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Original Research

Experiences of People With Persistent Nonspecific Neck Pain Who Used Immersive Virtual Reality Serious Games in the Home Setting: A Qualitative Study

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ABSTRACT

Objective. The purpose of this study was to explore the experiences of individuals with persistent nonspecific neck pain who used immersive virtual reality (VR) serious games at home for 2 weeks.

Methods. In this descriptive qualitative study, semi-structured one-on-one interviews were conducted at the participant's home after the 2-week period. Interviews were analyzed using qualitative content analysis. Sample size was determined using the information power concept (where "information power" refers to the amount of relevant information the sample provides for addressing the research question).

Results. Eleven adults with continuous or recurrent nonspecific neck pain participated in the study. Three main categories were identified. The first revolves around the home environment, revealing that participants had mixed perceptions about being at home, yet held a positive perspective on the utilization of immersive VR in that setting. The second pertains to immersive VR as a novel technology, indicating its overall comfort, user-friendliness, and varying degrees of immersion and presence experienced by the participants. The third focuses on exercising in immersive VR, drawing comparisons with conventional exercises, exploring the facilitators and barriers to usage, and addressing various aspects of integrating this technology into rehabilitation.

Conclusion. Immersive VR was deemed comfortable for almost all participants and easy to use. Participants found exercising in immersive VR motivating and enjoyable, compared to conventional exercises. The home environment proved suitable for using immersive VR, though challenges included autonomy and reduced human contact. Participants highlighted facilitators and barriers in using immersive VR serious games, as well as immersive VR's rehabilitation potential. They also underscored the crucial role of physical therapists for guidance, remote supervision, and personalized treatment.

Impact. These findings could help clinicians to better understand the experiences of individuals with persistent nonspecific neck pain when using immersive VR, as well as its use at home. This understanding can improve patient care and optimize the effectiveness of immersive VR as a treatment method.

Keywords: Exercise, Neck Pain, Physical Therapy, Qualitative, Virtual Reality

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INTRODUCTION

Neck pain is a prevalent musculoskeletal disorder, peaking in middle-aged adults and more common in women.[1] It ranks among the leading causes of disability in adults worldwide and imposes a significant societal and economic burden.[2,3] When the origin of pain is unknown, as is the case in most instances, neck pain is typically classified as "nonspecific."[4] Nonspecific neck pain (NSNP) has a poor prognosis after the initial few weeks, leading to incomplete recovery and high recurrence and persistence rates.[4–9] The current evidence for managing persistent NSNP supports the use of exercises, whether in clinical or home settings.[8,10–12]

Immersive virtual reality (VR), among other technologies, has recently emerged as an innovative method of rehabilitation for various musculoskeletal disorders, showing promising results.[13] Immersive VR refers to technology that creates an immersive experience within a 3-dimensional virtual, computer-generated world, typically achieved through the use of a head-mounted display.[14] Immersive VR has been studied for several years in the context of managing persistent neck pain, primarily involving exercises to improve range of motion, sensorimotor control, and cervical movement speed and accuracy.[15–21] It mainly relies on the use of serious games, defined as "*games that allow players to achieve a specific purpose using the entertainment and engagement component provided by the experience of the game*."[22] Serious games provide patients with the ability to play games and manage their conditions independently, reducing the need for supervision by a physical therapist and making it feasible for home use.[13] An increasing number of randomized clinical trials have been published and suggest that immersive VR is effective for persistent neck pain management, either as a standalone treatment or in combination with other interventions.[15–19]

According to the Evidence-Based Practice model, patient care decisions should consider the best available evidence, individual clinical expertise, and the patient's values, expectations, and preferences.[23] Considering the latter is crucial in individuals with persistent NSNP,[24] and this can be accomplished by exploring their experiences within the care process. Falsiroli Maistrello et al[24] argue for a greater integration of individual experiences into neck pain research, because capturing the patient's experience can be important for enhancing clinical effectiveness and delivering excellent patient-centered care.[25] If immersive VR is to be increasingly integrated into the management of persistent NSNP, there is a growing need for a deeper understanding of how individuals with persistent NSNP experience it. Exploring their experiences of using immersive VR at home can assist clinicians and researchers in developing, implementing, and optimizing home-based immersive VR rehabilitation. This approach can ensure alignment with patients' values, preferences, and expectations, promoting evidence-based practice and patient-centered care. Furthermore, recently published standards for the development of therapeutic VR interventions recommend engaging with patient end-users through human-centered design principles, such as patient interviews, as the initial step in the development of VR therapy.[26] Quantitative research assesses specific clinical outcomes but may not capture the intricate phenomena occurring during a patient's experience. Qualitative research helps analyze and understand experiences related to a particular phenomenon, offering insights into unexplored aspects of clinical practice, and facilitating the application of evidence-based interventions within a biopsychosocial framework.[27]

Despite the growing body of quantitative literature on using immersive VR for persistent NSNP management, there is a scarcity of qualitative studies exploring the experiences of using immersive VR serious games in individuals with persistent NSNP, whether or not at home. To our knowledge, only 3 studies have reported qualitative data on the experiences of individuals with persistent NSNP using immersive VR.[20,21,28] However, these studies were either supervised and conducted in a clinical setting[20,21] or had only 1 participant.[28]

Therefore, the research question for this qualitative study was: What are the experiences of individuals with persistent NSNP who used immersive VR serious games at home?

METHODS

Design

A generic qualitative research approach was chosen.[29,30] The study was influenced by constructivism, which posits that individuals develop their own subjective meanings of their experiences, and that knowledge is constructed through interactions between individuals and their environment, as well as between individuals and the researcher.[31] This study did not rely on any guiding theoretical framework.

