European Journal of Physical and Rehabilitation Medicine 2024 December;60(6):970-9
DOI: 10.23736/S1973-9087.24.08559-9

ORIGINAL ARTICLE

Digital technologies for pediatric rehabilitation: current access and use in the European Rehatech4child survey

Johanne MENSAH-GOURMEL [1, 2, 3, 4] *, Saranda BEKTESHI [5], Sylvain BROCHARD [1, 2, 3, 4], Elegast MONBALIU [5], Anca I. GRIGORIU [4, 6], Christopher J. NEWMAN [7], Marco KONINGS [5], Javier DE LA CRUZ [8], Christelle PONS [1, 2, 3, 4]

[1]UMR 1101, CHU Brest, University of Brest, Brest, France; [2]Physical Medicine and Rehabilitation Department, CHU Brest, Brest, France; [3]Pediatric Rehabilitation Department, Ildys Foundation, Brest, France; [4]Laboratory of Medical Information Processing, INSERM UMR 1101, Brest, France; [5]Neurorehabilitation Technology Lab, KU Leuven Bruges, Bruges, Belgium; [6]National Center of Neurorehabilitation for Children "Dr. N. Robanescu", Bucharest, Romania; [7]Pediatric Neurology and Neurorehabilitation Unit, Lausanne University Hospital, University of Lausanne, Lausanne, Switzerland; [8]imas12 Institute of Health Investigation, 12 de Octubre University Hospital, RICORS-SAMID, Madrid, Spain

*Corresponding author: Johanne Mensah-Gourmel, University of Brest, CHU Brest, UMR 1101, F29200 Brest, France. E-mail: johannemensah@gmail.com

ABSTRACT

BACKGROUND: Digital technologies such as robotics and treadmill-systems (RobTS), virtual-reality and active video-gaming (VR-AVG), and telehealth and apps (T&Apps) used within pediatric motor rehabilitation may promote recovery and improve function. However, digital technology uptake may be limited in clinical practice.
AIM: To explore access to and use of digital technologies for pediatric motor rehabilitation (DT4R) in Europe as a function of individual and environmental factors, as well as potential barriers to their use.
DESIGN: This observational study was based on RehaTech4child, a cross-sectional survey (2022), supported by the European Academy of Childhood Disability.
SETTING: Online survey available in 20 European languages.
POPULATION: The survey was disseminated through convenience and snowball sampling to pediatric motor rehabilitation professionals in Europe.
METHODS: The survey included items on outcomes (access, use, purposes of use and intention to use for the three categories of DT4R, *i.e.* RobTS, VR-AVG and T&Apps), determinants (socio-demographics, rehabilitation practice) and barriers. The association between access and use, and individual and environmental determinants was assessed using logistic regression adjusted for age, gender and profession.
RESULTS: Of the 1397 responses received, 635 were included. Respectively 67.7% and 74.3% of respondents reported using and having access to at least one of the three categories of DT4R. T&Apps and VR-AVG were used by 50.8% and 45.5% of respondents, respectively, and RobTS by 36.6% ($P<0.001$). Ease of access was the main determinant of use and frequency of use. Individual (*e.g.* age) and environmental (*e.g.* healthcare facility, patients' age) factors were access determinants. At least 70% of professionals intended to use a DT4R if available. Lack of financial resources and training were the most frequently reported severe barriers.
CONCLUSIONS: This study found that DT4R were already used in clinical practice by around two-thirds of respondents and that they generally wished to use them even more. Access was the main determinant of use and frequency of use.
CLINICAL REHABILITATION IMPACT: To facilitate access and use of DT4R, infrastructure and financial resources should be outlined, and training opportunities provided for professionals. Practice guidance should be developed and adapted for specific age groups and rehabilitation goals.

(*Cite this article as:* Mensah-Gourmel J, Bekteshi S, Brochard S, Monbaliu E, Grigoriu AI, Newman CJ, *et al.* Digital technologies for pediatric rehabilitation: current access and use in the European Rehatech4child survey. Eur J Phys Rehabil Med 2024;60:970-9. DOI: 10.23736/S1973-9087.24.08559-9)

KEY WORDS: Digital technologies; Rehabilitation; Child.

In recent years, new opportunities for motor rehabilitation delivery have been created by unprecedented technological advances.[1] Digital technologies for motor rehabilitation (DT4R) include mechanical or electronic systems powered by microprocessors, along with digital hardware and software, that are used in clinical practice to remediate impairment, facilitate recovery, and improve function.[2] Categories of DT4R for motor rehabilitation include robotics and treadmill systems (RobTS), virtual-reality and active video-gaming (VR-AVG), and telehealth and apps (T&Apps).[3] Evidence suggests DT4R may assist therapists in various task including providing repetitive training, automatic sensorimotor and proprioceptive feedback on performance[4] and quantitative evaluation of progress.[5] DT4R aim to make rehabilitation fun, engaging, and challenging, which increases motivation and therefore engagement in rehabilitation,[6, 7] particularly for children.[8-10] Combined with conventional therapy, DT4R may increase therapy time and thus intensity,[7] and enable home-therapy, thus decreasing the family care-burden.[9, 11] In addition, DT4R facilitate active self-management through interactive relations with healthcare professionals.[12] Furthermore, recent reviews[13-15] showed promising results that DT4R could safely improve function and the transfer of acquired motor skills to activities of daily living.

