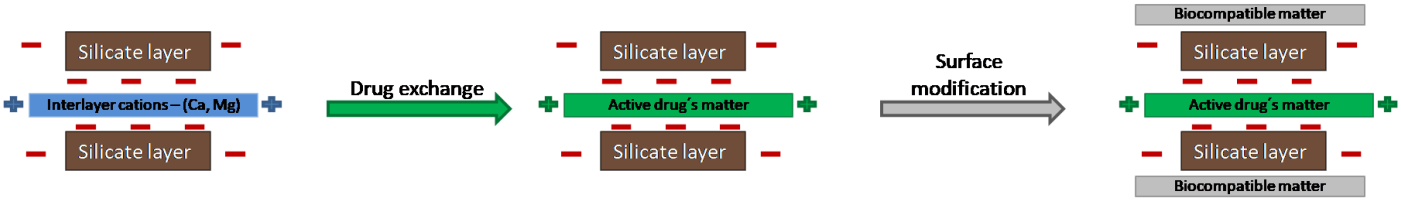

Figure 1: Graphical illustration of clay mineral filler preparation

The project was funded by the National Science Centre, Poland allocated on the basis of the decision No. 2023/49/B/ST11/03301, No. CZ.10.03.01/00/22_003/0000048 "REFRESH - Research Excellence For Region Sustainability and High-tech Industries", Project No. CZ02.01.01/00/22_008/0004631- "Materials and Technologies for Sustainable Development," funded by the European Union and the state budget of the Czech Republic within the framework of the Jan Amos Komensky Operational Program.

Silesian University of Technology, Faculty of Biomedical Engineering, Department of Biomaterials and Medical Device Engineering; Nanotechnology Centre, VSB – Technical university of Ostrava; Faculty of material science and technology, VSB – Technical University of Ostrava

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Computational Modelling of Head Injuries in Female Brains: Results and Prospects of the BAFHTA project

Carlos CARDOSO, Joana PINTO, Amirhossein GANDOMIROUZBAHANI, Marcos GOMES, Afonso SILVA, Fábio FERNANDES and Ricardo ALVES DE SOUSA

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The biomechanics of traumatic injuries from road crashes, falls, sports, and military events have been studied for decades. Traumatic brain injury (TBI), a leading cause of global death and disability (69 million cases yearly), remains understudied in women, despite sex differences in anatomy, physiology, and recovery. Factors like ergonomics, psychology, and endocrinology further influence outcomes, highlighting the need for sex-specific research. The BAFHTA (Biomechanical Analysis of Female Head Trauma) project aims to address this issue. Our presentation will focus on the biomechanical study of several pathologies on the female brain for different cases studies, ranging from sports to road accidents. All the developments from the creation of the head models to data collection and injury analysis will be presented and discussed. Project website: bafhta.web.ua.pt

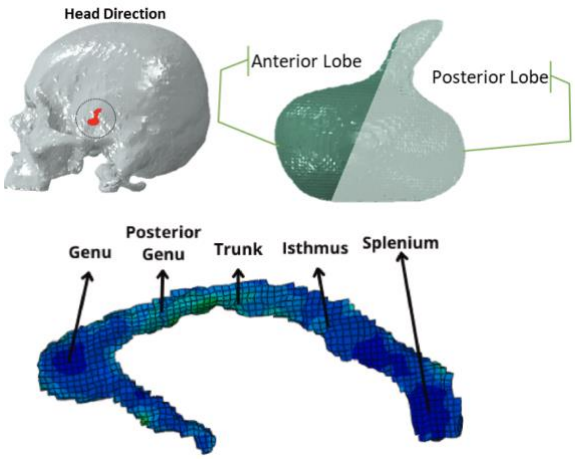

Figure 1: Analysis of the corpus callossum and pituitary gland regions after TBI

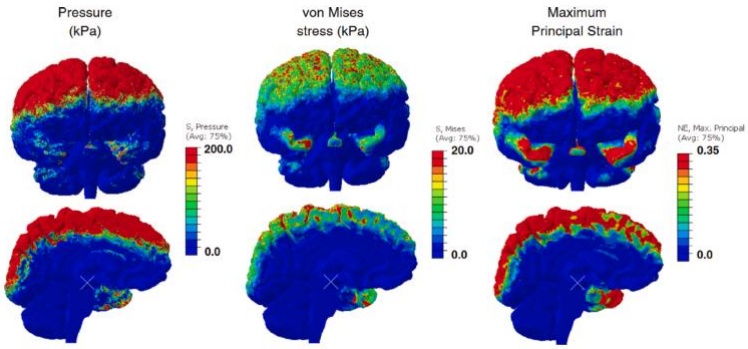

Figure 2: Different thresholds evaluated for brain injury outcomes.

Acknowledgments: University of Aveiro authors acknowledge the support given by the Portuguese Science Foundation (FCT) under grants PTDC/EME- EME/1239/2021 (BAFHTA), UIDB/00481/2020 and UIDP/00481/2020

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Designing for needs - challenges in developing medical equipment

Magdalena DUDA, Julia PAWLUK, Jacek ADAMECKI, Weronika BOJANOWSKA, Irmina LEPIARCZYK, Marlena ROMANÓW, Iwona CHUCHNOWSKA, Anżelina MAREK

Corresponding Author: Iwona Chuchnowska, e-mail: iwona.chuchnowska@polsl.pl

The aim of the project carried out as part of the XI competition for project-oriented education – PBL was to familiarize with the procedure of designing and manufacturing a medical device. As part of the project, a draft version of the frame was developed. The most important assumption when designing this product was to reduce its weight and ensure ease of assembly.

In order for a company to manufacture and implement such a medical product, it is necessary to previously implement a Quality Management System for Medical Devices (ISO 13485) and a Risk Management System in accordance with the PN-EN ISO 14971 standard ("Medical devices – Application of risk management to medical devices"). Risk management includes risk assessment throughout the entire lifecycle of the product. Various tools are used for this purpose. One of them is a strength analysis of the product. This analysis allows the identification of the most stressed areas of the structure and the study of the product's behavior under varying load conditions. Another important source of information about potential hazards is clinical testing. When designing a given element, it is necessary to focus on its functionality and adapt the design to the environment in which it will be used.

