

User Needs Analysis of Home-Based Rehabilitation Tools for Young Adults With Chronic Non-Specific Low Back Pain: A Design-Oriented Interview Study

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ABSTRACT

Chronic non-specific low back pain (CNSLBP) is increasingly prevalent among young adults and negatively affects daily functioning. Although exercise-based home rehabilitation is recommended, sustained engagement remains challenging in everyday contexts. This study investigates the user needs of home-based rehabilitation tools for young adults with CNSLBP from a human-centered design perspective. Fifteen participants aged 18–34 with chronic low back pain took part in semi-structured interviews addressing pain management experiences, rehabilitation practice, behavioral barriers, and expectations for rehabilitation support. Thematic analysis revealed that participants mainly relied on passive or short-term pain relief strategies and demonstrated fragmented rehabilitation behaviors. Key challenges included unclear exercise understanding, low confidence in execution, limited time, and difficulty maintaining routines. Participants emphasized the need for clear guidance, execution support, behavioral assistance, and basic progress awareness with minimal cognitive burden. These findings provide user-centered insights to inform the design of usable and sustainable home-based rehabilitation solutions for young adults with CNSLBP.

Keywords: Chronic non-specific low back pain, Home-based rehabilitation, User needs, Usability, User experience

INTRODUCTION

Low back pain (LBP) is one of the most prevalent health conditions worldwide and a major contributor to functional limitation and reduced quality of life (Balagué et al., 2012; Ferreira et al., 2023; Nijs et al., 2024). Approximately ten percent of individuals with low back pain experience symptoms lasting longer than three months and progress to chronic low back pain, of which about eighty five percent are classified as chronic non-specific low back pain (CNSLBP) (Maher et al., 2017). In recent years, CNSLBP has become one of the leading causes of disability globally, with a clear trend toward younger affected populations (Brown et al., 2021; Ferreira et al., 2023). Contemporary young adults are commonly exposed to prolonged sedentary behavior, insufficient physical activity, poor sleep quality, and increased psychological stress, and some also present elevated body mass index as an additional risk factor. Previous studies have demonstrated that

sedentary behavior, unhealthy lifestyle patterns, and high body mass index are closely associated with the onset and chronic progression of non-specific low back pain, and these risk factors tend to be concentrated within younger populations (Maher et al., 2017). Epidemiological evidence indicates that the prevalence of CNSLBP among young adults aged 18 to 34 years is increasing and may reach up to 23 percent (Brown et al., 2021). Beyond impairing physical function, this condition exerts long-term negative effects on learning performance, work capacity, and overall quality of life, while also imposing additional burdens on individuals and healthcare tools (Mahmoodpoor, 2021; Ferreira et al., 2023).

Interventions for chronic non-specific low back pain typically include pharmacological treatment, exercise based rehabilitation, physical therapy, and rehabilitation education (Maher et al., 2017). Existing evidence suggests that pharmacological approaches carry a risk of dependence during the chronic stage and are not considered first line treatments (Maher et al., 2017). In contrast, nonpharmacological interventions such as exercise therapy are widely regarded as a core strategy for managing CNSLBP in young adults (Hayden et al., 2021). Such approaches not only contribute to pain relief but also improve physical function and reduce recurrence, making them particularly suitable for home based rehabilitation (Hayden et al., 2021; Weise et al., 2022). However, the effectiveness of exercise rehabilitation is highly dependent on individuals' ability to understand training principles, perform movements correctly, and maintain adherence in real life contexts (Cochrane Effective Practice and Organisation of Care Group et al., 2023; Krkoska et al., 2023). Traditional rehabilitation models often rely on face to face guidance in clinical settings or require patients to complete prescribed exercises independently at home. For young adults, these models are frequently constrained by human factors such as fragmented schedules, limited rehabilitation knowledge, and insufficient guidance (Main et al., 2025; Cochrane Effective Practice and Organisation of Care Group et al., 2023). In the absence of external supervision, home based training is prone to movement errors, interruptions in training routines, and declines in motivation, which ultimately undermine the long term effectiveness of rehabilitation interventions (Krkoska et al., 2023).

With the advancement of intelligent technologies, increasing attention has been directed toward optimizing home-use rehabilitation support tools (Rintala et al., 2022; Lewkowicz et al., 2023). At a technical level, such tools offer opportunities for personalized training and behavioral support (Bataineh et al., 2024). However, their practical effectiveness largely depends on how well they align with users' cognitive characteristics, usage contexts, and everyday behavioral patterns (Grolier et al., 2023; Main et al., 2025). Therefore, systematically understanding the real needs of young adults with chronic non-specific low back pain in home based rehabilitation from a human factors and design perspective is essential for the development of sustainable, usable, and effective rehabilitation tools.