The digital health strategy recently adopted by the World Health Organization (WHO)[16] emphasizes the importance and potential of digital technologies to shape the future of global health and ensure improved access to healthcare services. Access and attitudes to technology use in clinical practice may differ across healthcare facilities, professions, and geographical locations.[17] Barriers to the use of digital technologies include environmental issues such as infrastructure, technical and logistic barriers, financial issues, and individual barriers such as lack of training and psychological barriers.[18, 19] However, access is a prerequisite to DT4R use, and barriers to use may vary with access and ease of access.[20] Furthermore, it is important to determine the intention of professionals to use DT4R when access is provided. The implementation of DT4R for children presents specific challenges, such as adaptation to growth and changing abilities, and the measurement of subtle changes with learning.[21] Gathering combined data on use, access, intention to use and barriers can deepen the understanding of barriers to DT4R use and identify levers to facilitate their implementation in pediatric rehabilitation.

The aim of this study was to assess DT4R use and access by professionals as a function of individual and environmental factors, and to determine the intention to use and potential barriers to use in the context of pediatric motor rehabilitation across Europe.

We hypothezise that: 1) access is a main determinant of use and ease of use; 2) access and use of DT4R may vary with individual and environmental determinants; 3) professionals intention to use may be high in the current context of rapidly developing DT4R; 4) the study of combined data may help to identify levers to promote their implementation.

Materials and methods

RehaTech4child was a voluntary online cross-sectional survey (2022) supported by the European Academy of Childhood Disability (EACD).[10] The study was conducted according to current French legislation (Loi Jardé 2012-300). Brest CHRU Institutional Review Board considered that ethical committee approval was not necessary. The study is reported according to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) and CHERRIES (Check-list for Reporting Results of Internet E-Surveys) guidelines and is registered on ClinicalTrials.gov (NCT05176522).

Survey description

The survey (https://www.surveymonkey.com/r/Rehatech-4childTEST) was divided into 2 parts (total 43 questions). Part 1 focused on individual determinants such as respondents' sociodemographic characteristics (profession, gender, age group, years of experience, and academic degree / diploma), and environmental determinants such as type of professional practice (current country of practice, type and size of healthcare facility), and the characteristics of their patients (age, diseases according to the International Classification of Diseases and Related Health Problems). Part 2 introduced DT4R and defined the three DT4R categories explored in the study (RobTS, VR-AVG and T&Apps). For each DT4R category, in parts 3, 4 and 5 respectively, respondents were asked about their use and frequency of use; type of device(s) used and purpose of their use according to the International Classification of Functioning; access and ease of access; intention to use; and barriers to implementation of the DT4R; responded on a 7-point Likert Scale. Details are provided in the protocol.[10] General access and use (yes/no) were defined in the analysis as the access to and the use of at least 1 device from 1 of the three DT4R categories. Detailed access and use were defined as the ease of access to and frequency of use of a device from

1 of the 3 categories. The outcome variables were dichotomized in the analysis, that is for general access, access to RobTS / VR-AVG / T&Apps, use of RobTS / VR-AVG / T&Apps and frequency of use, respectively, access was compared to no access, use to no use, frequent use (≥once/week) to rare use (<once/week).

Survey development and diffusion

After incorporating feedback from rehabilitation professionals, researchers, a parent of a child with disability, and the 17 EACD national coordinators,[10] the final survey was disseminated in 20 European languages through European and national networks to rehabilitation professionals. Data were collected by convenience and snowball sampling.[10] Exclusion criteria were: 1) respondent stating they did not practice motor rehabilitation with children; 2) respondent who did not completely respond to at least one part (3, 4 or 5); and 3) respondent from a non-EACD member country. Respondents were informed that their responses would be used for research purposes, and confirmed their acceptance.

Statistical analysis

Socio-demographic characteristics, type of professional practice and patients' characteristics were described using frequency distributions.

Frequency analysis was used to describe both general and detailed access and use. Non-parametric (Kruskall-Wallis, Wilcoxon) tests were used for between-groups comparisons. Purpose of use and intention to use were described using frequency distributions.

The association between access and use, and individual (age, gender, profession, years of experience) and environmental (European subregion, type and size of healthcare facility, children's ages, and ease of access when relevant) determinants was assessed using logistic regression adjusted for age, gender and profession.

Respondents were asked to rate a list of proposed barriers on a 7-point Likert Scale: 0, 1 and 2 were grouped as "not at all a barrier to small barrier"; 3 as "moderate barrier"; and 4, 5, and 6 were grouped as "major to extreme barrier". Responses were described using frequency distributions. Statistical significance threshold was $P<0.05$.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

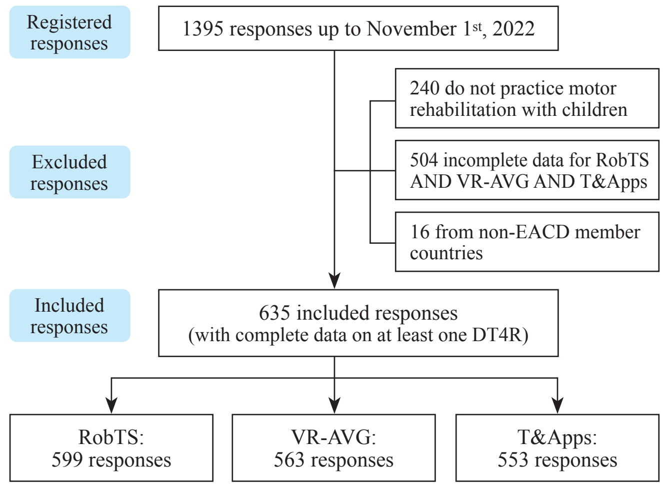

Figure 1.—Flow chart of the study.
DT4R: digital technologies for motor rehabilitation. RobTS: robotics and treadmill systems. VR-AVG: virtual-reality and active video-gaming. T&Apps: telehealth and apps.

