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# JMedXR Abstracts: XR4REHAB Conference

**Introduction from the Co-Chairs**

It is our pleasure to present the abstracts to you, which will be presented at the World Conference on Virtual Rehabilitation 2026 (WCVR 2026), hosted by University College Cork in partnership with XR4REHAB and the International Society for Virtual Rehabilitation (ISVR). These abstracts bring together the scientific, clinical, and technological contributions presented during the conference and reflect the remarkable breadth and momentum of the global virtual rehabilitation community.

WCVR 2026 convenes researchers, clinicians, technologists, designers, industry innovators, educators, students and trainees from around the world to explore the transformative role of immersive and intelligent technologies in rehabilitation and healthcare. Across keynote presentations, scientific sessions, workshops, demonstrations, posters and collaborative discussions, the conference highlights the growing impact of extended reality (XR) systems in supporting rehabilitation in its widest sense and reshaping models of care.

The papers represent a diverse and interdisciplinary body of work spanning physical, neurological, cognitive and psychological rehabilitation. Contributions address topics including immersive rehabilitation environments, serious games and exergaming, AI-enabled rehabilitation systems, digital therapeutics, tele-rehabilitation, wearable sensing, motion analysis, human-computer interaction, accessibility, co-design methodologies and implementation science. Together, these works demonstrate how advances in XR, artificial intelligence and interactive technologies are enabling more personalized and scalable approaches to rehabilitation.

A defining strength of WCVR 2026 is its commitment to translational and patient-centered innovation. Many of the papers presented here move beyond proof-of-concept systems to examine clinical integration, usability, effectiveness, and long-term adoption in real-world healthcare contexts. The abstracts therefore reflect not only technological innovation, but also the practical challenges involved in bringing immersive rehabilitation solutions into routine clinical practice.

The conference program further illustrates the international and collaborative nature of the field. Contributions from academic institutions, hospitals, rehabilitation centers and industry partners showcase emerging perspectives on neurorehabilitation, pain management, aging, mental health, mobility training, pediatric rehabilitation and remote care delivery. Several sessions also explore the future of rehabilitation through advances in embodied AI, adaptive interfaces, digital biomarkers and data-driven clinical decision support systems.

As virtual rehabilitation technologies continue to evolve at pace, the need for interdisciplinary dialogue and development of robust evidence to fit with that pace has never been greater. WCVR 2026 serves as a forum not only for presenting scientific advances, but also for building partnerships across disciplines and sectors. We hope these abstracts capture the spirit of collaboration, curiosity and shared purpose that has characterized this year's conference.

We extend our sincere gratitude to the authors for sharing their work and insights, to the reviewers and program committee members for their thoughtful evaluations; and to the organizing committees, keynote speakers, sponsors, volunteers and partners whose dedication made WCVR 2026 possible. Most importantly, we thank all participants for contributing to a vibrant and growing international community committed to improving rehabilitation and healthcare through innovation.

We hope that the research and discussions presented in these proceedings faithfully represent the theme of our conference this year - "Business, practice, research – Better together". Our goal is to inspire new collaborations, stimulate future discoveries, and ultimately contribute to more accessible, effective and human-centered rehabilitation worldwide.

W. Geoffrey Wright and Denis Martin
WCVR 2026 Co-Chairs

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**Combining Virtual Reality and Cognitive Behavioral principles in treating long-term pain: A feasibility study**

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**Background:** Long-term pain affects >20% of global population, burdens healthcare and reduces quality of life (QoL). Non-pharmacological treatments are limited, and immersive therapeutics remain under-researched. The goal of this study is to investigate feasibility, usability, and preliminary efficacy of immersive therapeutics with virtual reality (VR) in addition to standard care, among patients with long-term pain.

**Methods:** Patients from an outpatient clinic (N=28) received home-based immersive therapeutics with self-developed VR software based on cognitive behavioral patient education and skills-based exercises – alongside usual treatment. Head Mounted Displays (HMDs) were provided, with instructions for use minimum three times between clinic sessions, over three months or earlier at ended treatment.

Primary Outcome and Experience Measures: Health-related QoL (i.e., EQ-5D-5L), self-rated health (i.e., EQ-VAS), and general health assessment (i.e., Promis-29 profile). Patient- perceived health changes after three months were measured with the Patient Global Impression of Change (n=23). Usability and feasibility were assessed with System usability Scale (SUS), and usage recorded using a dedicated platform. Clinicians' experience with VR treatment was explored through qualitative analyses of in-depth interviews.