The final step before the market introduction of the product is its certification, which is carried out by an external company.

Acknowledgments

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Effect of pH and exposure time on mechanical properties and energy states of silicone and PVC gastric tubes

Maja ADAMIEC, Julia BRODNIEWICZ, Paulina CIOŁEK, Sylwia ŁAGAN

Maja Adamiec, maja.adamiec@student.pk.edu.pl

The aim of this study was to analyze changes in the functional properties of gastric tubes depending on environmental conditions and incubation time. The research subjects were gastric tubes made of PVC and silicone. A total of 20 samples, each 120 mm in length, were prepared. The samples were incubated in three pH environments—acidic, neutral, and alkaline—at a temperature of 37°C. After 2, 6, and 10 weeks, the samples were weighed and subjected to wettability and mechanical strength tests. The mechanical strength was assessed through a static tensile test, from which the Young's modulus was calculated. Wettability was evaluated using the sessile drop method with test liquids of varying surface tensions: distilled water, 1-bromonaphthalene, and glycerin. The study was conducted to identify the material exhibiting the greatest stability of mechanical properties under various environmental conditions [1,2].

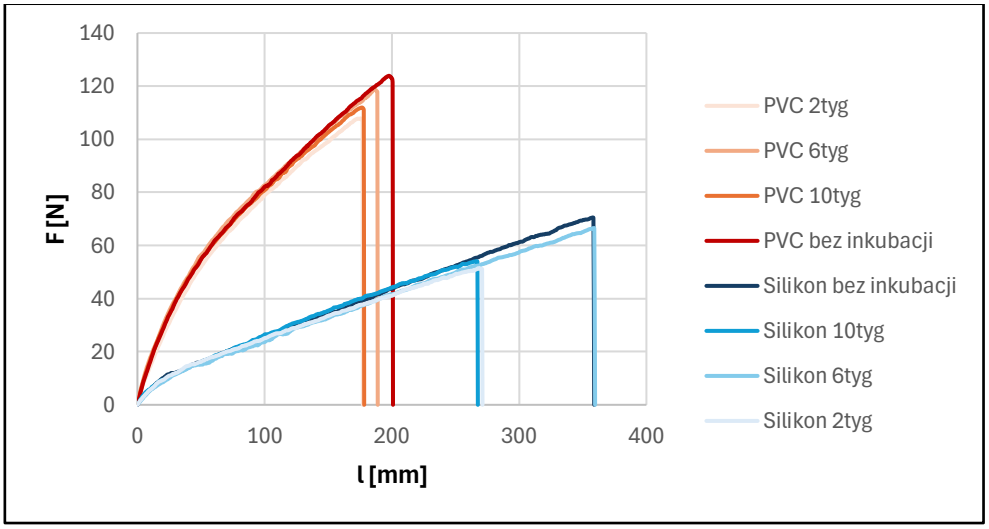

Figure 1: Tensile Test Graph (pH 2)

[1] CHROBAK A. , CIEŚLIK M. , JAŚKO K. , KURAS I. , ŁAGAN S., *Oznaczenie stanów energetycznych powierzchni zgłębnika żołądkowego po wybranych procesach starzenia materiału*, Kraków 2019
[2] OWCZAREK J. , SZUMILAK M. , NOWAK K. , *Medical devices used in enternal nutrition*, Łódź 2021

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Reducing Diagnostic Delay: Pre-processed fNIRS-Based AI Dashboard for Rapid Neurological Screening in Clinical and Rehabilitation Applications

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Functional near-infrared spectroscopy (fNIRS) is emerging as a promising non-invasive tool to study cortical hemodynamics. Timely and neurological assessment is critical in both acute and chronic medical conditions. This study proposes a human-centred, AI-powered dashboard designed to analyse fNIRS signals. In this study, an online available dataset of Parkinson's Disease and healthy subjects for the fine motor task of finger tapping is used. To remove the artifacts and noise, the data is pre-processed by Homer 3 software. Pre-processed fNIRS signals from 20 participants with PD and 20 age-matched healthy controls were used to extract comprehensive time-domain and frequency-domain features. These features were then used to train eight machine learning models. Random Forest achieved the best F1-score (0.75) and AUC (0.81) was integrated into an interactive diagnostic dashboard coded in Python using the Streamlit framework. The proposed platform offers usability in clinical and rehabilitation environments and offers rapid decision support for early diagnosis. The tool also aims to reduce diagnostic delays, enhance patient communication, and support rapid decision-making in clinics and rehabilitation centres. In the future, leveraging machine learning algorithms, the dashboard can be extended to automatically preprocess and analyse fNIRS signals and to detect abnormalities associated with conditions such as stroke, traumatic brain injury, and neurodegenerative diseases.

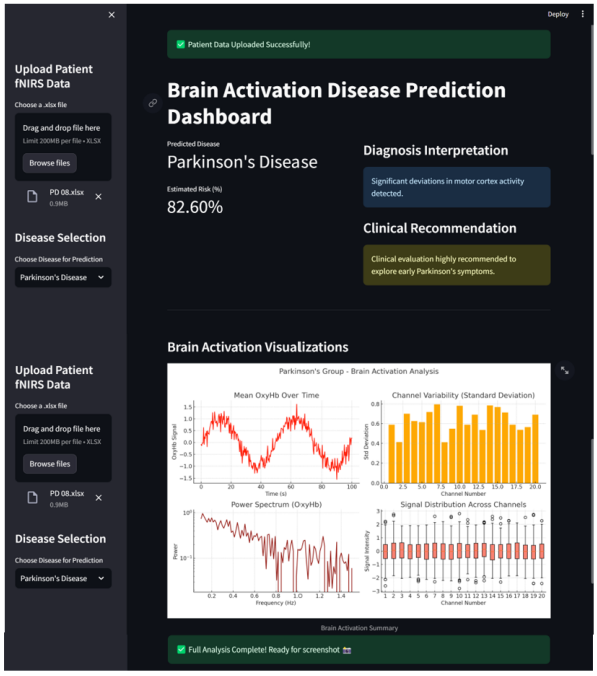

Figure 1: Dashboard Interface with Risk Score, Visualizations, and Clinical Summary