Results

A total of 1395 responses were obtained between 1st January and 1st November 2022, and 635 were included in the analysis; 599 responses were complete for RobTS, 563 for VR-AVG, 553 for T&Apps (Figure 1). Excluded respondents did not significantly differ from included respondents apart from reporting twice more frequently having an "other" profession, twice more frequently being based in Northern Europe, and half less frequently being based in Western Europe.

Participant characteristics

Among the 635 included responses, 528 respondents were female; 52.6% were physiotherapists, 26.1% physicians and 15% occupational therapists. Answers were evenly distributed across the age categories. Responses were obtained from 30/43 EACD-member countries, with Western Europe being the most strongly represented region; 55.2% of respondents worked in public healthcare facilities (Table I).

Use and access, purpose of use, intention to use

Almost 70% of respondents reported using DT4R from at least one of the three categories (Figure 2A). Use of T&Apps and VR-AVG was higher (50.8% and 45.5%) than use of RobTS (36.6%) ($P<0.001$). Regarding access, 75% of respondents had access to DT4R from one or more of the three categories (Figure 2B). Access to T&Apps was the most widespread (61.8%), followed by VR-AVG (52.6%)

Table I.—*Participant characteristics. Respondents' sociodemographic characteristics, type of professional practice, and characteristics of their patients.*

Parameters	Value
Sociodemographic characteristics	
Occupation	
Physical therapist	334 (52.6%)
Occupational therapist	95 (15.0%)
Physician	166 (26.1%)
Others	40 (6.3%)
Gender	
Female	528 (83.1%)
Male	105 (16.5%)
Other	2 (0.31%)
Age group (years)	
18-34	211 (33.2%)
35-44	174 (27.4%)
45-54	133 (20.9%)
>55	117 (18.4%)
Years of experience	14.5±11.1
<10	242 (38.1%)
10-19	195 (30.7%)
20-29	117 (18.4%)
>30	81 (12.8%)
Diploma / academic degree	
Bachelor's Degree (*e.g.*, BSc)	227 (35.7%)
Research Masters (*e.g.*, MSc)	120 (18.9%)
Clinical Masters (*e.g.*, MOT, MPT, MRSC)	168 (26.4%)
MD	134 (21.1%)
PhD	87 (13.7%)
Others	118 (18.6%)
Type of professional practice	
European subregion*	
Western Europe	260 (40.9%)
Northern Europe	102 (16.1%)
Eastern Europe	54 (8.5%)
Southern Europe	173 (27.2%)
Other	46 (7.2%)
Type of healthcare facilities	
Public healthcare facility	408 (55.2%)
Private healthcare facility	183 (24.76%)
Private practice	98 (13.26%)
Others	50 (6.77%)
Size of healthcare facilities	
<100 children per week	387 (60.9%)
>100 children per week	248 (39.1%)
Characteristics of patients	
Age (years)	
0-6	564 (88.8%)
7-11	516 (81.3%)
12-17	473 (74.5%)
Diseases	
Cerebral palsy	578 (91%)
Neoplasms of the nervous system	139 (21.9%)
Intracranial injuries (*e.g.*, traumatic brain injury)	260 (40.9%)
Autism spectrum disorders	320 (50.4%)
Disorders of intellectual development	350 (55.1%)
Nerve, nerve root and plexus disorders (*e.g.*, brachial plexus disorder)	230 (36.2%)
Polyneuropathies (*e.g.*, Charcot Marie Tooth)	214 (33.7%)
Diseases of myoneural junction and muscle (*e.g.*, muscular dystrophy, Steinert dystrophia, congenital myopathies)	364 (57.3%)
Diseases of the musculoskeletal system and connective tissue (*e.g.*, arthropathies, osteopathies and chondropathies)	193 (30.4%)
Congenital malformations and deformations of the musculoskeletal system (*e.g.*, Arthrogryposis, Ehler Danlos, congenital malformations of the limb(s) or of the spine, osteochondroplasia)	311 (49.0%)
Spinal dysraphism / spinal cord malformations	233 (36.7%)
Diseases of the respiratory system	80 (12.6%)
Diseases of the circulatory system (*e.g.*, heart and vascular diseases)	44 (6.9%)
Chromosomal abnormalities (*e.g.*, Down Syndrome)	371 (58.4%)
Injuries to the upper and lower limbs, injuries to the spine (*e.g.*, contusion, fracture, dislocation, sprain, …)	180 (28.3%)
Other	57 (9.0%)

*Countries listed by Pons *et al.*[10] in the protocol description had been classified according to the United Nations Geoschemes (https://unstats.un.org/unsd/methodology/m49/).