**Results:** Preliminary results showed an average SUS score of 82. EQ-VAS showed significant improvement (p=0.02), although the EQ-index did not significantly change (p=0.29). Pain Interference score was significantly reduced (p=0.02), while changes in other domains were small and non-significant (p>0.05). Preliminary qualitative analyses showed that clinicians found VR intervention highly usable and that the content aligns with therapeutic objectives, enhancing patient education, and improving retention of key information.

**Conclusions:** Preliminary findings indicate that fully immersive VR treatment combined with usual care, emphasizing patient education and skills-based content, is feasible and safe for managing long-term pain. Positive impact on QoL and pain interference were observed. More research is needed to explore the efficacy of VR treatment as additional or stand-alone treatment.

**Funding:** The Norwegian Foundation Dam.

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**Learning to move in a virtual environment: Do attentional deficits matter?**

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**Background:** Motor learning in adults may be disrupted by attentional deficits such as in Attention-Deficit Hyperactivity Disorder (ADHD). However, current evidence is mixed, as some studies reported differences in motor performance and learning between adults with and without ADHD, while others have found no differences. Virtual reality (VR) enables standardized training and accurate kinematic measurements of motor performance and learning. We evaluated differences in motor learning between adults with and without ADHD within a VR environment, as well as the relationships between motor performance, attentional deficits, intrinsic motivation and cognitive engagement during the learning process.

**Methodology:** Thirty-nine adults aged 18-40 (19 with ADHD) participated in a two-visit VR motor learning study. Participants performed a virtual archery task using an HTC Vive head-mounted display (20-shot pre-test, 5-minute training, 20-shot post-test, and 20-shot retention phases). Shot accuracy, kinematics and cognitive engagement (using frontal electroencephalography) were recorded. Attentional deficits and intrinsic motivation were assessed via the Adult ADHD Self-Report Screening Scale (ASRS) and the Intrinsic Motivation Inventory (IMI) respectively. Data was analyzed using repeated-measures ANOVA, independent t-tests and correlation analyses.

**Results:** ASRS scores in the ADHD group were significantly higher ($t=6.03$, $p<0.001$) and were correlated with levels of intrinsic motivational factors (Pressure-tension r=0.516, p=0.02; Perceived choice r=–0.478, p=0.03). In both groups, accuracy and kinematics similarly improved with training. In the ADHD group but not in controls, accuracy was correlated with higher intrinsic motivation (Enjoyment r=0.482, p=0.03; Perceived competence r=0.615, p=0.005). For the entire group, higher ASRS scores were correlated with higher cognitive engagement levels during the training phase (r=0.343, p=0.03).

**Conclusion:** Intrinsic motivation and cognitive engagement may represent compensatory mechanisms supporting preserved motor learning in VR for people with attentional deficits.

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**Development of a virtual reality solution enabling full-body ownership illusions during multi-joint lower-limb exercises: Addressing real-time motion tracking challenges**

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**Background:** Immersive virtual reality (VR) enables embodiment in virtual avatars with manipulable appearances, inducing body ownership illusions (BOIs) despite discrepancies between the virtual and physical body. BOIs show potential for musculoskeletal rehabilitation by modulating biopsychosocial factors

that limit engagement in exercise therapy, such as pain, kinesiophobia, and altered body perception. This may allow earlier or more intensive participation in therapeutic exercise. However, the application of BOIs in musculoskeletal rehabilitation remains underexplored, and available VR solutions for lower-limb rehabilitation are limited. Existing systems primarily support single-joint exercises and often require additional body-worn sensors for motion tracking. Therefore, we aim to develop a VR solution enabling avatar embodiment with real-time, sensorless motion tracking during complex, multi-joint lower-limb exercises.

**Methods:** The innovation was developed using commercially available hardware, including Meta Quest 3 VR headsets, Orbbec Femto Bolt cameras for real-time motion tracking, and a high-performance personal computer. The software environment was developed using a Unity real-time 3D development platform. The developed system supports markerless vision-based real-time motion tracking and enables avatar embodiment with visual manipulation of knee appearance, including perceived swelling and altered coloration. Selected multi-joint lower-limb exercises are currently supported.

**Results:** The system successfully enables real-time motion tracking during squats, lunges, and sit-to-stand tasks, with avatar embodiment and adjustable visual manipulation of knee appearance. Key technical challenges included motion tracking instability with body-segment misalignments, avatar jitter, forward leaning, and sensitivity to camera number, user positioning, and environmental factors. These barriers informed iterative refinements of calibration procedures and tracking configuration. Further technical details and system demonstrations will be presented.

**Conclusions:** Future development will focus on improving tracking robustness and expanding BOI manipulations, including limb narrowing, enhanced muscular definition, altered material properties, and manipulation of movement-related feedback (e.g., range of motion). These developments aim to support personalized VR-based rehabilitation and facilitate long-term clinical applicability.