RELATED WORK

Existing research on home-based rehabilitation tools has explored a variety of technology-supported solutions for managing chronic low back pain, including wearable smart devices, mobile health applications, and related emerging technologies (Rintala et al., 2022; Ulrich et al., 2023). These tools typically employ standardized exercise protocols, guided processes, or gamified designs to compensate for limited professional supervision and low adherence, and studies indicate that such interventions have the potential to improve pain relief, functional outcomes, and user motivation (Toelle et al., 2019; Weise et al., 2022; Garcia et al., 2022).

Wearable devices commonly rely on multimodal sensing technologies such as inertial measurement units, pressure sensors, or surface electromyography to capture physiological and postural data and provide feedback through posture monitoring, heat therapy, electrical stimulation, or massage to reduce lumbar fatigue and pain, with research focusing on lightweight design, comfort, and daily usability. For instance, Rodriguez et al. (2021) proposed a low-cost system using multiple IMUs to monitor trunk and pelvic posture in real time and deliver feedback when deviations exceed thresholds, assisting in correcting poor posture. Mobile health applications support home rehabilitation through exercise guidance, data recording, progress monitoring, and patient-provider interaction, with studies emphasizing interface optimization, personalized rehabilitation pathways, and the integration of multi-source data (Rintala et al., 2022; Ulrich et al., 2023). Applications such as the Kaia App integrate rehabilitation education, graded exercise programs, and mindfulness modules to facilitate self-management of chronic low back pain at home, demonstrating significant effects in pain reduction and improved accessibility (Toelle et al., 2019). With the advancement of artificial intelligence, big data, virtual reality, and augmented reality, home rehabilitation tools increasingly adopt multimodal integration (Menychtas et al., 2022; Conen et al., 2025). Virtual reality provides immersive, multisensory experiences that can shift attention away from pain or movement-related fear, thereby reducing perceived pain and promoting adherence (Garcia et al., 2022). For example, RabbitRun uses gamified training scenarios to guide trunk flexion and extension exercises, enhancing engagement and willingness to participate at home (Alazba et al., 2018). To address potential issues such as VR-induced dizziness, some studies combine augmented reality with psychological education, overlaying virtual coaches onto real environments to correct maladaptive beliefs about pain (Conen et al., 2025).

However, from a human factors, system design, and user experience perspective, existing research still has limitations. Discomfort from wearable devices, complex mobile application interfaces, and VR-related dizziness or high cost may reduce long-term adherence (Ulrich et al., 2023; Main et al., 2025). Tools vary widely in functionality, feedback modalities, and interaction methods, and few studies adopt a user-centered design framework or consider cognitive load, operational complexity, and long-term experience in real home contexts (Grolier et al., 2023; Main et al., 2025). Moreover, although the prevalence of chronic non-specific low back pain is increasing among young adults, most research has focused on older or clinical populations, paying

limited attention to differences in behavior motivation, daily routines, and contextual use among younger users (Brown et al., 2021). To address these gaps, this study adopts a design-oriented qualitative interview approach to systematically explore the real needs, behavioral patterns, and experience challenges of young adults with chronic non-specific low back pain during home rehabilitation, providing human factors evidence for developing home-based rehabilitation tools that prioritize user experience and behavioral support.

METHOD

A total of fifteen young adults with chronic low back pain were recruited through online channels to participate in this study. The inclusion criteria were as follows: age between 18 and 34 years; self-reported low back pain with a duration exceeding twelve weeks; no diagnosis of structural or specific spinal disorders; and a self-rated pain intensity score between three and six on the Visual Analogue Scale during pain episodes. The exclusion criteria included a confirmed diagnosis of lumbar disc herniation, scoliosis, spinal fracture, or inflammatory spinal disease, as well as a recent history of lumbar or spinal surgery. The sample size was determined according to the principle of data saturation, whereby recruitment was discontinued when subsequent interviews no longer yielded new themes. Ultimately, fifteen participants were included. To protect privacy, participants were assigned anonymized identifiers from A1 to A15, and their demographic characteristics are presented in Table 1. All participants were able to perform daily activities independently and complete the interviews, and all provided informed consent before participation.

Table 1: Demographic characteristics of interview participants (n = 15).