The Consolidated Criteria for Reporting Qualitative Research (COREQ)[32] and the Standards for Reporting Qualitative Research (SRQR)[33] checklists have been used to ensure explicit and comprehensive reporting of this study.

The study received approval from the Ethics Committee of the Cliniques universitaires Saint-Luc and Université Catholique de Louvain (B4032021000109), was preregistered on ClinicalTrials.gov (NCT05244681), and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent before the commencement of the study.

Participants

Participants were eligible for inclusion if they met the following criteria: being an adult (age $\geq$ 18 years) residing in Belgium; experiencing continuous or recurrent NSNP (ie, neck pain grades I and II according to the Neck Pain Task Force classification[34]) for at least 3 months; having a low susceptibility to motion sickness, as determined by the Motion Sickness Susceptibility Questionnaire – Short version[35,36] and the Visually-Induced Motion Sickness Susceptibility Questionnaire[37]; fluency in the French language; not exhibiting signs of sensorimotor dysfunction or uncorrected vision problems; not being pregnant or deaf. Voluntary participants were recruited through non-probabilistic sampling methods (eg, social networks, public places, acquaintances of the research team, word of mouth, physical therapists, and physicians). Sample size was determined using the information power concept.[38] Information power refers to the amount of relevant information the sample provides for addressing the research question. The more relevant information the sample holds, the fewer participants are needed, and vice versa.[38] Information power is guided by 5 key criteria: the study aim (narrow or broad), the specificity of the sample (dense or sparse), the application of established theory, the quality of the dialogue between researchers and participants (strong or weak), and the sample variation (homogeneous or diverse).[38]

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Intervention and Procedures

The VR headset used in this study was the all-in-one Pico G2 4K (PicoXR, China). The immersive VR serious games were sourced from the Corpus VR Personal app (InMotion VR, the Netherlands). Corpus VR Personal contains a cervical range of motion self-assessment program, and 15 games designed for neck exercise and relaxation training.

After eligibility screening, an initial 1-hour meeting was held at each participant's home. During this meeting, participants provided written informed consent, received an explanation of the VR headset and app operation, and were given 2 manuals (written for the study) covering all discussed information, including technical issue resolution instructions. Over 2 weeks, participants used the immersive VR system in their homes without restrictions. Nevertheless, they were encouraged to use it for a minimum of 10 minutes on at least 4 days per week. While this usage recommendation was arbitrary, it was deemed sufficient to ensure that participants had a substantial experience to discuss during the subsequent semi-structured interview. Participants had full autonomy and could contact the lead investigator for guidance or assistance in case of equipment issues. Immediately after the 2-week period (or within a few days), a second meeting was scheduled to conduct the semi-structured interview.

Data Collection

Qualitative data were gathered through semi-structured one-on-one interviews to acquire a comprehensive understanding of the experiences.[39] In order to maintain consistency in data collection, all interviews were audio-recorded and conducted by the same investigator (A.L.), a 26-year-old male orthopedic manual therapist with 1 year of clinical experience and PhD student. At the inception of this study, he had no prior experience in qualitative research. However, he has completed various qualitative research courses, including practical sessions on interviewing and data analysis.

Depending on participants' responses, exploratory or clarifying follow-up open-ended questions were posed as necessary. An inductive technique was employed by the investigator for conducting all interviews. It is noteworthy that the investigator had pre-existing relationships with 4 of the participants prior to the initiation of the study, including 1 relative, 1 friend, and 2 distant acquaintances.

An interview guide was developed in 2 phases. The first phase involved a comprehensive literature review and the second engaged 10 experts from various fields (ie, physical therapy, health research, engineering, and psychology) to identify the most critical aspects to explore in-depth when investigating the experiences of using immersive VR serious games at home in individuals with persistent NSNP. The interview guide, translated into English, is provided in Table 1.

Data Analysis

Semi-structured interviews were analyzed using qualitative content analysis as outlined by Elo and Kyngäs (2008).[40] Qualitative content analysis is a qualitative research method with the aim of providing a condensed and comprehensive description of the phenomenon under investigation, resulting in the development of categories that describe this phenomenon.[40]

The first 4 steps were done by the same investigator (AL). First, interviews were transcribed verbatim in Microsoft Word and de-identified to ensure anonymity and confidentiality. Second, each transcript was read and reviewed several times to immerse in and gain a thorough understanding of the data. Third, open coding of each transcript using an inductive approach was performed for the first time in Microsoft Word.[40–42] Fourth, the coded transcripts were imported into NVivo, version 20.6 (QSR International Pty Ltd) to facilitate the generation of initial categories (ie, topic summaries expressing the manifest content) through the grouping of similar codes.[41,43] The lists of categories were then organized into higher-order categories. These categories were assigned content-characteristic names and grouped into main categories. Fifth, 4 researchers (1 experienced and 3 novice qualitative researchers) read 1 or 2 transcripts to extract the main ideas (triangulation). Sixth, another open coding, grouping, categorization, and abstraction process was carried out based on the researchers' feedback and discussions among the research team, to obtain the final results.

The analysis was deliberately kept at an explicit level, as the aim was to provide a rich description of the data with a low degree of interpretation and a high level of abstraction, prioritizing the manifest content (ie, focusing on what the data say) rather than delving into latent content (ie, interpreting the underlying meaning of the text).[41,42]

The analysis process followed an iterative approach (ie, ongoing back-and-forth movement between the raw data, codes, and categories, with frequent reviews).