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### NeuroXRehab COST Action extended reality neurorehabilitation of spatial neglect and related disorders after brain injury

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**Vision:** Imagine being able to assess different subtypes of spatial neglect, such as motor or sensory neglect, and to distinguish these from related conditions like hemianopia using extended reality (XR). Based on this precise assessment, patients could receive personalised XR-based treatment programs targeting spatial neglect and co-occurring disorders such as hemiplegia. After discharge, therapy would continue seamlessly through telerehabilitation, enabling more intensive, flexible, and efficient recovery supported by remote clinical monitoring.

**Mission:** COST (European Cooperation in Science and Technology) is an EU-funded programme supporting interdisciplinary collaboration. NeuroXRehab is a newly established COST Action uniting neuropsychologists, clinicians, engineers, computer scientists, and rehabilitation experts. Its mission is to explore how XR can enhance the assessment and treatment of spatial neglect (SN) and related post-stroke disorders, foster knowledge exchange, develop guidelines, and promote innovation in neurorehabilitation.

**Working Groups**

**WG1: Meta-Study on Current Knowledge** Collects theoretical, empirical, technical, and clinical expertise and surveys XR technologies relevant to assessing and treating SN and related disorders.

**WG2: Assessment of SN and Related Disorders** Develops XR-based assessment methods to improve diagnostic accuracy, differentiate SN from related conditions, and establish common data elements for harmonised assessment.

**WG3: Treatment of SN and Related Disorders** Standardises XR-based treatment approaches and translates conventional and novel therapies into adaptable XR interventions for individualised rehabilitation.

**WG4: Data Collection and Sharing** Defines data policies, best practices, and ontologies, and develops a secure platform to support data sharing for multicentre studies on diagnostics and treatment efficacy.

**WG5: Multicentre Project Planning** Designs study protocols, objectives, and methodologies for future multicentre research evaluating the diagnostic and therapeutic potential of XR in SN rehabilitation.

**Contribute:** NeuroXRehab welcomes engaged and curious contributors who wish to support its mission and help advance XR-based neurorehabilitation.

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### Stroke mortality prediction for virtual rehabilitation: An explainable AI approach

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**Background:** Stroke remains the second leading cause of death globally, with over 7.25 million deaths recorded in 2021.

Effective post-stroke rehabilitation requires early identification of high-risk patients to guide intervention intensity and timing. This study presents an explainable artificial intelligence (XAI) framework for stroke mortality prediction across multiple time horizons, developed for integration into the virtual rehabilitation platform of the Centre for Immersive Technologies and AI Development (Braining) to enable early identification of patients at elevated risk for targeted rehabilitation planning.

**Methods:** Using data from 1,513 stroke patients in the MIMIC-IV dataset, a multi-task multilayer perceptron was trained to predict mortality probability at 1, 15, 30, 45, 60, and 90 days post-admission. The model incorporates demographic data, physiological variables, and feature vectors extracted from a novel clinical text processing pipeline combining named entity recognition and semantic clustering.

**Results:** The model achieved an average AUC-ROC score of 0.789 across all time points, reflecting how the multi-task architecture exploits the inherent relationships among mortality risk across time horizons, allowing earlier time points to inform predictions at later ones. Explainability analysis using SHAP and LIME consistently identified lower dosages, older age, and non-white race as associated with higher mortality risk.

**Conclusion:** By generating interpretable, time-varying risk trajectories, this system enables clinicians using Braining's platform to prioritise rehabilitation resources, personalise intervention intensity, and support informed care planning for stroke patients during critical recovery windows.

### *P07*

### Postural adaptation to a virtual reality roller coaster ride among young and older adults – indications for fall prevention and rehabilitation

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**Background:** Previous research suggests that virtual reality (VR) can serve as an effective tool for evaluating and training postural control responses and its processing due to distorted sensory input. The aim was to evaluate posturographic spectral responses and postural muscle co-contraction due to visual VR-stimulation, and adaptation to repeated VR-stimulations among young and older adults.

**Methods:** Twenty-eight young (mean 25.3 years) and 25 older (mean 74.8 years) adults were standing on a force plate performing two control tests (eyes open and closed) and thereafter repeatedly watched a 120-second VR-simulation of a roller-coast ride five times. Postural sway was analyzed as stability measures from force plate data. Electromyography was used to assess co-contraction index (CCI) among three muscle pairs: i) gastrochnemius-tibialis anterior, ii) peroneus-tibialis anterior, and iii) gluteus medius bilaterally. Repeated measures GLM ANOVA, Wilcoxon and Spearman's correlations were used for statistical analyses.