Participant ID	Age	Gender	Duration of LBP	Pain Intensity (VAS)	Previous Rehabilitation Experience
A1	26	Male	> 12 weeks	4	Yes
A2	22	Male	> 12 weeks	5	No
A3	28	Female	> 12 weeks	4	No
A4	30	Female	> 12 weeks	3	Yes
A5	22	Female	> 12 weeks	5	No
A6	28	Male	> 12 weeks	4	Yes
A7	24	Male	> 12 weeks	4	No
A8	25	Female	> 12 weeks	5	No
A9	26	Female	> 12 weeks	5	Yes
A10	32	Male	> 12 weeks	6	No
A11	21	Female	> 12 weeks	4	No
A12	23	Female	> 12 weeks	4	Yes
A13	25	Female	> 12 weeks	5	No
A14	25	Female	> 12 weeks	4	Yes
A15	22	Male	> 12 weeks	3	Yes

The interview guide was developed and refined based on the research objectives, a review of relevant literature, and discussions within the research team. Open-ended questions were primarily used to encourage participants to describe their lived experiences and personal perspectives in depth. The study followed a design-oriented research approach, with particular attention to users' perceptions, challenges, and needs in real-life contexts. The final interview guide addressed the following topics: how participants managed or coped with low back pain and the perceived outcomes; their understanding of home based rehabilitation training and the specific exercises or methods they were familiar with; factors that motivated or hindered their engagement in rehabilitation training; and their expectations regarding the problems a home based rehabilitation tool should address and the functions it should provide.

All interviews were conducted on a one-to-one basis, either online or in person, with each session lasting approximately 20 minutes and being audio recorded in full. After the interviews, the recordings were transcribed verbatim and checked against the original audio to ensure accuracy. The data were analyzed using thematic analysis. Through multiple rounds of reading, coding, and categorization, a set of representative themes was identified to capture the key characteristics of home-based rehabilitation needs among young adults with chronic non-specific low back pain, providing a foundation for subsequent design-oriented research.

RESULTS

All participants were aged 21-32 years, including nine females and six males, resulting in a relatively balanced gender distribution. Regarding prior rehabilitation experience, approximately half of the participants had received some form of rehabilitation training or guidance. In contrast, the remaining participants lacked systematic rehabilitation exposure, reflecting differences in rehabilitation engagement and practice among young adults with chronic low back pain. This diverse yet consistent sample in terms of disease duration provides a reliable qualitative basis for analyzing home-based rehabilitation knowledge, behavioral characteristics, and tool requirements.

Based on a thematic analysis of interview transcripts from 15 young adults with chronic non-specific low back pain four core themes were identified including current strategies for managing pain episodes understanding, practice of home-based rehabilitation drivers, barriers in rehabilitation behavior and expectations for home-based rehabilitation tools along with ten related subthemes encompassing passive coping behaviors focused on short-term pain relief challenges with recurrent pain and lack of long-term management insufficient systematic understanding of home rehabilitation fragmented training reliant on external demonstration pain-driven initiation of rehabilitation behavior constraints on adherence due to fragmented time adherence barriers caused by safety concerns fundamental need for clear and understandable exercise guidance expectations for feedback and behavioral support and preferences for low-burden tools that integrate into daily life.

Current Strategies for Managing Pain Episodes

During episodes of increased or acute low back pain, young adults with chronic non-specific low back pain generally adopted passive strategies aimed at immediate symptom relief rather than systematic or long-term management. Common strategies included resting, reducing activity applying heat, or using topical pain relief patches. Participants repeatedly described a pattern of responding only after pain occurs, with one participant stating, "I usually just lie down and rest or use heat which helps a little at the moment but a few days later it still hurts" (A3). Some participants occasionally used temporary external interventions such as massage or physiotherapy. Still, these were primarily passive, with another participant noting "when the pain is severe, I will get a massage, but it is not possible to do it regularly" (A7). Although most participants recognized the relationship between lifestyle and pain, their actual management strategies favored low-effort, short-term relief. Many participants considered existing approaches only provided temporary alleviation, with one summarizing "it only stops the pain for a while, but I do not feel that it really improves" (A10). This experience highlights an emergency-oriented self-management pattern among young adults and establishes a practical basis for initiating and maintaining home-based rehabilitation.

Understanding and Practice of Home-Based Rehabilitation

Participants generally had conceptual awareness of home-based rehabilitation. Still, they lacked a systematic understanding and operational knowledge with many stating "I know I should exercise but I am not really sure what or how to do it" (A10, A11, A13). Some participants could name exercises such as planks or stretches but this knowledge was mainly derived from short videos or social media "I have seen many videos but each one says something different and I do not know which is suitable for me" (A8). Training behavior was often fragmented and sporadic and relied on external demonstration for imitation "I always follow the video while doing it and I am hesitant to do it without watching" (A5). The absence of feedback mechanisms made it difficult to verify exercise correctness "I do not know if I am doing it right, so it is easy to give up" (A12). Overall, home-based rehabilitation remained at a stage of conceptual understanding and fragmented attempts among young adults, and had not yet developed into a stable, sustainable daily behavior, which provides context for exploring barriers to this behavior.

