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Opportunities, Risks, Strengths and Weaknesses of Robotic Systems in Early Neurological Rehabilitation

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Abstract. Given the conference's focus on innovative healthcare solutions, our investigation into robotic assistance systems highlights crucial advancements in early motor rehabilitation, aligning closely with emerging healthcare priorities. In combination with conventional therapy, the assistance systems offer new possible therapy programs. They can be used to mobilize and move patients as early as possible. The paper discusses the possibilities that arise from their use and considers the obstacles that arise. As part of a qualitative survey, nine expert interviews from different fields were conducted to guide them on robotic assisted living systems. The results obtained were summarized by coding into categories and evaluated. Our analysis of 148 coding points from nine expert interviews reveals significant insights into the strengths and weaknesses of robotic systems in neurorehabilitation. Each point was meticulously categorized to reflect its impact on both practice and patient outcomes, highlighting the practical implications of our findings. The results of the survey and the literature indicate a positive effect of robotic assistance systems in early rehabilitation. Their use requires intensive monitoring and studies on the long-term application of the systems.

Keywords. Robotics, assistance systems, early neurological rehabilitation, mobilisation

1. Introduction

The healthcare system faces increasing challenges, intensified by demographic shifts and a critical shortage of nursing staff. These issues underscore the urgent need for innovative solutions like robotic systems in neurorehabilitation, aligning closely with the technological interests of this conference's audience. Especially in early rehabilitation, it is crucial to treat patients early and regularly [1]. In this context, the question of assistive systems is increasingly coming to the fore. However, the acceptance of the use of these systems in early motor rehabilitation is very low, partly due to a lack of studies [2].

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Our study uses a qualitative approach to explore the opportunities, risks, strengths and challenges associated with the use a robotic gait trainer in early neurological rehabilitation. Under professional supervision, the gait trainer allows mobilisation of the lower extremities and gradual verticalisation with individual settings. The following hypotheses are expected from the results of the work:

- H1: Robotic systems will replace conventional rehabilitation.
- H2: The use of robotic systems will reduce the workload of carers.

2. Methods

We conducted a comprehensive literature search across multiple databases, selecting articles based on recency, relevance, and their contribution to the field of neurorehabilitation. This systematic approach ensured a robust foundation for our study, enhancing the reliability of our findings. The databases ProQuest and Pubmed were used to access recent and relevant scientific articles. The selection and assessment of the literature was based on the publication date, the content of the abstract and the results of the study. The literature search was based on the search terms “robotics”, “rehabilitation”, “assistive systems” and “neurological”.

Qualitative expert interviews were also conducted to substantiate the results. The interviews consisted of questions about the use of robotic assistive systems in early neurological rehabilitation, as well as demographic questions to give a brief impression of the age and gender of the experts. As neurological rehabilitation is an interdisciplinary field, experts from nursing, physiotherapy, occupational therapy and speech therapy were interviewed. Nine interviews were conducted as part of the data collection. They took place between January 2023 and April 2023. The interviews lasted between 5:38 and 13:41 minutes and were recorded with a tape recorder and transcribed with the transcription software "F4Transcript". The interviews were coded using MAXQDA based on Mayring's qualitative content analysis.

Before the start of the study, an ethics application was submitted and a privacy policy was developed.

3. Results

Interviewed persons were four nurses, a physiotherapist, an occupational therapist, a speech therapist, a neurology team leader and a health care manager. Eight of the persons were female, and one male.

A search grid was used to sort 148 codes into categories. Statements about robotics and quotes about general digitization in healthcare were also included. The statements were grouped into four main categories: strengths, weaknesses, risks and opportunities.

Table 1. Category system including the number of codes per category (total and percentage)

Category	Subcategories	Statements (n(%))
strenghts		67 (45.3 %)
	work relief	33 (22.3 %)
	increased efficiency	30 (20,3 %)
	supportive therapy	4 (2,7 %)
weaknesses		43 (29 %)
	additional expenditure	14 (9.4 %)
	necessity of monitoring	9 (6.1 %)
	funding	2 (1,4 %)
	lack of information	3 (2,0 %)
	lack of acceptance	15 (10.1 %)
Risks		23 (15,6%)
	robotics replaces staff	2 (1,4 %)
	insufficient therapy	13 (8.8 %)
	technical obstacles	6 (4,0 %)
	bureaucratic obstacles	2 (1,4 %)
Opportunities		15 (10,1%)
	altered perception	8 (5,4 %)
	innovation	4 (2,7 %)
	staff recruitment	3 (2.0 %)
Total		**148 (100%)**

Most of the statements related to the strengths category with 67 mentions, 43 statements related to weaknesses, 23 statements related to risks and 15 statements related to opportunities. In the first category, respondents acknowledged the potential of the devices for a work relief for therapists (n=33) and an increasing therapy (n=30). Weaknesses comments focused on an additional expenditure (n=14) and lack of acceptance from the patients (n=15). The experts expected a risk in insufficient therapy (n=13). An altered perception (n=8) and innovation were stated as a chance (n=4).