Table 2 provides an overview of the methods employed in the design and conduct of the study to enhance the trustworthiness of the data.[40–42,44–46]

Given the constraints of word limit in this manuscript, we are unable to provide an exhaustive description of the methodology used in our study while fully adhering to the SRQR and COREQ checklists. For a more detailed description and explanation of the methodology (such as characteristics and reflexivity of the lead investigator, and justification for the research design, sample size, and data analysis), please consult the Supplementary Appendix.

Compliance With Trial Method

Initially, the research intended to employ a thematic analysis, but after careful consideration and comparison of several methodologies, it was deemed unsuitable for addressing the research question. This is because it requires a higher level of interpretation by examining latent content along with manifest content. Given that the primary goal was to analyze manifest content exclusively, a more fitting approach was found in qualitative content analysis, as explained in detail in the Supplementary Appendix.

Role of the Funding Source

The funders played no role in the design, conduct, or reporting of this study.

RESULTS

Flow of Participants Through the Study

Eleven participants were interviewed between June 2022 and December 2022. The median age was 43.5 years (range: 24–64 years), and 7 of them were female. Participants came from various occupations, employment statuses, and geographical locations. The duration of NSNP varied from 15 months to

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Table 1. Semi-Structured Interview Guide

Topics	Questions
Introduction	1) Could you start by telling me a bit about yourself? 2) What experiences have you had with immersive virtual reality (before this one)?
General experience	3) How have you used the immersive virtual reality serious games at home? 4) Can you tell me about your experience with using immersive virtual reality serious games at home?
Cervical range of motion self-assessment	5) What do you think about the possibility of assessing your cervical range of movement by yourself?
Immersive virtual reality serious games	6) What was/were your favorite game(s)? Why? 7) Which game(s) did you like least? Why? 8) How immersed did you feel in the games when you were using them? 9) Do you think that using games has benefited you or could benefit you in any way? Why? 10) What do you think is/are the aim(s) of using these games in immersive virtual reality? 11) Would you like to be able to adjust the difficulty of the games as you progress? Why? How?
Usability and acceptability	12) What do you think of wearing the virtual reality headset? 13) How easy was it to navigate the virtual reality headset menus and play the games?
At-home implementation	14) How would you describe using the virtual reality headset (and games) at home? • What do you think are the advantages of using the virtual reality headset (and games) at home? • What do you think are the disadvantages of using the virtual reality headset (and games) at home?
Adherence to usage recommendations	15) Were you able to comply with the usage recommendations, which were to use the games for at least 10 minutes, 4 days a week? If not, why? • What do you think has facilitated using the games at home? • What do you think have been the barriers to using the games at home?
Perspectives	16) If you could change (remove or add) anything to the games, what would it be? 17) Would you recommend using immersive virtual reality serious games at home for other people with neck pain? Why?
Final questions	18) Before ending the interview, would you like to add anything else about the games or their use at home (eg, particular experiences)? Are there any important subjects that we haven't covered yet? 19) How did you experience the interview?

more than 20 years. Seven and 4 individuals had recurrent and continuous NSNP, respectively. Five participants had prior experience with immersive VR, but none in a rehabilitation context. Participant characteristics are presented in Table 3.

Ten interviews were conducted face-to-face at the participant's home, and 1 interview was conducted remotely via video call on Microsoft Teams. Interview durations ranged from 45 to 88 minutes (median of 54 minutes).

Main Findings

Three main categories were identified: "the home environment," "use of a new technology," "exercising in immersive VR." Each main category comprises several categories. Table 4 presents the main categories, categories, subcategories, and examples of associated codes identified through the inductive qualitative content analysis. The main categories, categories, and subcategories are illustrated using representative quotes from the participants in Table 5.

The Home Environment

Mixed Feelings of Being at Home

Being at home was perceived very positively by the participants, who highlighted numerous advantages. The main ones included timesaving (such as not having to travel to the physical therapist), fewer constraints, and the ability to perform exercises peacefully in the preferred location, at the preferred time, and in the preferred manner. While most participants found no disadvantages to being at home, 3 mentioned the loss of human contact that one might have with a physical therapist.

Autonomy was perceived positively by some and negatively by others. Some found it less restrictive and preferred to be autonomous, while others felt that being alone at home with no one to supervise the exercises could encourage procrastination and increase the risk of abandoning the VR headset or postponing sessions for an extended period. Several participants emphasized the importance of self-discipline when it comes to exercising; highlighting that it depends on the individual themselves.

Using Immersive VR at Home

Overall, participants used the games during their leisure time, primarily at the end of the day, in moments of relaxation after work. The use of immersive VR at home was generally viewed positively, with participants expressing that the VR headset was readily accessible, and exercises could be performed anywhere within their home. Some participants emphasized the importance of having a calm environment. However, being responsible for the maintenance and ensuring the equipment remains in good condition could be seen as a potential downside of using immersive VR at home by several participants.

Most participants used it alone, but some used it in the presence of others, engaging in conversation or simply being in the same room. According to their experience, using immersive VR went unnoticed by those around them, and the presence of other people did not seem to affect the performance of the exercises, although it might impact the feeling of immersion

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Table 2. Trustworthiness of the Data