**Results:** The first VR session produced significantly increased use of energy within both the high frequency (>0.1 Hz) and low frequency (< 0.1 Hz) ranges compared to control test with open eyes. This was more pronounced among older adults. Mean and standard deviation CCI of the three muscle pairs were positively correlated with both increased high and low frequency postural sway. Performing repeated VR-sessions significantly decreased energy used within the high frequency range and the CCI in both groups.

**Conclusions:** Older adults showed more pronounced reliance on somatosensory reflexes and mechanical stiffness during VR-stimulation, indicated by larger energy use within the high frequency range and with larger CCI measures. Both groups showed significant adaptations over repeated sessions. This ability to adapt to visually induced sensory conflicts over repeated VR sessions indicates its potential role in balance training and fall prevention. This should be investigated in future longitudinal intervention studies.

The study was funded by Lions Skane research foundation.

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### ROHKEA VR: Implementing a home-based immersive Virtual Reality-Cognitive Behavioural Therapy (VR-CBT) intervention for chronic pain

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**Background:** ROHKEA VR is a 12-week Cognitive Behavioural Therapy (CBT) and graded exposure program designed as a scalable, home-based alternative to hospital-delivered multidisciplinary pain management. Delivered through immersive virtual reality, the intervention aims to address well-documented implementation barriers in chronic pain services, including limited workforce capacity, geographic inequities, patient fatigue, and inconsistent attendance. By embedding structured psychological care within an accessible digital platform, ROHKEA VR represents a service innovation targeting reach, feasibility, and sustainability.

**Methods:** This qualitative study explored implementation-related factors influencing acceptability, engagement, and perceived impact among six participants living with chronic illness. The program features SAMI (Semi-Automated Mentoring Intelligence), a digital avatar whose role evolves from directive instructor to supportive, relational guide. Participants described SAMI as central to intervention uptake, with the developing therapeutic alliance enhancing adherence to treatment. The relational design appeared to function as an implementation mechanism, strengthening user engagement and reducing attrition risk in a fully remote format.

**Results:** Interpretative Phenomenological Analysis generated four themes with implementation relevance. First, Acceptability and Therapeutic Alliance: SAMI's personable and responsive characteristics fostered trust and psychological safety, supporting sustained participation. Second, Mechanisms of Change and

Psychological Flexibility: participants reported shifts from avoidance to acceptance and values-based coping, indicating fidelity to core CBT processes within a digital modality. Third, Self-Regulation and Agency as Intervention Targets: immersive VR contexts enabled attentional retraining and threat reappraisal, reinforcing skill acquisition. Fourth, Feasibility and Habit Formation: the program's structured daily routine supported behavioural consistency and transfer of skills to real-world settings, highlighting potential for long-term maintenance.

**Conclusion:** Participants also noted improved communication about pain within family systems, suggesting broader contextual impact. Framed through an implementation science lens, ROHKEA VR demonstrates promise as an acceptable, feasible, and potentially scalable digital health model capable of extending evidence-based pain care beyond traditional hospital environments while preserving therapeutic alliance and treatment integrity.

**Funding:** Torbay Medical Research Fund.

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### Validating XR-Compatible Affective Sensing for Objective Detection of Chronic Pain During Activities of Daily Living

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**Background:** Eye tracking and facial biosignal monitoring are core behavioural sensing features within virtual and extended reality (XR) systems, enabling inference of attention, affect and user state. However, these sensing components are rarely validated independently in clinical populations outside immersive environments. This validation study translates XR-compatible affective sensing hardware into a real-world rehabilitation context to determine its capacity to detect behavioural indicators of chronic pain during activities of daily living (ADLs). A secondary aim is to evaluate user experience, comfort and perceived usability to determine clinical practicality and acceptability.

**Methods:** This cross-sectional validation study is currently recruiting 10 adults (≥18 years) with diagnosed chronic pain. Participants complete two standardised ADLs within a simulated occupational therapy ADL suite. OCOsense™ smart glasses capture multimodal behavioural data including facial EMG activation, optomyography-derived expression metrics, head movement, postural orientation and attentional indices. Sessions are video-recorded (SMOTS system), and trained clinicians rate observable pain behaviours using a structured scoring framework. Data streams are time-synchronised. Primary analysis will examine concordance between wearable-derived metrics and clinician ratings using correlation and agreement statistics. Participants complete validated pain measures (VAS, TSK-11). A qualitative component, consisting of brief post-task semi-structured interviews and comfort/usability ratings, will explore device wearability, perceived burden and acceptability.