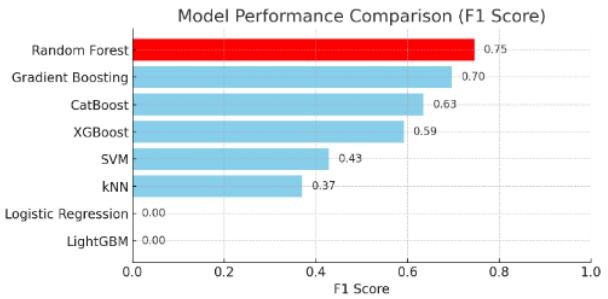

Figure 2: Model Performance Comparison (F1 Score Across 8 Classifiers)

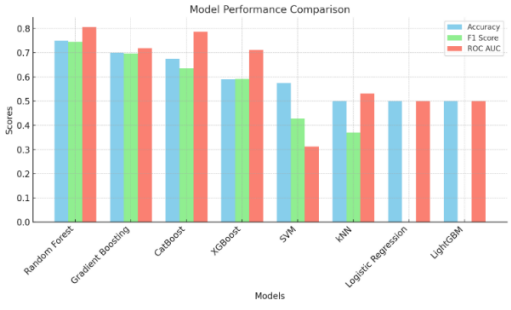

Figure 3: Model comparison with Logistic Regression showing the best performance

This project was conducted under the supervision of PhD candidate Tayyaba Nosheen. No external funding was received.

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The design methodology of interactive toys for therapy

Stanisław GIREK, Magdalena NOWAK, Jolanta ZABUSKA-MACZUR, Małgorzata MUZALEWSKA, Paweł ŁÓJ

Corresponding Author: Stanisław GIREK e-mail; sg306226@student.polsl.pl

The design methodology of interactive therapy toys includes several important stages to ensure effectiveness and usability. It starts with analysis and research, involving visits to therapy centers to understand the needs of future users. Then comes idea generation, inspired by consultations with center staff, to develop innovative solutions for children with various conditions. In the prototyping phase, initial toy versions are built using 3D printers, machining equipment, and workshop tools, supported by supervisors. These prototypes are then tested in therapy centers, and feedback from staff is used to make improvements. After adjustments, the final toys are implemented in centers to assist rehabilitation and support therapists. This structured process ensures that interactive toys meet specific user needs and contribute to effective therapy sessions.

Figure 1: Consulting prototypes

Figure 2: Testing prototypes

ADDITIONAL INFORMATION: Politechnika Śląska, Katedra Podstaw Konstrukcji Maszyn, SKN AI-METH; Integral SENSO, Specjalny Ośrodek Szkolno-Wychowawczy Dąbrowa Górnicza, AIUT.

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Application of numerical methods in the biomechanical analysis of injuries resulting from accidents

Oliwia GRZĘDA[1], Mariusz PTAK[2]

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This thesis is intended to evaluate the effects of dynamic loads on the protective effectiveness of a speedway helmet using reverse engineering methods and numerical simulations. The research is based on a detailed representation of the geometry of the actual helmet, obtained from computed tomography (CT) data. An advanced model of the human head was used in the analyses, allowing a realistic assessment of the overload affecting on the brain and the potential injury risk during an accident. In addition, the work involved reverse engineering a section of the track of the Olympic Stadium in Wroclaw, to replicate real-word collapse conditions as accurately as possible. The simulations cover various collision scenarios typical of speedway sport. The results obtained allow an assessment of the protective effectiveness of the helmet based on stress distributions and acceleration values affecting on the head. The conclusion of the study can make an important contribution to further work on improving the safety of motorsport riders.

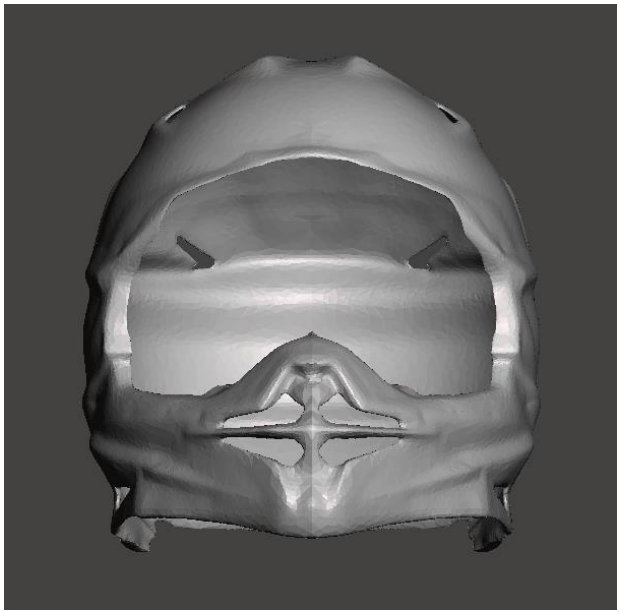

Figure 1: Geometry model of the speedway helmet

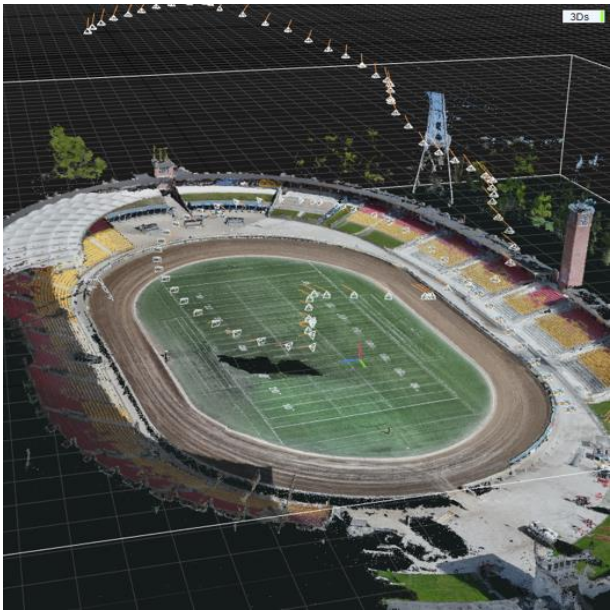

Figure 2: Reverse engineering of the Olympic Stadium in Wroclaw

[1] Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Department of Mechanics, Materials and Biomedical

[2] Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Department of Machine Design and Testing

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Automation of biomechanical computations using artificial neural networks.