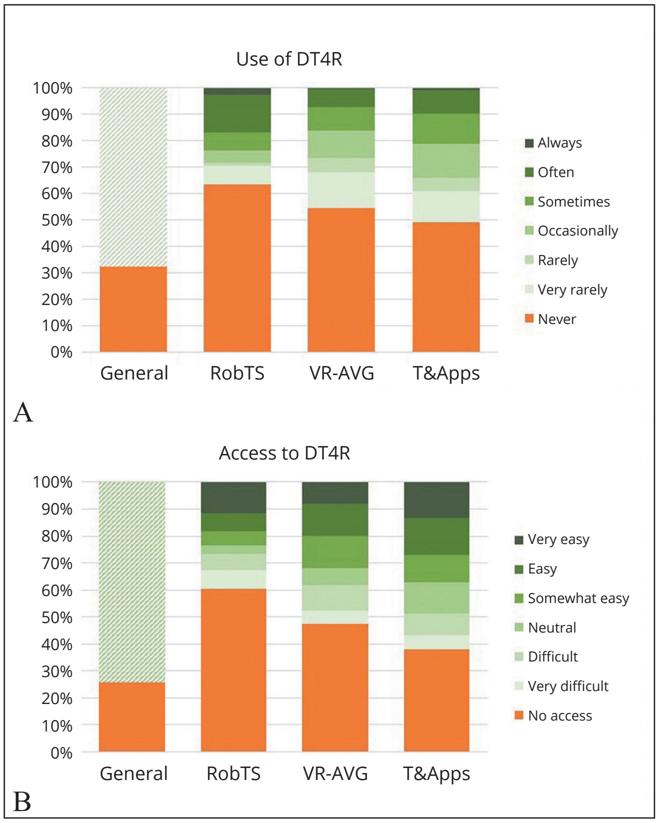

Figure 2.—A) Use and frequency of use of digital technologies for motor rehabilitation (DT4R). B) Access and ease of access to DT4R. RobTS: robotics and treadmill systems. VR-AVG: virtual-reality and active video-gaming. T&Apps: telehealth and apps.

and RobTS (39.6%) (P<0.001). Non-users of a given DT4R did not have access to it in 88.7%, 83.4%, 74.3% of the cases for RobTS, VR-AVG and T&Apps respectively. Regarding the purpose of use, RobTS were used to train walking and moving (33.2%), to improve joint, bone, muscle and movement function at the lower limb level (32.4%) and at the trunk level (26.4%). VR-AVG were used to improve lower limb (29.5%) and trunk function (28.8%), and to train changing and maintaining body position (27.8%). T&Apps were used to improve lower limb function (18.9%), to work on changing and maintaining body position (17.7%), and to facilitate community, social and civic life (17.2%). If they had access to them, 76.6%, 74.2% and 69% of all respondents at least somewhat agreed they would use RobTS, VR-AVG and T&Apps, respectively.

Determinants of access

For general access to DT4R, gender, profession, or size of healthcare facility were not significant determinants, whereas professional's age, years of experience, European subregion, type of healthcare facility, and children's ages were statistically significant determinants. For instance, respondents aged 35-44 years and >55 years reported lower access than those aged 18-24 years (OR 0.46, 95% CI 0.28-0.75, and OR 0.47, 95% CI 0.27-0.83, respectively). Professionals working in private healthcare facilities reported higher access than professionals working in public facilities (OR 2.25, 95% CI 1.35-3.74). Professionals caring for younger children only (younger than six years old) report-