**Results:** Data collection is ongoing. At presentation, agreement statistics between XR-derived behavioural metrics and clinician-rated pain behaviours will be reported alongside feasibility indicators (signal stability, calibration success). Preliminary thematic analysis of user feedback will describe comfort, usability and perceived clinical relevance.

**Conclusions:** By validating XR-compatible behavioural sensing technology in a real-world clinical context and evaluating user acceptability, this study informs the credibility and translational potential of eye and facial tracking as objective components within immersive and hybrid XR pain rehabilitation systems.

**Acknowledgement:** Elizabeth Casson Trust pump-primer award.

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### Feasibility of active video games to promote physical activity in children and youth isolated post bone marrow transplant: A feasibility study

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**Background:** Children and youth recovering from a bone marrow transplant can experience significant deconditioning due to prolonged bed rest and treatment side effects. Active video games (AVGs) have shown promise in pediatric rehabilitation by increasing motivation to participate in longer durations of therapy, yet the feasibility of using this modality in medically fragile populations remains unexplored. This study evaluated the clinical feasibility (demand, satisfaction and practicality) of using the Nintendo Switch within physiotherapy and occupational therapy interventions for children and youth in isolation following bone marrow transplantation.

**Methods:** This six-week feasibility study was conducted in the in-patient hematology-oncology unit at CHU Sainte-Justine, Quebec's provincial pediatric stem cell transplant centre. The unit was provided with a medical-grade chariot hosting a television screen, the Switch console and games and accessories. Physiotherapists and occupational therapists received a two-hour in-person training session, access to virtual educational resources, and ongoing virtual support. Data were collected through demographic questionnaires, therapist logbooks, a satisfaction questionnaire, and semi-structured interviews. Descriptive statistics summarized usage and satisfaction while qualitative content analyses synthesized therapist-identified facilitators and barriers.

**Results:** Eight therapists (5 physiotherapists, 3 occupational therapists) used the Nintendo Switch 12 times with 10 children (mean age 10.5, range 5–16 years). Mean session duration exceeded 45 minutes. Clinician satisfaction was high (mean 6.67/7). The most frequent treatment objectives were preventing deconditioning (29.4% of sessions) and promoting motivation (23.5% of sessions). All therapists reported positive impressions and intent to continue using the Switch. The primary barrier was infection prevention and control protocols, while the primary facilitator was increased youth adherence to therapy.

**Conclusions:** Integrating the Nintendo Switch into physiotherapy and occupational therapy interventions in a bone marrow transplant unit is feasible and well-received by clinicians. Next steps include exploring children's and parents' perspectives and conducting effectiveness studies comparing exergaming to traditional approaches.

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**Feasibility of a revised home-based serious game cognitive training system TREKOG in elderly**

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**Background:** Global population aging is projected to result in adults aged 65+ outnumbering children by 2080. As aging is closely linked to cognitive decline, pharmacological treatments remain limited, non-pharmacological options such as cognitive training are crucial. Additionally, home-based, self-administered approaches address mobility and access barriers. This study evaluates the feasibility of the TREKOG training system.

**Methodology:** TREKOG is a cognitive training system developed specifically for the elderly population (presented at the World Conference on Virtual Rehabilitation 2024). The software has been updated by adding features such as new minigames and strategy-based education. It is a self-administered serious game made for home-based cognitive training that includes tasks focused on memory, attention, visuomotor coordination, and other cognitive domains in an ecologically valid, immersive environment of an apartment building. A group of 30 cognitively healthy older adults will participate in a home-based cognitive training programme using TREKOG. Feedback will be collected using questionnaires assessing acceptance, overall experience, subjective cognitive state, and well-being. Cognitive state will also be assessed before and after the programme using neuropsychological tests focused on multiple cognitive domains and general cognitive health. Results will be analysed to evaluate the feasibility of the updated tool and protocol.

**Results:** The results will include feedback on the acceptability of TREKOG, overall experience and preliminary effects on cognitive domains measured by neuropsychological tests, well-being and subjective cognitive state.

**Conclusion:** This study will provide insight into participant engagement, acceptability and key feasibility aspects supporting the use of the updated TREKOG training system for home-based cognitive training in community-dwelling older adults. The results will serve as foundation for subsequent effectiveness studies of the TREKOG training system.

The TREKOG software was created in the project PoC of commercialisation concepts formulated by ILA II CZ.07.1.02/0.0/0.0/16_040/0000369 and the project OP JAK entitled Research of Excellence on Digital Technologies and Wellbeing, CZ.02.01.01/00/22_008/0004583 co-financed by the European Union.