Weronika KANDULSKA, Matylda KRYŚ, Tomasz WALCZAK

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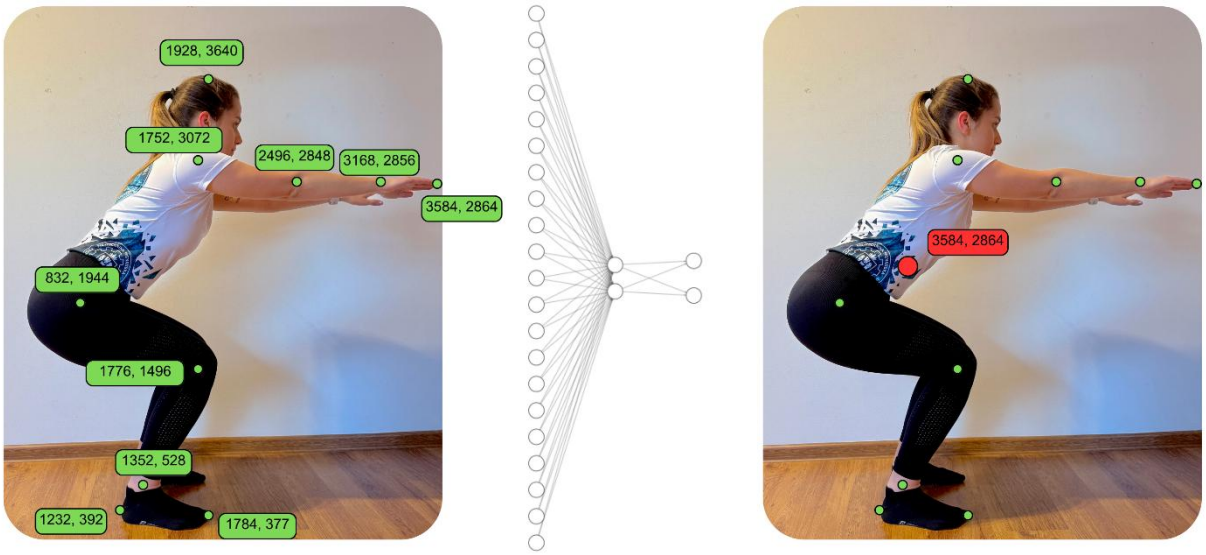
This study presents the development of an artificial neural network for estimating the human body's center of mass. The training data were collected using the BTS SMART system and included spatial coordinates of markers placed at key anatomical landmarks. The network recives pixel coordinates of selected joints and the subject's body mass as inputs, and produced the pixel coordinates of the center of mass as outputs. The model was trained on sagittally symmetrical poses in which the lower limbs served as the base of support. It was then tested on new data derived from images of individuals performing different exercises. After training the network and normalizing the pixel coordinates, the network successfully predicted the location of the center of mass, confirming the method's practical applicability for markerless motion analysis in fields such as sports and rehabilitation.



Neural network input: pixel coordinates of key body markers and body mass.

Architecture of the artificial neural network

Neural network output: predicted pixel coordinates of the center of mass

Figure 1. Neural network process: input data (left), model architecture (center), output prediction (right).

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Comparative Analysis of the Mechanical Properties of Surgical Sutures

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The aim of this study was to evaluate the mechanical performance of four surgical sutures (PGA, PDO, PA, silk) before and after 14 days incubation in saline solution. All sutures (size 3/0) differed by structure (monofilament/braided) and resorbability. Tensile strength was measured before and after incubation at 37°C. Contrary to expectations of a 25% strength loss, only a slight decrease was observed. Nylon showed the highest stability; PGA had a greater decline. Overall, all sutures maintained sufficient mechanical properties, crucial for early wound healing, supporting their clinical use.