Criteria	Techniques Performed and Application Procedures
Credibility	• Appropriate choice of the qualitative approach (generic) and method of data collection (individual semi-structured interviews) according to the aim of the study (ie, to investigate singular experiences of a particular phenomenon). • Interviews were conducted face-to-face at the participants' homes, fostering a relaxed and private conversation, in a well-known environment for them and an open non-judgmental atmosphere. • Interviews were audio-recorded and transcribed verbatim. • Sufficient amount of data obtained to answer the research question (according to the information power concept). • Report of representative quotes from the participants to illustrate the analysis process and results (Table 5). • Description of the principal investigator's background, qualifications, and experience, and acknowledgment of his role in the process of collecting, analyzing, and interpreting the data (Suppl. Appendix). • Translation of the original French quotes to English by an independent licensed translator to mitigate potential translation bias. • Dialogue among multiple researchers (with diverse qualitative research expertise and knowledge) about the main categories, categories, and subcategories (triangulation).
Transferability	• Thick descriptions of the study performed, providing details of the characteristics of the context in which the research was carried out, its setting, the researchers involved, the participants, and the data collection and analysis procedures (Suppl. Appendix). • Rich presentation of the findings and report of appropriate quotes (Table 5).
Dependability	• In-depth transparent descriptions of the analytic steps taken in the study (such as sampling strategies, eligibility criteria, data collection, and analysis procedures). • Backup records of raw data (recordings, field notes, transcripts) and other documents for each step of the analysis (open coding, grouping, categorization, abstraction, researchers feedback on transcripts). • Provision of the semi-structured interview guide in the manuscript (Table 1). • Demonstration of the process involved in generating subcategories, categories, and main categories (Table 4).
Confirmability	• Report of authentic quotes to point out from where or from what kinds of original data main categories, categories, and subcategories were formulated (Table 5). • Backup records of raw data (recordings, field notes, transcripts) and other documents for each step of the analysis (open coding, grouping, categorization, abstraction, researchers feedback on transcripts). • Demonstration of the process involved in generating subcategories, categories, and main categories (Table 4).
Authenticity	• Various experiences and rich description of the phenomenon under study by including a diversity in the sample (in terms of age, sex assigned at birth, professional status, prior immersive virtual reality experience, and type and duration of nonspecific neck pain).

Table 3. Characteristics of Participants

Participant ID	Sex[a]	Age (Y)	Profession/Occupation	Neck Pain Duration (Y)	Neck Pain Type	Prior Immersive Virtual Reality Experience (Yes/No)	Symptomatic During Study (Yes/No)
1	Male	30	Employed (human resources)	3	Recurrent	No	Yes
2	Female	26	Self-employed (psychologist)	1.25	Recurrent	Yes (gaming)	Yes
3	Female	48	Unemployed	10+	Recurrent	No	Yes
4	Female	25	Employed (logopedic)	2	Continuous	No	Yes
5	Female	55	Employed (university professor)	10+	Continuous	Yes (culture)	Yes
6	Female	28	Employed (client services)	10+	Recurrent	Yes (gaming)	Yes
7	Male	55	Employed (secondary school teacher)	Several[b]	Recurrent	No	No
8	Male	55	Employed (commercial agent)	Several[b]	Recurrent	No	Yes
9	Female	24	Student	4	Continuous	Yes (culture)	Yes
10	Female	64	Retired	10+	Continuous	Yes (culture)	Yes
11	Male	57	Self-employed (electrician)	20+	Recurrent	No	Yes

[a]Sex assigned at birth. [b]Participants were unable to give an exact duration.

and presence. Relatives had a positive perception of the fact that participants were using immersive VR at home. They found it funny, were curious, and some even took the opportunity to play the games, which they enjoyed.

Use of a New Technology

Hardware and Software

Wearing the VR Headset

All participants except 1 found the VR headset to be very comfortable, whether they wore glasses or not. Several participants mentioned that they didn't notice the weight of the VR headset and that they quickly forgot about it once it was well-adjusted and they were playing the games. However, comfort may have a time limit, as 1 participant mentioned that the VR headset remains comfortable up to a certain duration (around 30 minutes), after which it becomes uncomfortable.

Ease of Use

All participants found using the VR headset, controller, and application to be easy and intuitive. The explanations

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Table 4. Main Categories, Categories, Subcategories, and Examples of Associated Codes[a]

Main Categories	Categories	Subcategories	Codes
The home environment	Mixed feelings of being at home		Comfort of use at home
			Lack of human contact
	Using immersive VR at home		Headset readily accessible
			Appreciation of relatives
Use of a new technology	Hardware and software	Wearing the VR headset	Forgetting headset while playing
			Comfortable headset wear
		Ease of use	Easy to use
			Hard to find buttons
	Particularities of immersive VR	Parallel universe	Loss of sense of reality
			Parallel world
		Feeling of immersion and presence	Looking for physical contact
			Role of scenery in immersion
Exercising in immersive VR	Type of exercise		More stimulating than conventional exercises
			Motivation to do exercises in virtual reality
	Facilitators and barriers to usage		Reminder to exercise because of the headset
			Pain during exercise as a barrier
	Game versus therapy		Overcoming limits with virtual reality
			Doing the exercises without realizing it
	Role of the physical therapist		Adapting games to the patient
			Importance of being monitored by the physical therapist
	Potential in rehabilitation		Diversifying treatment with virtual reality
			Regularity of sessions

[a]VR = virtual reality.

provided during the initial appointment were sufficient for participants to use immersive VR independently, as most of them did not need to refer to the explanatory documents provided at the beginning of the study. However, 3 participants did mention having some difficulty in locating certain buttons on the VR headset during their initial uses.

Particularities of Immersive VR

Parallel Universe

Several participants felt that immersive VR transported them to a separate world, a parallel universe where they felt detached from the real world around them, often resulting in a loss of the sense of reality. It did not seem to depend on having already experienced immersive VR before.

Feeling of Immersion and Presence

Most participants experienced a feeling of immersion and presence that varied from game to game. The primary factor influencing this, as reported by participants, was the game design, including the depth, scenery, and realism of the environment. The realism of the environment influenced positively among individuals new to video games but negatively among those with greater video game experience, as the latter tended to compare it to game consoles. Other factors, such as sounds, content, and the level of activity in the game (active versus passive engagement), were also mentioned to influence the feeling of immersion and presence.