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**What do clinicians tell us about their use of telerehabilitation and associated ethical and equity-related considerations? Findings from a national rehabilitation clinician survey in Canada**

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**Background:** Telerehabilitation has expanded rapidly in Canada, accelerated by the COVID-19 pandemic. While it offers opportunities for access, it also raises ethical challenges. This study assesses clinicians' usage of telerehabilitation across professions, including practices related to key ethical considerations such as equity, confidentiality, consent and risks.

**Methods:** A cross-sectional national survey was completed by 683 rehabilitation clinicians across professions (physiotherapy, occupational therapy, speech-language pathology, psychology/neuropsychology, vision therapy, and audiology). Descriptive statistics were used to summarize responses and we examined associations between professions and practice-related outcomes using cross-tabulations with Pearson's chi-square tests.

**Results:** A majority of clinicians used telerehabilitation (83%), with 77% who began using it during the pandemic. 69% used a hybrid approach (combining in-person and remote care), while 31% exclusively used telerehabilitation . Nearly 70% reported access barriers from lack of internet, equipment, or patient digital literacy. 30% did not use specific measures to ensure data confidentiality. 73% said that they were unable to perform procedures they normally conduct in person. Only 23% of respondents felt adequately trained for telerehabilitation, raising concerns about quality, efficacy and safety. While the vast majority of respondents did not feel patients sustained harm, 8.1% reported harm to a patient during telerehabilitation. Significant differences emerged by profession across multiple domains, including telerehabilitation uptake, perceived effectiveness, barriers, workload, and future use. Speech-language pathologists and occupational therapists showed higher adoption of telerehabilitation, while physiotherapists reported lower uptake and greater concerns about client suitability. Perceived effectiveness also varied significantly, with physiotherapists most likely to view telerehabilitation as less effective than in-person care.

**Conclusion:** Our research highlights practice-related issues in telerehabilitation, including ethical considerations, shaped in part by professional role and scope of practice. Findings underscore the need for profession-sensitive ethical guidance, standardized privacy practices, equity-focused implementation tools, and formal training to support safe and just telerehabilitation.

**Funding:** Canadian Institutes of Health Research and Canadian Medical Association, Réseau provincial de recherche en adaptation-réadaptation.

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**Co-development of a virtual reality software focused on service encounters for people living with aphasia**

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**Background:** Following stroke, communication disorders such as aphasia can significantly limit social participation, particularly in everyday service interactions that remain difficult to address in therapy. To better support real-world communication goals in rehabilitation, our team is developing a virtual reality (VR) tool for clinical use. Building on a prior needs assessment with people living with aphasia and speech-language pathologists, this study aims to define user-driven design specifications for VR scenarios supporting everyday interactions in rehabilitation.

**Methods:** This study is part of a broader user-centered project guided by a Design Thinking process (needs assessment → co-design → prototype development → clinical testing) to develop a VR tool for aphasia rehabilitation. We describe the co-design phase conducted at the Lucie-Bruneau Rehabilitation Centre (Canada). Five adults with aphasia and two speech-language pathologists participated in focus groups. Participants were divided into two groups; each attended two sessions to generate and refine VR scenarios. The primary outcome is a set of user-driven design specifications for a VR rehabilitation tool. Audio recordings were transcribed verbatim and will be analyzed using qualitative descriptive analysis with QDA Miner.

**Anticipated results:** The present co-design phase will identify priority environments for practice (e.g., restaurant), user goals, and desired scenario content. For each stage of an interaction, from entering to exiting an environment, participants will specify communication tasks to practise and therapeutic targets. The study will also document preferred strategies, stressors (e.g., noise, time pressure), and desired feedback following practice. These findings will generate detailed, user-informed design specifications to guide prototype development of a VR tool adaptable to different aphasia profiles and suitable for integration into speech-language rehabilitation.

**Conclusion:** This study will generate user-driven design specifications that will inform the next stages of prototype development and clinical testing of a VR tool intended to support social participation goals in speech-language rehabilitation.

**Funding:** Invent_T, Université de Montréal.

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**Usability and acceptability of home-based virtual reality physiotherapy system for people with knee osteoarthritis in the Saudi Arabian context**

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**Background:** Knee osteoarthritis (KOA) is a joint condition that affects quality of life, and exercise is a cornerstone of its management. Saudi people with KOA report many challenges to exercise adherence, mainly a lack of motivation and accessibility issues. A virtual reality (VR)-based physiotherapy system could be a promising solution; however, its usability and acceptability in this context are still unknown. This mixed-method study evaluates the usability and acceptability of a VR-based physiotherapy system (ArSPIN-VR) as a promising exercise tool for people with KOA in Saudi Arabia

**Methods:** A mixed-methods study design was employed, including a think-aloud usability session with the ArSPIN-VR system, followed by standardised questionnaires and a semi-structured post-test interview. Quantitative data from the Arabic System Usability Scale (A-SUS), the Arabic VR System Usability Questionnaire (A-VRSUQ), and the Arabic Technology Acceptance Model (A-TAM) were analysed using descriptive statistics. Qualitative data from think-aloud sessions were analysed using content analysis, and post-test interviews were analysed using thematic analysis.