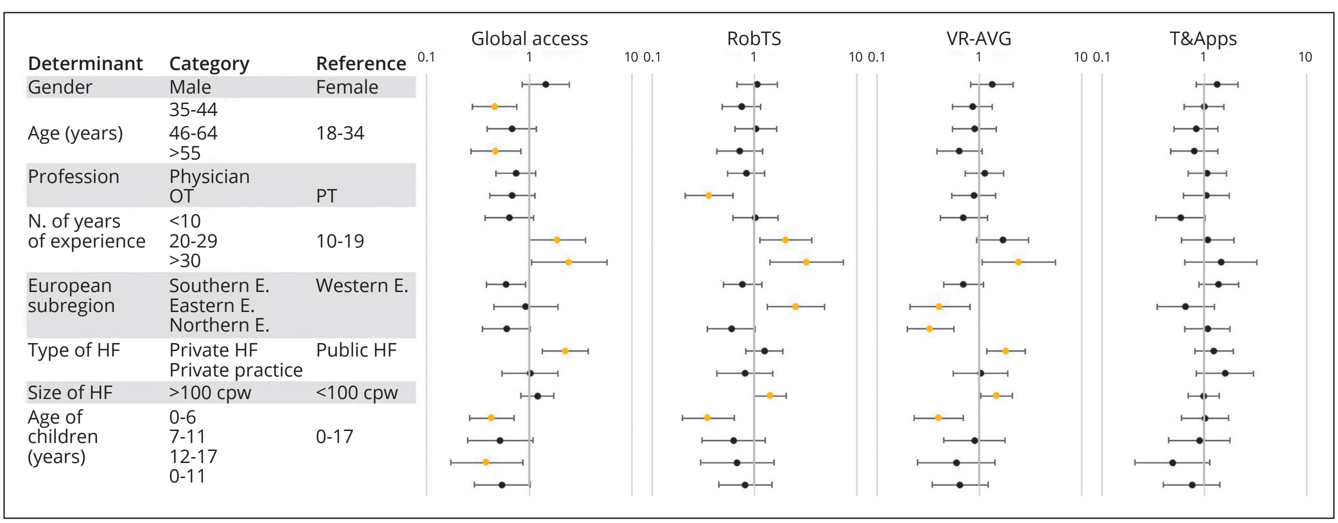

Figure 3.—Determinants of access. Odd ratios are represented for each category studied compared to the reference category, with their 95% confidence intervals. In yellow, statistically significant results (P<0.05).
cpw: children per week; HF: healthcare facility; OT: occupational therapist; PT: physiotherapist; E: Europe; RobTS: robotics and treadmill systems; VR-AVG: virtual-reality and active video-gaming; T&Apps: telehealth and apps.

ed lower access than professionals working with children of all ages (OR 0.43, 95% CI 0.26-0.71) (Figure 3) (Supplementary Digital Material 1: Supplementary Table I).

For RobTS, gender, professional's age or type of healthcare facility were not significant determinants of access. Profession, number of years of experience, European subregion, size of healthcare facility, and children's ages were statistically significant determinants. For VR-AVG, the influence of explored determinants was similar apart from profession (non-significant differences) and type of healthcare facility (statistically significant determinant). For both technologies, professionals caring for younger children only reported less access than professionals working with children of all ages (OR 0.35, 95% CI 0.2-0.64, and 0.4, 95% CI 0.2-0.64, for RobTS and VR-AVG respectively), and professionals working in bigger healthcare facilities (>100 children per week) reported more access than professionals working in smaller facilities (OR 1.43, 95% CI 1.01-2.04, and OR 1.48, 95% CI 1.04-2.1, respectively). For T&Apps, no significant differences were observed across the explored determinants.

Determinants of use and frequency of use

Non-users generally had no access to DT4R. Therefore, we studied the determinants of use for professionals who had access to DT4R, including, if applicable, "ease of access" defined as access somewhat easy to very easy (easier access) *versus* very difficult to neutral (more difficult access).

For each category of DT4R, ease of access was the main and a major determinant of use *versus* no use.

Regarding frequent use *versus* rare use (Figure 4) (Supplementary Digital Material 2: Supplementary Table II), for RobTS, gender, profession, years of experience, type of healthcare facility, children's ages were not significant determinants. Professional's age, European subregion, size of healthcare facility, and ease of access were statistically significant determinants. For VR-AVG, the influence of explored determinants was similar apart from professional's age (non-significant differences). For instance, when access was easier, professionals reported 11.94 (95% CI 6.25-22, RobTS) and 5.81 (95% CI 2.99-11.32, VR-AVG) times more frequent use than when access was more difficult. For T&Apps, no significant differences were observed across the explored determinants, except for gender, children's ages and ease of access. For instance, professionals caring for children aged 12-17 years reported more frequent use than professionals working with children of all ages (OR 3.78, 95% CI 1.04-13.79).