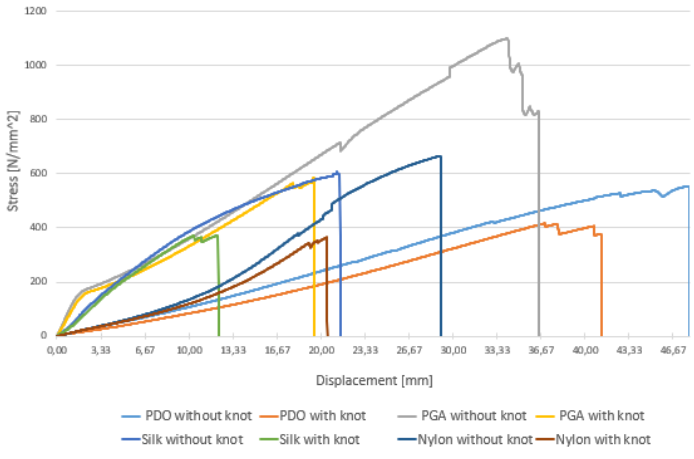

Figure 1: Tensile test curve of surgical sutures after incubation

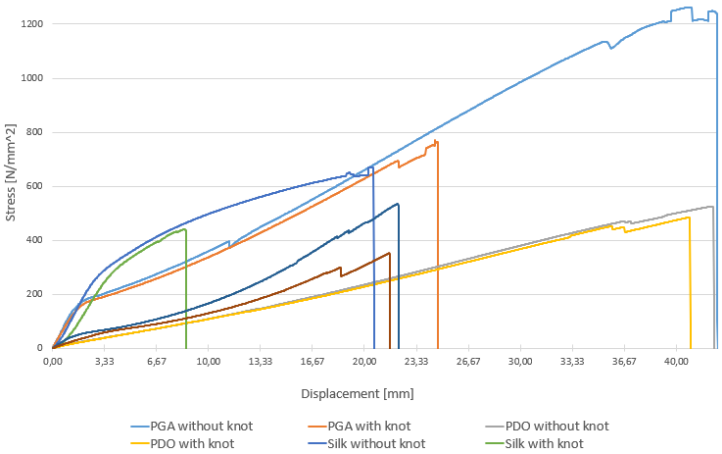

Figure 2: Tensile test curve of surgical sutures before incubation

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Application of polymeric biomaterials in the treatment of glioblastoma multiforme defect: promises, advances, and challenges - an overview of available solutions

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Glioblastoma (GBM) is the most aggressive primary brain tumor in adults, characterized by rapid growth, infiltration, and resistance to therapy [1]. Standard treatment includes maximal safe surgical resection, radiotherapy, and chemotherapy with temozolomide [2, 3]. However, complete tumor removal is rarely achievable due to its infiltrative nature, leading to recurrence [2]. Postoperative radiotherapy and chemotherapy aim to target remaining cancer cells, but long-term outcomes remain poor [3]. Recent approaches have investigated biomaterials for filling brain defects after resection and for local drug delivery. These materials are classified into synthetic types, such as polyethylene glycol and natural materials, including collagen, alginate [4, 5]. Synthetic materials offer customizable mechanical properties and degradation rates, while natural ones offer superior biocompatibility and better mimic the extracellular matrix [5]. Biodegradable hydrogels, in particular, enable sustained local delivery of chemotherapeutic agents, enhancing drug concentration at the tumor site while potentially minimizing systemic toxicity [4].

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Review of in vitro studies for optimizing mathematical models of wound healing

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Abstract. This review evaluates in vitro experimental studies on the effects of selected physical factors—including ozone, ultraviolet radiation, and electromagnetic fields—on fibroblast proliferation and antimicrobial activity against clinically relevant pathogens. The primary objective is to identify and organize key experimental parameters that can inform the construction of mathematical models of wound healing, especially those integrating physical interventions alongside biochemical dynamics. Studies were categorized using an adapted PICO framework according to model type, exposure conditions, controls, and outcomes. Consistent findings indicate that ozone and UV-C exhibit rapid biocidal activity, while electromagnetic fields modulate inflammation and tissue regeneration without impairing cell viability. The extracted parameters—including dose, frequency, and readouts such as CFU or MTT values—form a foundation for the future development of mathematical simulations. This synthesis highlights a lack of standardization across studies and calls for improved reporting and more physiologically relevant models to support translational applications.

Keywords: wound healing, in vitro, fibroblast proliferation, antimicrobial activity, ozone therapy, ultraviolet light, electromagnetic fields, Pseudomonas aeruginosa, Staphylococcus aureus, Candida albicans, mathematical modeling

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Investigation of the structural and mechanical properties of plateau tissue affected by osteoarthrosis

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Osteoarthrosis (OA), a degenerative joint disease which disrupts knee biomechanics through malalignment such as varus deformity, shifting the mechanical axis medially. This imbalance triggers uneven load distribution, driving structural remodeling of articular tissues. Our study investigates mechanical and structural adaptations in tibial plateau tissue from advanced OA patients undergoing total knee arthroplasty. Combining scanning electron microscopy (SEM) and high-resolution micro-computed tomography (µCT), we quantified morphometric parameters including bone volume fraction (BV/TV) and trabecular thickness (Tb.Th). SEM imaging revealed clear pathological changes, including microstructural degradation at the bone-chondral tissue interface, extensive microcracks in the subchondral bone and bone structural disruption extending into deeper areas of the tissue. The data revealed remodeling processes and microstructural alterations in the knee joint associated with osteoarthrotic degeneration.

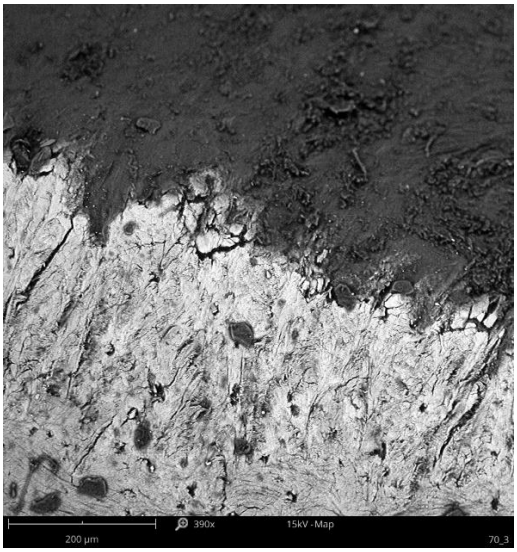

Figure 1: SEM image showing osteochondral interface in tibial plateau specimen exhibiting advanced-stage osteoarthrosis