**Results:** Twenty-eight participants with KOA (mean age 61.1 ± 12.8 years) demonstrated good system usability (A-SUS: M = 72.3, SD = 5.0) and above-average VR-specific usability (A-VRSUQ: M = 71.4, SD = 13.7). Additionally, a high technology acceptance was reported, with all A-TAM subscales substantially above the midpoint (ease of use: 5.72; usefulness: 6.20; intention to use: 6.04 out of 7). Qualitatively, the participants highlighted enjoyment, motivation, and pain distraction as key benefits, alongside sensor reattachment difficulty and technical instability as primary barriers.

**Conclusions:** This study demonstrates that a home-based VR physiotherapy system (ArSPIN-VR) is both usable and acceptable for people with KOA in Saudi Arabia. The challenges and recommendations identified also reflect broader issues in implementing VR rehabilitation across diverse healthcare settings. Following targeted technical refinements, future research should progress to randomised controlled trials to establish clinical efficacy across diverse populations.

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**Assessment of cervical reaction acuity in patients with axial spondyloarthritis (axSpA) using virtual reality (VR): A cross-sectional study**

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**Background:** Axial spondyloarthritis (axSpA) is a chronic inflammatory rheumatic disease affecting the spine and sacroiliac joints, leading to pain, stiffness, reduced mobility, and disability. While range of motion impairments are well documented in axSpA, less is known about cervical sensorimotor functions, including movement reaction time, velocity and acuity. The aim of this study was to assess cervical sensorimotor function in axSpA using a VR-based Cervical Reaction Acuity (CRA) test, its associations with disease-related measures, and test–retest reliability.

**Methods:** This cross-sectional study included adults aged 18–65 years with axSpA (n=49) and age-matched healthy controls (n=50). The CRA test was used to measure cervical reaction time, peak velocity, and task completion time. Group differences were analysed using Quade's non-parametric ANCOVA. Associations between CRA outcomes and disease-related measures were examined using Spearman's rank correlations. Test-retest reliability of the CRA test was evaluated in the axSpA group using intraclass correlation coefficients (ICC).

**Results:** Participants with axSpA demonstrated significantly lower peak velocity compared with healthy controls ($p < 0.001$, partial $\eta^2 = 0.17$). No significant group differences were observed for reaction time or task completion time ($p > 0.10$). Associations between CRA outcomes and disease-related measures were low to moderate ($r_s = 0.30–0.52$, $p < 0.05$), with the strongest relationships observed for functional and mobility measures. Test–retest reliability varied across outcomes: peak velocity showed good reliability (ICC = 0.89), task completion time moderate reliability (ICC = 0.74), and reaction time poor reliability (ICC = 0.22).

**Conclusions:** Cervical sensorimotor function, particularly movement velocity, appears impaired in axSpA. The VR-based CRA test shows promise as a complementary assessment tool for identifying motor control impairments not captured by traditional clinical measures. These findings support further investigation of VR-based assessments in axSpA and its potential role in rehabilitation interventions.

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### Virtual reality–based cervical sensorimotor assessments demonstrate discriminative ability between individuals with chronic traumatic neck pain and asymptomatic controls

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**Background:** Impaired sensorimotor function is common in people with traumatic neck pain. Sensorimotor assessments are important for identifying dysfunction, guiding interventions, and evaluating outcomes, yet feasible objective assessment methods remain limited. Virtual reality (VR) offers a potential solution; therefore, the aim of this study was to (i) investigate VR-based sensorimotor tests' ability to discriminate individuals with chronic traumatic neck pain (CTNP) from asymptomatic controls (CON), and (ii) to examine the VR-tests' association with neck pain, disability, and fear of movement in the CTNP group.

**Methods:** This cross-sectional study included 103 participants aged 18–65 (55 CTNP, 48 CON). Participants completed VR-based cervical sensorimotor tests (range of motion, movement sense, joint position sense, postural sway, and cervical reaction acuity test). Orthogonal projections to latent structures – discriminant analysis (OPLS - DA) was used to analyze the ability of the VR variables to differentiate between groups. OPLS regressions were used to analyze associations between VR variables and neck pain, disability and fear of movement.

