

Exoskeletons as Smart Devices for Personalised Therapy – Current Concepts in Orthopaedic Care

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Introduction: Exoskeletons are wearable robotic devices to stabilize, assist, or enhance human movement. Initially developed for industrial applications, these systems have evolved into clinical rehabilitation and, more recently, lightweight consumer devices. While evidence exists for neurological conditions such as stroke and spinal cord injury, their role in orthopaedics is emerging.

Methods: This work provides a structured narrative overview of exoskeletons, outlining the transition from point-of-care rehabilitation systems to consumer-oriented, joint-specific assistive devices (knee, hip, ankle). Furthermore, exploratory testing of lightweight consumer hip and knee exoskeletons (Dnsys X1/Z1) was conducted at our motion lab to assess their potential for clinical applications.

Results: Stationary, multi-joint devices (e.g., Hocoma Lokomat) and portable, lower-body systems (e.g., ExoAtlet) are used in supervised clinical rehabilitation. In contrast, medical-grade devices for daily life (e.g., Ottobock C-Brace) and lightweight consumer devices designed for outdoor applications (e.g., Hypershell X, Dnsys Z1, Skip MO/GO) are emerging. Supported activities include walking, stairs, ramps, and sit-stand transfers. Recent orthopaedic studies indicate potential improvements in gait parameters and joint mobility, while passive upper-body exoskeletons may reduce physical strain among orthopaedic surgeons. Initial exploratory testing was successfully completed, providing preliminary insights into device usability and user perceptions.

Conclusion: Exoskeletons are transitioning from clinical tools to scalable, real-world assistive technologies. In orthopaedics, they offer potential applications in rehabilitation and daily mobility. Future work at our research unit will assess patient and healthcare professional perceptions, expectations, and device usability to explore the potential for translating outdoor mobility-assistance devices into clinical orthopaedic care.

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Biosketch – Rene Peter Bremm

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CURRENT AND PAST POSITIONS

Current: Senior Scientist, Human Motion, Orthopaedics, Sports Medicine and Digital Methods (HOSD) platform, Luxembourg Institute of Health (LIH), under Dr. Bernd Grimm (PI); dedicated to the SmILE project and further human motion-related initiatives.

2020–2023: Coordinated and conducted a clinical research project at the Centre Hospitalier de Luxembourg, National Department of Neurosurgery (headed by Dr. Frank Hertel), focusing on clinical gait analysis and diagnostic models for neurological disorders combining smart wearables and machine learning.

Prior: Data Steward, Luxembourg National Data Service, delivering data governance and stewardship services for the public sector.

EDUCATION

2019: PhD in Engineering Sciences, University of Luxembourg – Systems Control Group (led by Prof. Dr. Jorge Gonçalves), Luxembourg Centre for Systems Biomedicine. Doctoral work on closed-loop deep brain stimulation paradigms using wearable sensors to improve therapeutic outcomes for movement disorder patients.

2015: Training on advanced research prototypes for neuromodulation therapy, Neural Engineering Laboratory, Mayo Clinic, US.

OTHER RELEVANT PROFESSIONAL ACTIVITIES AND ACCOMPLISHMENTS

Electrical engineer and senior research professional with over a decade of experience in clinical research with smart wearable technologies.

Lecturer on medical technology, Trier University of Applied Sciences (2023).

Biosketch – Bernd Grimm

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Prior: Human Motion Institute, affiliated with the Department of Clinical Applications of Computational Medicine, TU Munich, Germany – development and validation of wearable devices and digital biomarkers as clinical trial endpoints.

Founder and Director, AHORSE orthopaedic research foundation, Zuyderland Medical Center, training hospital of Maastricht University, the Netherlands – pioneered wearable sensor applications for measuring human movement and physical activity, with a focus on clinical assessment of hip and knee surgery outcomes; methods now used by international universities and the basis of several PhD theses.

Lectureship in Applied Mechanics, University of Bath, UK.

EDUCATION

PhD in Biomedical Engineering, University of Bath, UK.

OTHER RELEVANT PROFESSIONAL ACTIVITIES AND ACCOMPLISHMENTS

His unit operates as a partner with LIROMS (Luxembourg Institute of Research in Orthopedics, Sports Medicine and Science), running the hospital-based Human Motion Lab (HML, CHL Eich) and the national movement laboratory for athletes (SportFabrik, LIHPS), researching mobility metrics towards improving patient outcomes, personalized rehabilitation and injury prevention.

Visiting Fellow, University of Bath, UK; Honorary Research Fellow, School of Clinical Science, University of Bristol.

Editorial Board Member, Journal of Translational Orthopaedics (JOT) and Medicine in Novel Technologies and Devices (MEDNZD); Associate Editor for Basic Science, EFORT Open Reviews (journal of the European Federation of National Associations of Orthopaedics and Traumatology).

Past-President, European Orthopaedic Research Society (EORS); President, International Combined Orthopaedic Research Societies (ICORS), 2022–2025.

Invited keynote speaker at international symposia on wearable movement-analysis methods.