Drivers and Barriers in Rehabilitation Behavior

Multiple factors with fragmented time influenced rehabilitation behavior concerns about safety, and a lack of behavioral support were the primary barriers. Young participants faced fast-paced daily routines that made maintaining regular training difficult "after work, I am already tired, and it is hard to find time every day to exercise" (A6). Concerns about performing exercises incorrectly created safety anxiety with one participant noting, "I am afraid that doing it wrong will make the pain worse, so I have not really

practiced” (A2). In addition, lack of external supervision or motivation led to interruptions in training “at first I may exercise for a few days, but if no one reminds me, I quickly forget” (A7). These interacting factors made long-term adherence challenging, indicating that behavioral lapses among young adults are not due to negative attitudes but result from environmental constraints cognitive uncertainty and insufficient behavioral support.

Expectations for Home-Based Rehabilitation Tools

Participants consistently expressed the need for clear guidance, process feedback and behavioral support in home-based rehabilitation tools. Clear and understandable exercise instructions were considered the most fundamental function, with one participant stating, “it is best if it can show me step by step how to do it rather than just giving a name of the exercise” (A9). Immediate feedback during training could enhance safety and confidence, “if it can tell me whether I am doing it correctly, I will feel more assured” (A4). Behavioral support, such as structured training plans and continuous reminders, could reduce decision burden and improve adherence “if it can arrange the plan for me so I do not have to think about what to do each time, it might be easier to stick with it” (A14). Basic progress feedback was also seen as important for sustaining long-term motivation, “seeing some improvement makes me want to continue” (A1). Participants prioritized tools that could naturally integrate into daily life and minimize cognitive and operational load rather than pursuing complex technological features. Overall, young adults with chronic non-specific low back pain emphasized user-friendly design and ongoing behavioral support to facilitate adherence and long-term rehabilitation outcomes.

DISCUSSION

This study employed qualitative interviews to systematically examine the actual needs, behavioral patterns, and experiential pain points of young adults with chronic non-specific low back pain in the context of home based rehabilitation. The findings indicate that most participants relied on passive management strategies aimed primarily at relieving immediate discomfort, with limited engagement in systematic or long-term rehabilitation planning. A clear tendency toward reactive, short-term coping characterized by their self-management behaviors. This pattern is consistent with descriptions of young adults with chronic low back pain reported in prior studies. It suggests that, although this population demonstrates a basic level of health awareness, shortcomings remain in the continuity and proactivity of rehabilitation behaviors (Brown et al., 2021; Cochrane Effective Practice and Organisation of Care Group et al., 2023). These results highlight the need to design home-based rehabilitation tools to support a transition from passive symptom driven responses to active, regular rehabilitation practices.

Further analysis revealed that, at both the cognitive and practical levels, young users generally lacked a structured understanding of training principles and operational logic. Rehabilitation activities were commonly performed

through fragmented imitation based on short videos or social media content. In the absence of effective feedback mechanisms, users found it difficult to verify the correctness and safety of their movements, which in turn undermined training confidence and sustained motivation. Key behavioral drivers and barriers were primarily associated with fragmented time availability, concerns about safety during movement, and the lack of external supervision. Young users demonstrated a strong preference for flexible training arrangements and low cognitive burden, and they were prone to discontinuing training when faced with uncertainty or psychological pressure. Within this context, expectations regarding home-based rehabilitation tools were relatively focused. Core requirements included clear, step by step guidance, immediate feedback, behavioral support, and basic displays of progress or training related data, whereas complex technological features were not considered a priority. Although wearable devices, mobile applications, and virtual or augmented reality technologies can support posture monitoring, process feedback, and interactive experiences, their design should emphasize lightweight implementation, ease of use, and integration into everyday life to reduce adoption barriers and enhance long-term adherence among young users.

Overall, this study elucidates the behavioral patterns and experiential challenges encountered by young adults with chronic non-specific low back pain during home-based rehabilitation, providing direct evidence to inform tool design centered on user experience and behavioral support. From a design perspective, home based rehabilitation tools should explicitly address the key obstacles observed in real-world use, including insufficient understanding of training movements, concerns about execution safety, and the tendency for rehabilitation behaviors to be interrupted. Accordingly, rehabilitation tools should reduce comprehension costs through clear explanations and visual demonstrations of movements, strengthen execution confidence through real-time or process-oriented feedback, and support the sustained integration of training into daily routines through structured yet flexible training arrangements, thereby improving the feasibility and stability of home-based rehabilitation.

CONCLUSION

This study systematically examined the needs and behavior of young adults with chronic non-specific low back pain in home-based rehabilitation from a human factors perspective. Users primarily rely on passive, short-term pain relief strategies, with limited understanding of exercises and low adherence due to fragmented schedules, safety concerns, and lack of feedback. Core requirements for rehabilitation tools include clear guidance, real-time feedback, behavioral support, and progress tracking, while complex technical features are secondary. Tools should minimize cognitive load, enhance confidence and safety, and support consistent engagement through structured yet flexible training. Multimodal technologies should be integrated into daily routines to improve usability and long-term adherence. These findings provide evidence for human-centered design of effective home-based rehabilitation tools.

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