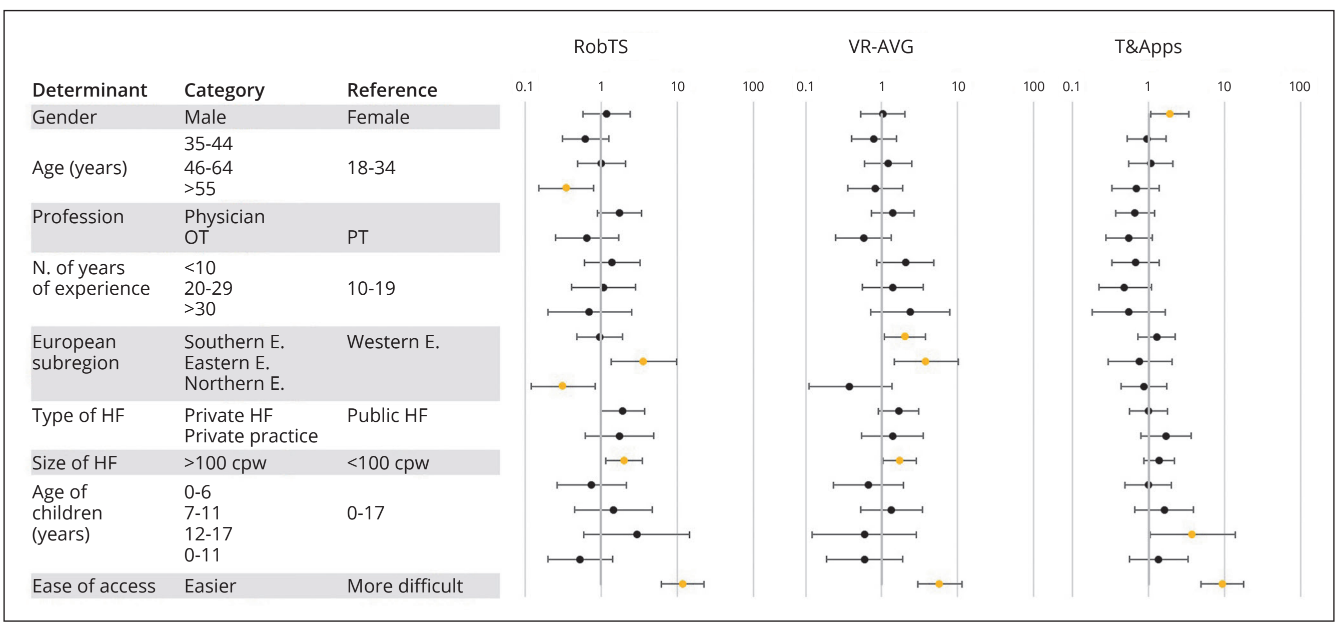

Figure 4.—Determinants of use. For respondents who declared having access to a given DT4R: comparison of those who use it once/week or more with those who use it less than once/week. Odd ratios are represented for each studied category compared to the reference category, with their 95% confidence intervals. In yellow, statistically significant results (P<0.05).
cpw: children per week; HF: healthcare facility; OT: occupational therapist; PT: physiotherapist; E: Europe; RobTS: robotics and treadmill systems; VR-AVG: virtual-reality and active video-gaming; T&Apps: telehealth and apps.

Barriers

The two barriers with the highest number of “major to extreme” ratings were a lack of financial resources and lack of initial training and training opportunities. Space-related issues were considered as a “major to extreme” barrier for 56.1%, 43.3% and 23.9% of respondents for RobTS, VR-AVG and T&Apps respectively. The two barriers with the highest number of “no barrier,” or “minor barrier” ratings were technophobia and lack of motivation of children and families. Opinions were divided regarding lack of accessible assistance, lack of accessible evidence, robustness, time needed to learn to use a DT4R, time to set up and tidy up (Figure 5).

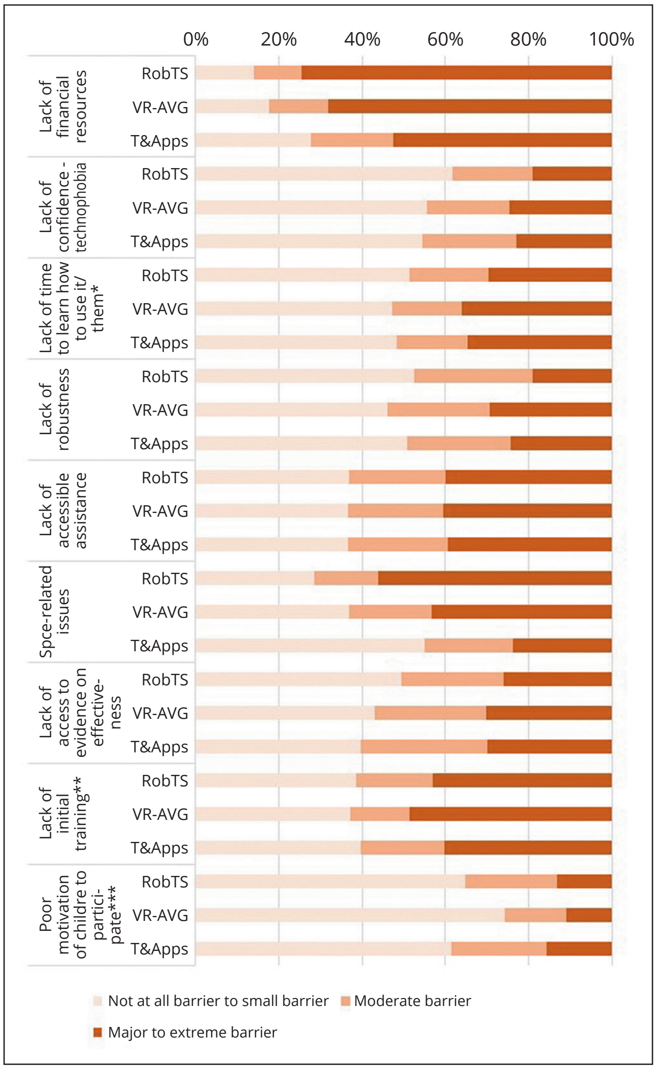

Figure 5.—Barriers to the implementation of digital technologies for motor rehabilitation (DT4R).
RobTS: robotics and treadmill systems; VR-AVG: virtual-reality and active video-gaming; T&Apps: telehealth and apps.
*Results were similar for the time to set up and tidy up; **results were similar for the lack of continued professional training; ***results were similar for the motivation of families to participate.

Discussion

This study found that DT4R were already used in clinical practice by around two-thirds of respondents, and that they generally wished to use them even more. The distribution of access across the three DT4R categories varied in a similar manner to the distribution of use, and non-users generally did not have access to DT4R. As hypothesized, both individual factors (professional’s age, years of experience and profession) and environmental factors (European sub-region, type and size of healthcare facility, and children’s ages) were determinants of access. Ease of access was a major determinant of use and frequency of use. Lack of financial resources and training opportunities were unanimously considered as barriers to DT4R use. Lack of motivation of children and families and technophobia were unanimously not considered as barriers. Therefore, given the strong intention to use DT4R, we aimed to identify from these results levers to facilitate DT4R implementation.