**Results:** The OPLS-DA model ($R^2Y = 0.34$, $Q^2 = 0.27$) indicated that 34% of the variance in group membership was explained, with a predictive ability of 27%. CTNP was characterized by reduced range of motion, impaired movement sense, increased postural sway, lower movement velocity, and longer task completion time. A weak OPLS model suggested that higher neck disability was associated with reduced range of motion, greater postural sway, and higher age. No valid models were identified for neck pain or fear of movement.

**Conclusions:** VR-based assessments show promise as objective method for identifying sensorimotor impairments and may support clinical decision-making. The weak associations between VR tests and neck disability highlight the need to complement assessment with self-reported measures to capture the multidimensional nature of neck pain.

### *P36*

### Electroencephalography indices variation in immersive virtual reality for the upper limb

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**Background:** Post-stroke fatigue affects up to 40% of people with stroke, caused by stress, poor motivation, physical exercise and cognitively demanding tasks. Real-time fatigue detection can improve quality of life and reduce its impact on recovery. A system that can monitor fatigue associated with exercises could enable rehabilitation optimisation and personalisation, consequently maximising recovery. Electroencephalography (EEG) is a promising objective method for determining fatigue, due to its non-invasive nature, sensitivity to brain-state changes and high temporal resolution.

This study developed and tested a fatigue-inducing, custom upper limb, immersive virtual reality (IVR) game involving continuous arm movements, using a real-time adaptive EEG, exploring how the fatigue index (FI) and Engagement index (EI) vary across cortical locations.

**Methodology:** Fifteen healthy participants (5 females; aged 30 ± 5.9 years; 13 right-handed) simultaneously wore a Meta Quest 2 VR headset and g.*tec's* Unicorn 8-channel EEG headset. Data were acquired at 250 Hz from Fz, C3, Cz, C4, Pz, PO7, Oz and PO8, referenced and grounded at the left and right mastoids, respectively. Power spectral density was extracted using Welch's method with a 500-sample Hanning window and 50% overlap. Relative power was computed for theta (4 – 8 Hz), alpha (8-13 Hz) and beta (13-30 Hz) bands. The FI was calculated by the formula $(\theta+\alpha)/\beta$; the EI as its inverse $\beta/(\theta+\alpha)$.

**Results:** Friedman tests revealed significant variation across EEG channels for FI ($\chi^2 = 58.00$, $p < 0.001$) and EI ($\chi^2 = 58.00$, $p < 0.001$, $X = 0.637$). Higher FI was observed in the frontal region, due to elevated theta activity associated with fatigue monitoring. EI was elevated in the parieto-occipital region, resulting from increased beta activity caused by high visual processing demands of IVR.

**Conclusion:** EEG mental indices vary across cortical locations and can inform electrode placement for real-time adaptive VR rehabilitation systems.

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### A fatigue-responsive real-time adaptive brain-computer interface for virtual rehabilitation

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**Background:** Upper Limb (UL) Rehabilitation after stroke requires repetitive movements that can cause monotony, increase fatigue and reduce adherence. Rehabilitation gamification has improved outcomes but not adequately addressed personalisation. Typical virtual reality (VR) games do not allow for dynamic adaptation based on individual's neurophysiology, to inform personalised engagement. This research proposes a real-time Electroencephalography (EEG) system that adapts VR game difficulty based on fatigue index (FI).

**Methodology:** An adaptive system featuring a passive Brain-Computer interface (pBCI) with a custom immersive VR game requiring repetitive UL movements was developed. EEG signal was acquired at the Fz location, using g.tec's 8-channel EEG headset and filtered online with 50 Hz notch and 0.5–60 Hz bandpass filters. Butterworth filters from g.tec's Hi.SyS system were used to filter theta + alpha (4–13 Hz) and beta (13–30 Hz) frequency from Fz in real-time, using Simulink, Matlab 2020a. The FI ((theta+alpha)/beta) was calculated as the ratio of successive two-minute averages over a ten-minute period. Percentage changes between these ratios were evaluated according to predefined thresholds and sent via User Datagram Protocol to Unity, triggering difficulty changes.

This was tested in fifteen participants who completed the system usability scale (SUS) questionnaire.

**Results:** The gaming difficulty was successfully adapted in six participants, with four experiencing an increase, one a decrease and one, an increase and then decrease. The individual variations support the case for personalised adaptive systems in rehabilitation. The SUS score had a "good" rating by participants (mean± SD: 79.7 ± 10.9). A barrier of the system is the discrepancy in expected and observed changes in difficulty levels, perhaps due to shorter time windows.

**Conclusion:** The system demonstrates that a real-time adaptive EEG-VR system is feasible for rehabilitation. Future work will investigate various time windows to optimise adaptation sensitivity and clinical validation in people with stroke.

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