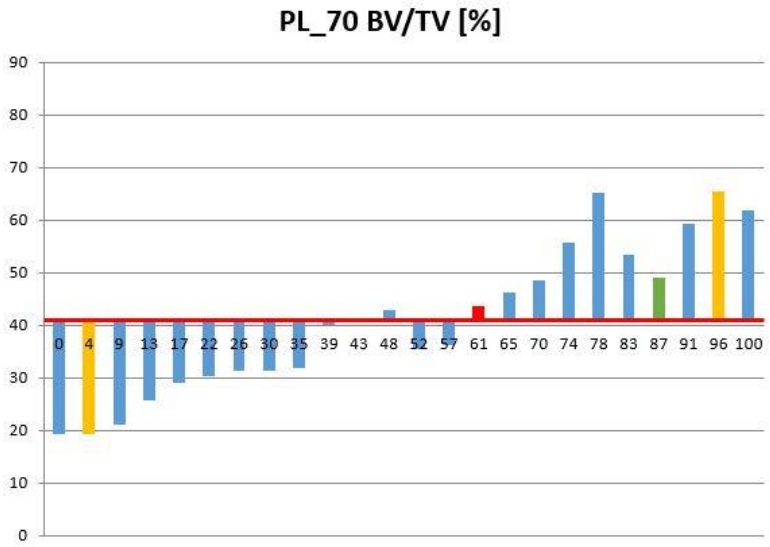

Figure 2: Percentage variation of the BV/TV parameter along the sample

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Comparison of marker-based and markerless motion capture system in Y Balance Test assessment

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The project aims to evaluate the effectiveness of the markerless motion capture system OpenCap compared to the traditional marker-based Vicon system. OpenCap uses standard mobile devices (e.g., iPhones), offering a low-cost, accessible, and less intrusive alternative to traditional systems. The analysis was based on the Y Balance Test, performed while standing on one leg and reaching with the big toe of the non-supporting foot in three directions: anterior, posteromedial, and posterolateral (Fig. 1, 2). The study was conducted on first-league women's football team athletes, providing a relevant sports context. The main parameters analyzed were the relative maximum reach distances, expressed as a percentage of leg length. In this study we used three devices - two iPads and one iPhone. This test is commonly used to assess dynamic balance and lower limb stability.

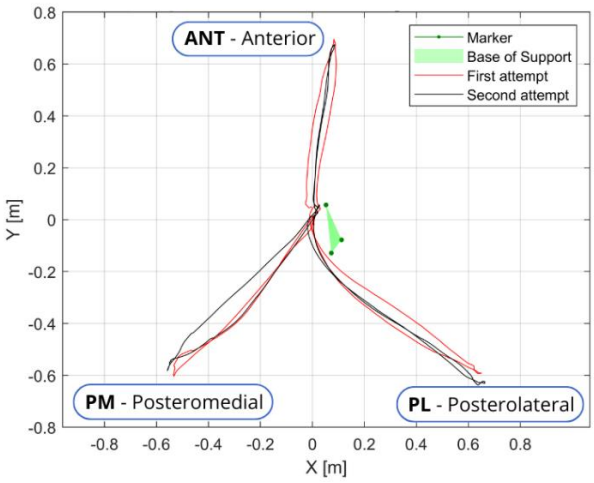

Figure 1: Big toe trajectory relative to the supporting limb during two Y Balance Test attempts, with labeled directions of excursion

Figure 2: OpenCap View of the Y Balance Test

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Structural, Mechanical and Biological Characterization of Highly Porous Poly(L-lactide)/Hydroxyapatite Composite Structures

Authors (without affiliation)

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This article presents the results of research on highly porous polymer-ceramic materials based on biodegradable poly(L-lactide) (PLLA), produced using phase separation, freeze-drying, and porogen leaching techniques. The aim of the study was to evaluate the impact of pore structure and the addition of hydroxyapatite (HAp) on the mechanical properties of the material. Pore morphology was analyzed, mechanical compression tests were carried out, and the susceptibility of the foams to hydrolytic degradation was assessed under simulated physiological conditions. The results showed that larger pore sizes lead to a reduction in mechanical stiffness, while the presence of HAp improves the elastic modulus and structural stability of the material. The findings indicate the potential application of PLLA foams in tissue engineering and in implantable biomaterials.

Keywords: poly(L-lactide), polymer foams, hydroxyapatite, mechanical properties, tissue engineering

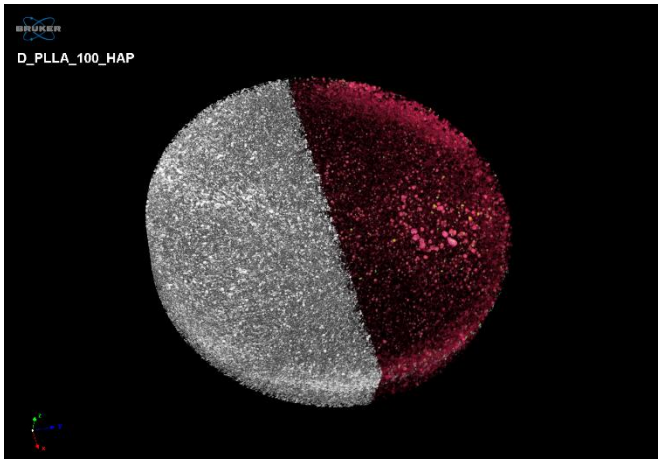

Figure 1: Micro-computed tomography (microCT) imaging of the sample performed during density analysis.

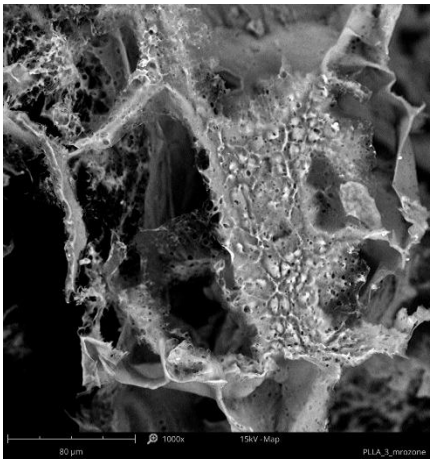

Figure 2: Porous structure of the foam sample observed using scanning electron microscopy (SEM).