Ensuring easy access to DT4R for all

Although DT4R, especially T&Apps, are expected to improve equity of access to healthcare,[19, 22] the WHO has recently warned about inequities induced by current disparities in access to digital technologies.[20] In rehabilitation, access has been stated as a key priority to facilitate DT4R adoption.[23] However, access is generally not considered a barrier per se in the literature and is not often included as such in studies about barriers and enablers.[24] In our study, not only was access the main determinant of use, but ease of access was a determinant of frequency of use, highlighting the need for large improvements in access and ease of access to DT4R. Furthermore, respondents from private and bigger healthcare facilities reported more access to DT4R. Besides, a lack of financial resources was considered as a major barrier to the implementation of DT4R in this study and others.[18, 24] This finding underlines the need to outline material and logistic conditions to ensure easy access to DT4R for all. Further studies should focus on understanding why access to DT4R is easier in certain healthcare facilities to identify conditions that facilitate DT4R implementation. Collation of national guidelines on the effective implementation of DT4R would facilitate analysis of field data.[20]

Influence of socio-demographic characteristics of the respondents

As far as we know, few studies have compared access to and use of DT4R between different European countries. A European vision could facilitate the identification of levers to improve the uptake of DT4R. Some trends emerged in our study in the different European subregions. For instance, professionals from Eastern Europe reported a higher frequency of DT4R use regardless if access was easier than in the rest of Europe (RobTS) or less easy (VR-AVG). This suggests that when professionals are used to using DT4R, they make efforts to involve them more frequently in their practice. This finding echoes the high intention to use DT4R of rehabilitation professionals.

The younger respondents used DT4R most frequently. This finding may be linked to the need for training revealed in the analysis of barriers. Tremendous developments have been made in DT4R recently, and younger professionals may have benefited from training in their undergraduate studies, highlighting the need for both undergraduate and continued professional training to facilitate the implementation of DT4R.[18, 19]

Specificities of DT4R use depending on the child's age and rehabilitation goals

Use of and access to DT4R varied according to the ages of the children who were cared for. Professionals caring for younger children reported less access to and use of RobTS and VR-AVG. Those DT4R may not always be adapted to, specifically designed for or validated for children and their changing abilities,[21] particularly very small or young children[9] or those with severe cognitive impairments;[25] therefore, the lack of existing technological devices may at least partly explain the limited access for these specific populations. Furthermore, the impact of the use of virtual-reality on child development is debated[26] and data regarding this specific question is scarce; therefore, both manufacturers and pediatric societies[4] remain cautious in their recommendations for its use, especially for younger children. Recommendations based on solid evidence would avoid the stigmatization of technologies that may be useful for children.[26] Furthermore, the scarcity of data[26] echoes the lack of access to evidence reported as a barrier by half of respondents. As found previously,[4, 8, 9] the lack of motivation of children and families was not considered as a barrier to DT4R implementation.

The purpose of using DT4R varied with the ages of the children and type of DT4R. RobTS was used to train walking and moving, and VR-AVG to train the lower limbs and trunk and maintaining and changing body positions, which corresponds to current recommendations.[4, 8] Recommendations also support the use of VR-AVG to train upper-limb function.[4, 8] RobTS and VR-AVG are considered to efficiently increase task repetition and intensity, however further research is needed to determine the effect on more complex tasks and the transfer to the real-world environment. T&Apps was used to facilitate community, social and civic life. This finding echoes the fact that professionals caring for children aged between 12 and 17 years reported more frequent use of T&Apps than other professionals. Indeed, apps may be particularly suited for teenagers and young adults.[27] In rehabilitation, there is some evidence that T&Apps may facilitate the participation of children and youth with disabilities.[28]

These results suggest the need for specific recommendations regarding DT4R use according to: 1) the child's age – as proposed by Demont *et al.* for motor rehabilitation in cerebral palsy;[29] and 2) the purpose of use of the DT4R – as has been studied for VR-AVG and rehabilitation goals;[30] and the need for devices specifically designed and validated for children.

Limitations of the study

This study has several limitations. First, we did not use a validated questionnaire as none were available for our purpose. Therefore, we built our questionnaire using literature evidence[10] and pilot with a variety of respondents. Second, because of the convenience and snowball sampling, the sample may be not representative. However, this limitation was minimized by translating the survey to numerous European languages and disseminating it through national coordinators, resulting in responses from 30/43 countries. We found differences in the access to and use of DT4R in the different European subregions, however, the samples of respondents were not evenly distributed across Europe, despite dissemination of the survey through national coordinators. Further studies should focus on understanding why access to DT4R is easier in certain healthcare facilities and European subregions to identify conditions that facilitate DT4R implementation. Furthermore, to obtain a representative sample, data about the epidemiological characteristics of rehabilitation professionals would have been necessary, however they are scarce. Results on use and access might be overestimated due to a selection bias towards respondents interested in DT4Rs; however, their experience may have provided a more specific point of view on barriers, and the estimated associations with determinants are minimally hindered by limitations in representativeness.

Further research should complete these results with feedback from children and families.

Conclusions

DT4R are already used in clinical practice and professionals generally wish to use them even more. Our results suggest that DT4R implementation can be improved by outlining infrastructure and financial resources to ensure easy access to DT4R for all; developing specific recommendations for DT4R use according to the child's age and the purpose of use of the DT4R considering the need for devices specifically designed and validated for children; increasing the level of evidence of DT4R; and providing training opportunities for health professionals.