Exercising in Immersive VR

Type of Exercise

Many participants compared immersive VR exercises to conventional ones. The primary difference reported was that immersive VR exercises are more enjoyable and stimulating due to the gamification. Two participants also mentioned that exercising in immersive VR helps distract their mind and forget about pain. Participants also believed that immersive VR could enhance the completion of exercises by increasing their motivation and enabling them to perform the exercises without the need to remember the specific steps (reducing cognitive constraints). In this way, immersive VR was seen as a helpful guide for carrying out the exercises.

Two participants found the software in immersive VR advantageous, offering quantifiable data for self-assessment, progress visualization and tracking, and exercise completion verification, benefiting both the patient and the physical therapist. However, 3 participants, already heavily exposed to screens, saw "screen overload" as a potential downside of exercising in immersive VR.

Facilitators and Barriers to Usage

Nearly all participants adhered to the usage recommendations. The primary factor frequently mentioned by participants as enhancing their game utilization was their commitment to completing the exercises (for this study), which some likened to fulfilling a personal contract. The game's playful nature and the presence of challenges and objectives served as additional facilitators for some participants. The VR headset's presence in the real environment also facilitated the usage, acting as a reminder to perform the exercises. Other factors that facilitated usage included ease of use, experiencing beneficial effects (during or after using the games), and discovering immersive VR and its associated games.

The primary barrier to usage put forward by participants was the occurrence of side effects while using the games. Several participants encountered immersive VR side effects, such as nausea or dizziness, predominantly when using a game that

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Table 5. Main Categories, Categories, Subcategories, and Representative Quotes From the Participants[a]

Main Categories	Categories	Subcategories	Representative Quotes
The home environment	Mixed feelings of being at home		That means I can do it at a time and place of my choosing. When I feel like it, being relax, above all. So there's no need to leave home, no need to travel and so on. It's a lot less restrictive than having to go somewhere. *(06, female, 28 y old)*
			Ah well, doing it at home is great. You don't have to go anywhere, it's pleasant, you do it at a time that suits you, at a time of day when it's calm, you don't have to go out, there is no need to find parking for your car. Well, that's it, anything you can do at home is always more pleasant. *(10, female, 64 y old)*
			As always when you're at home, it's also a question of being at home, of saying to yourself, well, some days you're tired, some days you don't have time... I mean, when you have an appointment, you force yourself to keep it, you adjust your timings to get there, and that's it. When you're like that, it's being able to tell yourself... in fact you can do it whenever you like, so you can procrastinate [...] and I think that's the part that's a bit more complicated to stick to. *(01, male, 30 y old)*
			That is not how it happened, but if over time there was a commitment where I said to myself "well, I'll leave it, I don't want to, I don't have the courage" and then... we might stop doing it, or put the sessions much further apart. But if you do it at the physiotherapist, well, you have an appointment every Monday at 4 pm, so every Monday at 4 pm you're there. *(08, male, 55 y old)*
			I think the disadvantages are that... if you're doing it on your own at home, there's a loss of human contact. *(02, female, 26 y old)*
			You have to have a bit of discipline, say to yourself "I'm going to do it" or "I've got the time." Spending 10 minutes or 15 minutes doing it may seem like nothing, but it's true that you have to have the discipline to do it. *(11, male, 57 y old)*
	Using immersive VR at home		It was rather when I had the time, at the end of the day, after getting home from work for example, that I did that. I thought it was a bit of a release. *(08, male, 55 y old)*
			Well, you can do it anywhere. It's practical, plus the battery is pretty good, so you can really use it anywhere. [...] It's comfort. *(09, female, 24 y old)*
			We're no longer in the virtual world then, because we have someone to talk to, but that doesn't change anything in terms of the work involved in the games. *(07, male, 55 y old)*
			I mean, it's quite inconspicuous, it doesn't take up much space. You can adjust the sound so you can even do it while sitting in the armchair next to someone. I mean, even if someone is watching TV, that doesn't stop you from doing it either. *(01, male, 30 y old)*
			So when I told my husband yesterday that I was going to return it today, he said "oh I want to try it once" and so he played along. He too thought it was great but, well, it was the experience, it was the fun. *(10, female, 64 y old)*
			Just be careful with it, but... If you take it with you, well, I've taken it with me to my partner's house, so yes, you have to be careful not to damage it. And that's it. That's a detail, I think. *(07, male, 55 y old)*
Use of a new technology	Hardware and software	Wearing the VR headset	First of all, I tried it with and without glasses, so that's something positive, because you can do it with or without glasses. *(10, female, 64 y old)*
			But otherwise, once it is in place properly, I think you forget about it pretty quickly. When you're in your game, I think you forget about it pretty quickly. *(07, male, 55 y old)*
			When you're wearing the headset, you are really submerged in it. After a while, say half an hour, it can feel a bit oppressive. *(10, female, 64 y old)*
		Ease of use	I don't think it could be simpler, it's really intuitive. Booting up is fairly quick, starting up the controller and all that is responsive, and then you land directly in the main menu, then starting up the applications is quick. *(01, male, 30 y old)*
			I didn't even have to reread the instructions. It was fairly intuitive, so it was easy. *(11, male, 57 y old)*
			It's very quick, and you can get to the games very quickly. It doesn't take long... Because at the start I said to myself "come on, I'll start at 3 pm," but I thought "but by the time I get everything up and running it'll be 3:05 pm." No. I start at 3 pm and I'm in the programme a few seconds later. *(10, female, 64 y old)*

(*Continued*)