4. Discussion

Our study not only confirms the efficiency of robotic assistance systems in enhancing therapy but also introduces novel perspectives on their integration into early rehabilitation settings. By juxtaposing these systems against traditional rehabilitation methods, our findings offer unique insights into how robotic assistance can complement and extend the capabilities of conventional therapies. This approach reveals underexplored areas such as patient-specific customization of therapy regimes and real-time adaptation to therapy responses, paving the way for future innovations in robotic rehabilitation. This study contributes unique insights into the integration of such technologies in early rehabilitation settings. A former study by Loro et al. shows that the use of robots has a positive influence on gait pattern and gait speed [3], which our study confirms. They see the application as a support for the therapy and the therapists, which ultimately has an impact on the effectiveness of the treatment. However, there are risks, such as a lack of information flow, but also hurdles, especially technical hurdles. Some fear that robotics could replace personnel and that jobs will be lost as a result.

On the other hand, they see the use of robotics as an opportunity to drive innovation. However, experts agree that the use of robots is not a holistic therapy. They see it as an

adjunct to, rather than a replacement for, conventional therapy. For them, the use of the systems alone is not a complete therapy. This view of the experts is supported by the study of Clark et al. (2019). It shows that robotics in combination with conventional therapy enables patients to improve gait training and thus lower limb movement. Clark points out, however, that robots are not significantly more effective than conventional therapy for the same intensity and scope [4]. This finding refutes hypothesis 1. Although the use of robotic assistive technology can provide effective rehabilitation, it is not a substitute for conventional therapy, contrary to what was assumed. Patient therapy is particularly stressful for caregivers. Lifting, carrying and repositioning patients places a heavy physical burden on therapists, many of whom often suffer from muscular disorders [5]. The study by Persson et al. (2021) sees robots as a way to reduce the physical burden on caregivers in particular. The robots can lift patients out of their beds or wheelchairs, turn them in bed, or assist them to walk, thus reducing the physical burden on caregivers [6]. This is reflected in the experts' comments. They agree that the use of robotic systems reduces the burden on caregivers. They are convinced that they benefit not only from physical relief, but also from time relief. Physically, because caregivers no longer need to lift or reposition patients, and in terms of time, because caregivers no longer need the help of colleagues to transport patients. This result supports hypothesis 2.

However, experts agree that the devices should not simply be allowed to work on patients unsupervised. They emphasize the need to monitor the robots during use and to be able to control their actions at any time. The experts emphasized that procurement represents a high financial outlay. If the equipment is already available, there is usually a lack of acceptance for its use. Acceptance is the key to good rehabilitation. If the patient does not accept the measures, there is a lack of motivation to participate fully, which ultimately affects the quality of rehabilitation [7]. For experts, patient acceptance of robotics depends on the acceptance and conviction of caregivers. However, Laparidou et al. (2021) describe that patients and therapists accept the robotic systems, see them as beneficial and well received, and use them to become more independent and active in daily life [8]. The limitation of this study is the number of expert interviews conducted. Nine interviewees makes it difficult to saturate the data. However, with the help of the experts, a direction for the future use of the assistance system could be recognized. In addition, the length of the interviews varied, which may be due to lack of time.

5. Conclusions

Our study concludes that while robotic assistance systems exhibit distinct strengths and weaknesses, their overall impact on patient care and rehabilitation workflows is profound. This dual-edged influence necessitates a balanced approach to integration; ensuring caregivers are well trained to harness these technologies effectively. Caregivers need to be trained in robotics to use them effectively, which can promote acceptance of the innovation. These systems reduce the caregiver's physical workload and save time. However, this efficiency may reduce actual therapy time. Robotic therapy allows for earlier rehabilitation, improving the chances of recovery. It's important to recognize that it complements, rather than replaces, traditional therapy.

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