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Biomechanical analysis of abdominal aortic aneurysms

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Projects scope includes numerical analysis of blood flow in an abdominal aortic aneurysm before and after stenting surgery. As part of the work, two variants of geometric models were developed – one mapping the pathologically changed aorta, the other – taking into account the presence of a stentgraft. Additionally, the models and analyses were differentiated by parameters such as aneurysm wall thickness. For both cases, a numerical analysis of blood flow through the vessel were carried out, which allowed to obtain data on the distribution of velocity, pressure and forces acting on the vessel walls. These results were then used as loads in the mechanical analysis of the vascular wall, carried out by the finite element method (FEM), to determine the distribution of stresses and strains. The purpose of the comparison of both cases was to assess the effect of stenting on flow conditions and changes in mechanical loads acting on the vessel wall. This analysis can provide information on the effectiveness of the treatment and help to predict the risk of aneurysm rupture.

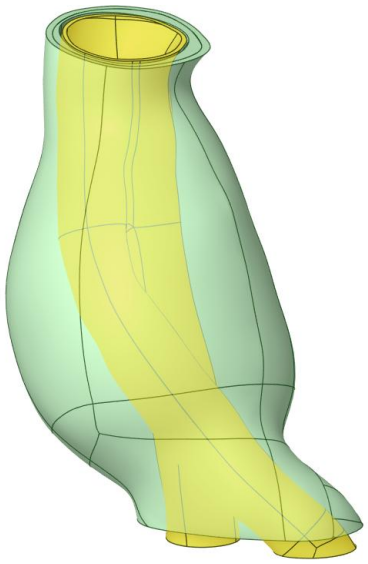

Figure 1: Geometry model of the aorta with an endovascular stent graft

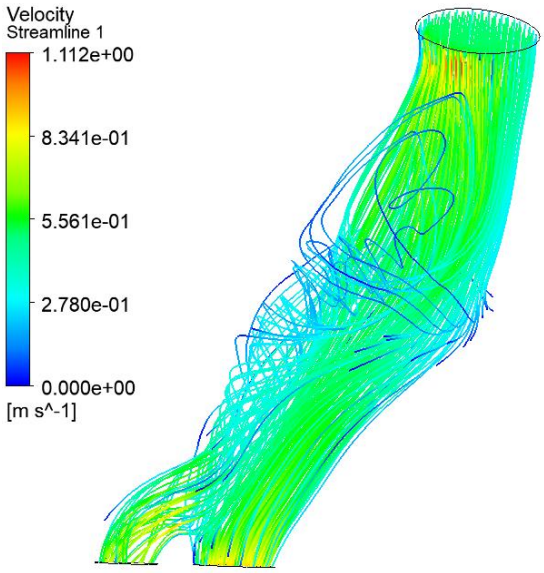

Figure 2: Streamline representation of aortic blood flow

Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Department of Mechanics, Materials and Biomedical Engineering
Wroclaw Medical University

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Hexapoint design for general use and conceptual design of a Braille reader for visually impaired users

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In response to the growing needs of blind individuals, a modular device (Figure 1) was developed, designed to reproduce Braille characters. Additive manufacturing technologies were used to produce the mechanical components, enabling high precision in reproducing the character geometry while optimizing the device's mass and size. The hexapoint mechanism incorporates an electromagnetic system responsible for the controlled, multi-stage displacement of the pins. The use of additive manufacturing methods and electromagnets resulted in a reduction of both the device's weight and production cost while ensuring the highest quality. Through statistical data analysis and end-user research, the prototype was adapted to meet ergonomic requirements. The final design (Figure 2) enables integration with existing public information systems and mobile devices, supporting the social inclusion process for individuals in need.

Figure 1: Modular design of a single hexapoint module

Figure 2: Braille reader composed of multiple modular hexapoint units

ADDITIONAL INFORMATION: The project was carried out as part of the activities of the Scientific Club of Biocybernetics and Biomedical Engineering at the Military University of Technology.

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Postural Control in Smokers vs. Non-Smokers: A Comparative Study

Martyna Przybylska, Klaudia Śmiełowska, Jakub Wołosz, Jakub Sornek, Patryk Pasternak, Hanna Zadoń, Piotr Szaflik, Robert Michnik

Postural control is a complex process integrating visual, vestibular, and proprioceptive input. This study aimed to assess the effect of smoking on balance by comparing stabilographic parameters in smokers and non-smokers. Fifty participants (average age: 21) were examined using a Zebris stabilometric platform under two conditions: eyes open, eyes closed. Results showed a significant increase in mean COP (center of pressure) velocity in smokers after smoking, especially with eyes closed (from 8.4 mm/s to 11.5 mm/s). These findings suggest that nicotine impairs postural stability and neuromuscular coordination, particularly when visual cues are removed.

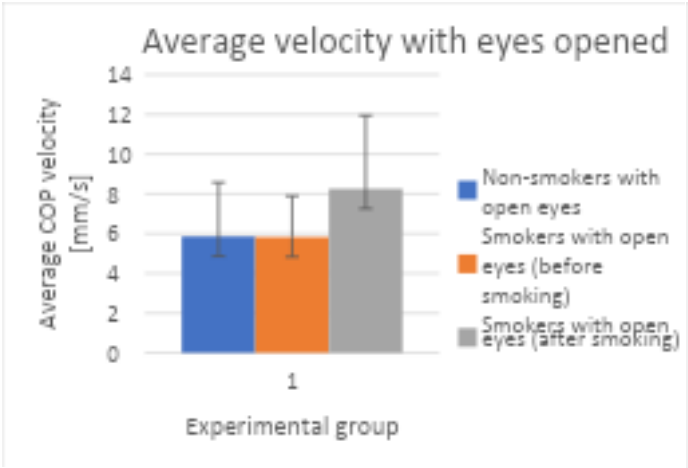

Figure 1: Graph of average eye-open velocity in nonsmokers and smokers before smoking