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Table 5. Continued

Main Categories	Categories	Subcategories	Representative Quotes
	Particularities of immersive VR	Parallel universe	It's special because you're in a world of your own, and you don't have any visual contact with the real world. *(02, female, 26 y old)*
			Yes, it's almost a parallel world, isn't it? It's quite... You lose the notion of knowing that there's a world that's evolving calmly around you, you're in that game... yeah. *(07, male, 55 y old)*
		Feeling of immersion and presence	No, it was very lively, you get the feeling that you're really in the mine. I felt like I was at an amusement park. *(04, female, 25 y old)*
			Well, wearing a headset like this, you are really immersed, because even if there's someone else in the room, you're much less distracted than if you were in front of a tablet or a computer. Because there is no side view that can distract you. *(08, male, 55 y old)*
			There's not enough realism in the game to really get into it. *(11, male, 57 y old)* I really had the impression that... like looking at a screen, you feel like you are not in it. But with others, you feel like you're really there. Sometimes I was afraid of the snake, afraid it would eat me. No, no, I'm joking. *(07, male, 55 y old)*
Exercising in immersive VR	Type of exercise		But I think it does add some challenges, a bit of fun, a bit of innovation. It's a bit of a change from doing "silly" exercises. *(05, female, 55 y old)*
			When you're using the headset, it's different compared to when you're doing the exercises with someone or on your own. It is difficult to ignore reality, but when you have the headset on, you go somewhere else. In the end, yes, you go somewhere else to try and calm yourself down a bit. *(04, female, 25 y old)*
			Well, you get distracted when you're doing the exercises in virtual reality. I think you're more focused on the game and you're less aware of the moves you're making. So, on the one hand, it might feel like it goes quicker, because if I'm told "you have to do up-down, up-down, up-down for 10 minutes," with nothing in front of me, it might seem longer, more boring. Whereas with the game [...] our attention is focused on an objective. *(06, female, 28 y old)*
			The advantage of something like this is that you don't have to remember so much, as you're not... like... that's not my thing at all, having to remember the exercises, the ways of doing them. So I'd say it's like a guide. *(08, male, 55 y old)*
			I think that this could encourage a lot of people to finally do these exercises. *(02, female, 26 y old)*
			Yeah, I don't think I'd do it if I didn't have the headset. If you'd asked me to do 5 types of exercise every day for 15 days, I might have been less motivated. The fact that it's still a bit of a game, and that it's a discovery etc., allows you to do that. *(11, male, 57 y old)*
			The advantage is that we have quantifiable and qualifiable data that we can compare to see whether or not there has in fact been an improvement. *(01, male, 30 y old)*
			Here, for example, we could, with a memory card or something, see if I've really spent the time on it. When I do my exercises at home, nobody can check. Only the ones I do in front of the physio can be checked and confirmed. But with this, we'll at least be able to see if it's been done, I think. *(07, male, 55 y old)*
			It's still technology and it's still having screens in front of your eyes. So that's also my very personal opinion, which is that we're already very exposed to screens. *(02, female, 26 y old)*

(*Continued*)

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Table 5. Continued

Main Categories	Categories	Subcategories	Representative Quotes
	Facilitators and barriers to usage		No, from the moment I made the commitment... Doing it was the honourable thing to do, otherwise there was no point in making you move. So, there was a sort of contract, and I made sure that I stuck to that contract. *(07, male, 55 y old)*
			I think the difference is that, here I had this headset which was there to remind me that I had to do it. *(10, female, 64 y old)*
			And I think it's the games that are a bit more fun [...]. I think it's that side of things too, because in the end that's what makes you want to carry on or not. The fact that you're having fun while you're working encourages you to keep going and do it again. *(01, male, 30 y old)*
			Frankly, it moved quite a bit and I felt dizzy. [...] I think I did 2 laps and then I stopped because yeah, it was making me a bit sick. *(02, female, 26 y old)*
			It stuck something in me, it hurt too much. So I stopped doing it straight away. *(04, female, 25 y old)*
			I tried 2–3 others, the first I didn't understand, I moved on to another one, I didn't understand it either, I said "that's OK I'll leave it at that." *(07, male, 55 y old)*
			But here, as it was free, any time of the day, well it's much easier to implement it into the day's program. The fact of being freer is mainly that. *(06, female, 28 y old)*
	Game versus therapy		Well, that's the playful part. You work without really realising it. *(01, male, 30 y old)*
			So I think that's what's good about it too, that we're pushing ourselves by doing it. So that's why, frankly, I think it's great. *(03, female, 48 y old)*
			We're more into the subconscious of the exercises. If you're doing the exercise, well, you're aware of what you're doing, so you may set your own limits to the exercise, but here you're in a virtual world, so you automatically follow the movements a bit and that forces you to go further, I think. I have the impression that you can go further, progress more, but also – and here I come back to this – injure yourself more easily. Because we're into the subconscious, we might do movements that we wouldn't make otherwise. *(11, male, 57 y old)*
			Well, I think that if it's not used properly and you forget the beneficial side of it and try to force it too much, I think that might in fact have the opposite effect. It's always a question of remembering... not losing sight of the therapeutic side and not the game side. *(01, male, 30 y old)*
			You need to be able to combine the two, say "we've got something more recreational" and at the same time retrain your neck. You really have to combine the two. *(11, male, 57 y old)*
	Role of the physical therapist		I don't think it should be used no matter how. I think it needs to be accompanied. I think it's very important that it's accompanied. [...] It shouldn't be sold like, "this will solve your neck problems." No, it needs to be accompanied by a physiotherapist and evaluated, analysed, and adapted. *(10, female, 64 y old)*
			I think it's always useful to have a professional that guides you. I think that's what they're trained to do, and it's also more motivating to see someone analysing, doing the therapeutic side. I don't think you can cure yourself of everything. *(08, male, 55 y old)*
			Because in the end, it's better to get information from a professional too, who will be able to make better recommendations and to whom you can also ask questions. So the physiotherapist always needs to be available, of course, and you need to know that you can ask someone who knows, so that you don't go too far and do things wrong. *(06, female, 28 y old)*
	Potential in rehabilitation		Well, as soon as you feel that it's starting really to bother you, well you can have a tool at your disposal and that's great. *(04, female, 25 y old)*
			I think the aim may be to treat yourself more quickly, because the tool is available 24 hours a day, 7 days a week, so it allows you to increase the number of sessions you do. I think that's the main advantage of the headset. *(01, male, 30 y old)*
			Because when I'm in a bit more pain at a given moment, well, I say to myself "well, I've got the headset." If I feel like I need to relax a bit, I know it works. Otherwise, if I'm in pain at a given moment, I say to myself "well, the physio's tomorrow, it's not today... never mind, I'm going to be in pain." *(04, female, 25 y old)*
			I think it could be beneficial. I think this kind of technology could be beneficial in terms of functioning. *(11, male, 57 y old)*

[a]VR = virtual reality.

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induced a sensation of bodily movement within the virtual environment, leading to game interruption. Additionally, 2 participants experienced pain during or after sessions, with one discontinuing the session immediately (for that session only) and the other taking several days to resume. Wearing the VR headset can also limit use over time according to 2 participants. Other reported barriers included difficulties in understanding the exercises, screen overload, lassitude, forgetfulness, and time constraints.

Some factors were reported as both facilitators and barriers to using the games. The difficulty in completing the exercises had a dual influence, either discouraging participants or motivating them through the challenge of successful completion. The movements involved and the presence of challenges or scores also played a dual role. The freedom to use the games had mixed effects, potentially encouraging procrastination or making it more convenient for participants to perform their exercises at times that suited them, without adhering to a fixed schedule.

Finally, enjoying games encouraged participants to use them more and for longer durations, whereas disliking games prevented their usage. Initially, participants often tried out each game randomly but eventually gravitated toward the ones they preferred while discontinuing the ones they disliked. Game appreciation depended on various factors unique to each participant. However, the primary factors influencing game appreciation, as highlighted by participants, included the movements within the game, the playful aspect, the experience of beneficial or adverse effects, game design (eg, content, sounds, scenery, challenge), the activity within the game, as well as the ease of exercise performance and comprehension.

Game Versus Therapy

Several participants mentioned working without realizing it, as they would forget they were exercising due to the immersive game context. Moreover, participants observed that the movements in immersive VR were often greater than in real life, driven by the game's objectives, which pushed them to surpass their limits. This effect had both positive and negative aspects; it could allow them to work in unusual ranges of motion and make greater progress, but it could also pose potential risks, leading to unconscious movements and potential pain.

Several participants made a distinction between the gaming and therapeutic aspects, emphasizing the importance of both. They stressed that while the gaming element is crucial, it is essential to maintain focus on the therapeutic objectives to avoid unintended consequences. Ideally, these 2 elements should be integrated.

Role of the Physical Therapist

Some participants believed that an effective utilization of games in immersive VR, including exercise progression and appropriate game selection, requires training and ongoing guidance. They also emphasized the importance of tailoring the games to their specific issues, capabilities, and progress.

Nearly all participants spoke of the crucial role of the physical therapist in the use of immersive VR at home. The physical therapist's responsibilities include providing advice, prescribing exercises tailored to the patient's clinical condition, monitoring treatment progress, analyzing quantitative data from the software, and being available for any necessary assistance, such as addressing technical issues or explaining exercises. This collaborative approach could help customize treatment and cater to patients' specific needs.

Potential in Rehabilitation

Many participants expressed various ways in which immersive VR holds potential in rehabilitation. Some highlighted its ability to increase the frequency of exercise sessions and expedite recovery by ensuring regularity, motivate individuals to engage in exercises, and even distract them from the rehabilitation process. Moreover, some participants found having the VR headset readily available allowed them to address pain as it arises, without the need to wait for a physical therapist's appointment. Most participants reported experiencing positive effects when using the immersive VR serious games and believed in the potential benefits of immersive VR in rehabilitation. They also considered it an innovative and intriguing approach worthy of further exploration.

DISCUSSION

This qualitative study aimed to explore the experiences of using immersive VR serious games at home in individuals with persistent NSNP. This is the first study in this population to provide insights into both the experiences of using immersive VR and its use in the home-setting.

The home environment was found suitable to use immersive VR, with numerous advantages reported. Relatives viewed it positively, and participants could use it in the presence of others, potentially aiding its home implementation and usage as social influence is a key factor in technology use intention.[47] While most enjoyed using immersive VR at home independently, the lack of human contact with a physical therapist and autonomy could be barriers. One solution is maintaining contact with the physical therapist during independent home immersive VR use, preserving the benefits of being at home while ensuring human contact and reducing procrastination due to autonomy. Telerehabilitation is a promising alternative, showing effectiveness comparable to in-person physical therapy.[48,49]

Immersive VR seems generally well-accepted in this population, as indicated by the participants' experiences. Nearly all participants found wearing the VR headset comfortable, without weight or discomfort issues during gameplay. To ensure optimal comfort, participants emphasized the importance of precise headset adjustment, highlighting the need for careful consideration of headset positioning to enhance patient overall experience when using immersive VR. All participants found the hardware and software user-friendly. Most participants grasped the use of immersive VR after just a single explanation, which is significant since "effort expectancy," which relates to system usability, influences technology use intention.[47] Maximizing the feeling of immersion and presence is important for enhancing the immersive VR experience. While certain factors affecting immersion and presence are consistent among participants, others may differ from person to person. Clinicians should consider individual-specific factors and select games that offer a heightened feeling of immersion and presence. Having a comfortable and user-friendly technology that can induce immersion and presence is crucial, as these have been reported as facilitators for the implementation of VR in healthcare.[50]