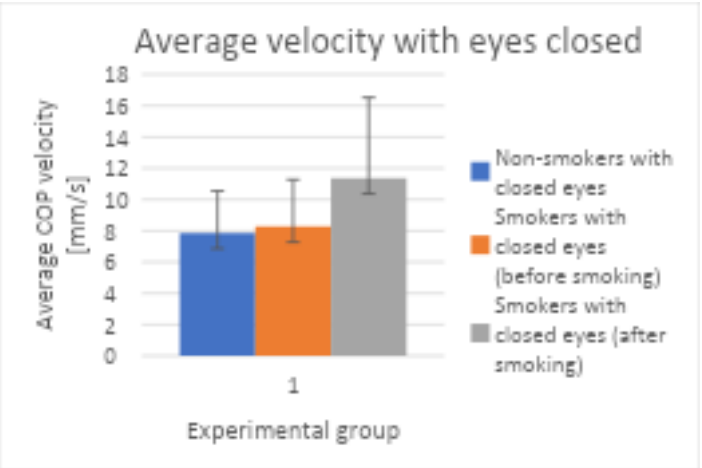

Figure 2: Graph of average eye-closed velocity in nonsmokers and smokers before smoking

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Smoking and Movement – How Nicotine Impacts Our Gait

Martyna Przybylska, Klaudia Śmiełowska, Jakub Wołosz, Jakub Sornek, Patryk Pasternak, Hanna Zadoń, Piotr Szaflik, Robert Michnik

This study investigates the impact of tobacco smoking on gait parameters in adults aged 18–23. A total of 50 participants were divided into smokers and non-smokers. Gait was analyzed using a Zebris FDM dynamographic platform, and statistical tests were conducted using MATLAB and Excel. Smokers showed tendencies toward higher walking speed and longer step lengths, while non-smokers exhibited slightly higher step frequency. However, no statistically significant differences were found between the two groups in any of the measured parameters ($p > 0.05$). The right step length approached significance ($p \approx 0.100$), suggesting a potential trend worth further exploration. Despite visible differences in mean values, the findings highlight the need for larger sample sizes to confirm these trends. This research contributes to understanding how nicotine may subtly influence motor functions such as walking.

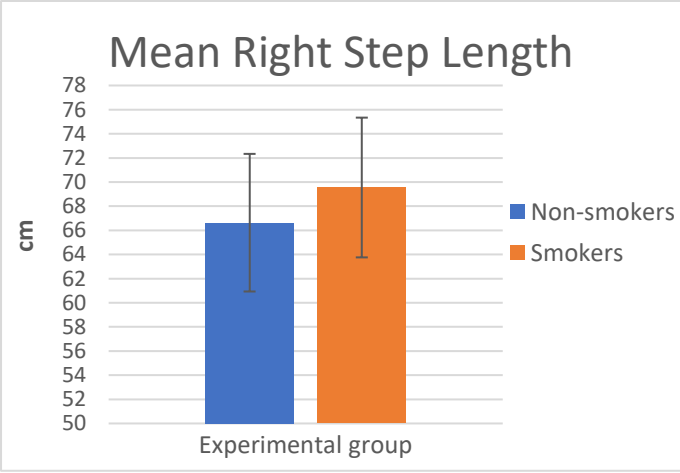

Figure 1: Graph of group mean right step length

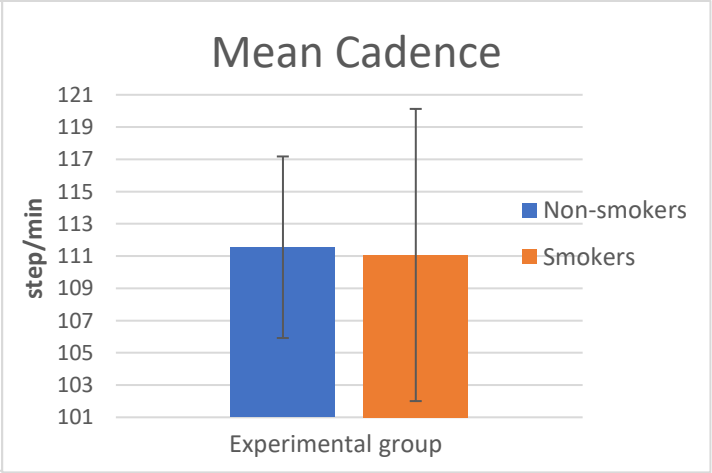

Figure 2: Graph of group mean cadence

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A sensory system demonstrator for immersive interaction on quadruped platforms

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The sensory system demonstrator is a separate and additional device designed to enhance the Unitree Go1 EDU quadruped robotic platform. The device is based on 12 FSR sessors, crafted in 3D printing technology. The system mimic dog's ears responding in real time to interactions. Each interaction triggers a reaction, which is visually represented by light emitted from the casing. Depending on the applied pressure color of the light changes gradually starting with green when applied pressure is light, shifting to yellow to show discomfort, and red to simulate a level of pressure that would cause pain to a real animal. An advantage of the system is its aesthetic design, which enhances the overall appearance of the robot and makes it more appealing to children. The entire setup used in robo-dog therapy, provide a safe way to observe a child's behavior toward a robotic dog without risking harm to a living animal. Device enables immersive interaction monitoring with the sensory system demonstrator.

Figure 1: Prototype of the device mounted on a quadruped platform.

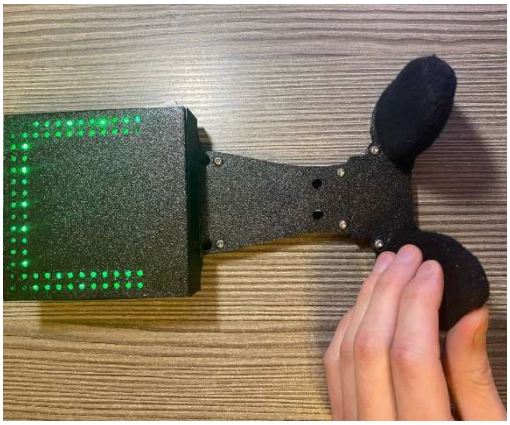

Figure 2: Visualization of the sensory system demonstrator's operation while touching the ears.

ADDITIONAL INFORMATION: Politechnika Śląska, Katedra Podstaw Konstrukcji Maszyn, SKN AI-METH; ReXio, Specjalny Ośrodek Szkolno-Wychowawczy Dąbrowa Górnicza.