Ensuring adherence to home exercises is a significant challenge in musculoskeletal physical therapy, impacting

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treatment effectiveness.[51] In this study, participants shared various facilitators and barriers to using immersive VR serious games. Some barriers, like time constraints, forgetfulness, or exercise-related issues, are common in those with persistent neck and back pain.[52–56] But there are specific barriers in immersive VR, such as cybersickness, needing attention, as it has also been reported as a barrier to implementation of VR in healthcare.[50] Specific questionnaires[35–37] can help clinicians identify patients prone to cybersickness when using immersive VR. Yet, other factors should also be considered.[57] Clinicians should also take into account patient's game preferences, as these can influence usage and, consequently, exercise adherence.

Participants found immersive VR exercises more favorable than conventional ones, citing notable advantages, especially the gamification and playful elements. Similar findings have been reported in other studies involving individuals with persistent neck pain.[20,21,28] Nevertheless, it's crucial to balance therapeutic with gaming aspects, to progressively work in unusual ranges of motion while avoiding unintended consequences such as pain. Participants also noted that immersive VR games could enhance exercise completion by boosting motivation, a notion supported by a recent narrative review emphasizing gamification's potential to enhance motivation in musculoskeletal rehabilitation.[58] This is significant as motivation is a common barrier to exercise adherence in individuals with musculoskeletal pain.[54,55] By emphasizing the playful and gamification elements and boosting motivation, immersive VR has the potential to improve adherence to home exercises, potentially increasing treatment effectiveness.

Participants stressed the importance of the physical therapist's role when using immersive VR at home. Their desire for personalized treatment and close supervision aligns with the study by Falsiroli Maistrello et al[24] and is consistent with evidence-based practice and patient-centered care principles.[23,59,60] Participants also highlighted immersive VR's rehabilitation potential, as observed in Zauderer et al.'s study.[21] This is noteworthy because patient expectations for an intervention can significantly impact the care process and its outcomes, with positive expectations enhancing intervention effectiveness.[61,62]

This study offers valuable insights into the experiences of using immersive VR and its utilization at home, adding to the existing quantitative literature on immersive VR for individuals with persistent NSNP. It provides clinicians with guidance for implementing immersive VR in the management of individuals with persistent NSNP by considering their experiences, fostering a more patient-centered approach to care. This understanding can also guide researchers in the design and optimization of interventions using immersive VR for individuals with persistent NSNP.

Strengths and Limitations

A strength of this study is the duration of the intervention, enabling in-depth exploration of the use of immersive VR at home. Moreover, the free usage promoted a natural and unrestricted experience. Other strengths are the strict adherence to recommended checklists,[32,33] the transparent and reproducible methodology, the insurance of trustworthiness criteria, the coverage of the entire experience through the use of a comprehensive interview guide, and the inclusion of a diverse group of individuals with persistent NSNP (including males and females of varying ages, professional statuses, neck pain duration and type, with and without prior immersive VR experience), which facilitated the identification of both common and contrasting experiences. Nonetheless, there are some limitations. First, participants' voluntary involvement and some prior relationship with the principal investigator might have influenced their experiences. Second, the eligibility criteria could introduce bias by excluding individuals more susceptible to motion sickness, with sensorimotor dysfunction or uncorrected vision problems. Third, social desirability bias could affect participants' responses to interview questions, potentially leading to inaccurate reporting of their experiences, despite assurances of confidentiality and open expression.

In conclusion, immersive VR was deemed comfortable for almost all participants and easy to use. Participants found exercising in immersive VR motivating and enjoyable, favorably comparing it to conventional exercises. The home environment proved suitable for using immersive VR, offering numerous benefits. However, autonomy and the loss of human contact could hinder using immersive VR at home. Participants highlighted facilitators and barriers associated with the use of immersive VR serious games, as well as immersive VR's rehabilitation potential. While participants valued independent use, they also emphasized the vital role of physical therapists for guidance, remote supervision, and personalized treatment.

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CRediT – CONTRIBUTOR ROLES

Alexandre Luc (Conceptualization [lead], Data curation [lead], Formal analysis [lead], Investigation [lead], Methodology [lead], Software [lead], Validation [lead], Visualization [lead], Writing—original draft [lead]), Nicolas Lambricht (Formal analysis [equal], Visualization [equal], Writing—review & editing [equal]), Isabelle Aujoulat (Formal analysis [Supporting], Methodology [equal], Supervision [equal], Writing—review & editing [equal]), Christine Detrembleur (Conceptualization [equal], Methodology [equal], Supervision [lead], Writing—review & editing [equal]), Laurent Pitance (Conceptualization [equal], Methodology [equal], Supervision [lead], Writing—review & editing [equal]).

SUPPLEMENTARY DATA

Supplementary data are available online.

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ETHICS APPROVAL

This study received approval from the Ethics Committee of the Cliniques universitaires Saint-Luc and Université Catholique de Louvain (B4032021000109). All participants provided written informed consent before the commencement of the study.

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CLINICAL TRIAL REGISTRATION

This study was registered at ClinicalTrials.gov: NCT05244681.

DISCLOSURES AND PRESENTATIONS

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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DATA AVAILABLITY

The authors can be contacted to obtain data for this study.

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