References

1. Kendall E, Oh S, Amsters D, Whitehead M, Hua J, Robinson P, *et al.* HabITec: A Sociotechnical Space for Promoting the Application of Technology to Rehabilitation. Societies (Basel) 2019;9:74.

2. Liu L, Miguel Cruz A, Rios Rincon A, Buttar V, Ranson Q, Goertzen D. What factors determine therapists' acceptance of new technologies for rehabilitation – a study using the Unified Theory of Acceptance and Use of Technology (UTAUT). Disabil Rehabil 2015;37:447–55.

3. Chen Y, Abel KT, Janecek JT, Chen Y, Zheng K, Cramer SC. Home-based technologies for stroke rehabilitation: A systematic review. Int J Med Inform 2019;123:11–22.

4. Rééducation et réadaptation de la fonction motrice de l'appareil locomoteur des personnes diagnostiquées de paralysie cérébrale; 2021 [Internet]. Available from: https://www.has-sante.fr/upload/docs/application/pdf/2021-12/_reco355_argumentaire_paralysie_cerebrale_cd_2021_10_21_post-endossement_lg.pdf [cited 2024, Sep 23].

5. Burton Q, Lejeune T, Dehem S, Lebrun N, Ajana K, Edwards MG, *et al.* Performing a shortened version of the Action Research Arm Test in immersive virtual reality to assess post-stroke upper limb activity. J Neuroeng Rehabil 2022;19:133.

6. Faria AL, Latorre J, Silva Cameirão M, Bermúdez I Badia S, Llorens R. Ecologically valid virtual reality-based technologies for assessment and rehabilitation of acquired brain injury: a systematic review. Front Psychol 2023;14:1233346.

7. Zanatta F, Giardini A, Pierobon A, D'Addario M, Steca P. A systematic review on the usability of robotic and virtual reality devices in neuromotor rehabilitation: patients' and healthcare professionals' perspective. BMC Health Serv Res 2022;22:523.

8. Novak I, Morgan C, Fahey M, Finch-Edmondson M, Galea C, Hines A, *et al.* State of the Evidence Traffic Lights 2019: Systematic Review of Interventions for Preventing and Treating Children with Cerebral Palsy. Curr Neurol Neurosci Rep 2020;20:3.

9. Phelan I, Carrion-Plaza A, Furness PJ, Dimitri P. Home-based immersive virtual reality physical rehabilitation in paediatric patients for upper limb motor impairment: a feasibility study. Virtual Real (Walth Cross) 2023;27:1–16.

10. Pons C, Brochard S, Grigoriu A, Newman CJ, Monbaliu E, Mensah-Gourmel J, *et al.* Digital technologies for motor rehabilitation in children: protocol for a cross-sectional European survey. BMJ Open 2023;13:e069034.

11. Wade SL, Narad ME, Shultz EL, Kurowski BG, Miley AE, Aguilar JM, *et al.* Technology-assisted rehabilitation interventions following pediatric brain injury. J Neurosurg Sci 2018;62:187–202.

12. Arntz A, Weber F, Handgraaf M, Lällä K, Korniloff K, Murtonen KP, *et al.* Technologies in Home-Based Digital Rehabilitation: scoping Review. JMIR Rehabil Assist Technol 2023;10:e43615.

13. Castelli E, Beretta E, De Tanti A, Arduini F, Biffi E, Colazza A, *et al.* Robot-assisted rehabilitation for children with neurological disabilities: Results of the Italian consensus conference CICERONE. NeuroRehabilitation 2022;51:665-79.

14. Liu C, Wang X, Chen R, Zhang J. The Effects of Virtual Reality Training on Balance, Gross Motor Function, and Daily Living Ability in Children With Cerebral Palsy: Systematic Review and Meta-analysis. JMIR Serious Games 2022;10:e38972.

15. Han Y, Park S. Effectiveness of virtual reality on activities of daily living in children with cerebral palsy: a systematic review and meta-analysis. PeerJ 2023;11:e15964.

16. World Health Organization. Global strategy on digital health 2020-2025. Geneva: World Health Organization; 2021.

17. Bower KJ, Verdonck M, Hamilton A, Williams G, Tan D, Clark RA. What Factors Influence Clinicians' Use of Technology in Neurorehabilitation? A Multisite Qualitative Study. Phys Ther 2021;101:pzab031.

18. Borges do Nascimento IJ, Abdulazeem H, Vasanthan LT, Martinez EZ, Zucoloto ML, Østengaard L, *et al.* Barriers and facilitators to utilizing digital health technologies by healthcare professionals. NPJ Digit Med 2023;6:161.

19. Stoumpos AI, Kitsios F, Talias MA. Digital Transformation in Healthcare: Technology Acceptance and Its Applications. Int J Environ Res Public Health 2023;20:3407.

20. World Health Organization. Equity within digital health technology within the WHO European Region: a scoping review. Copenhagen: WHO Regional Office for Europe; 2022.

21. Christy JB, Lobo MA, Bjornson K, Dusing SC, Field-Fote E, Gannotti M, *et al.* Technology for Children With Brain Injury and Motor Disability: Executive Summary From Research Summit IV. Pediatr Phys Ther 2016;28:483–9.

22. Senbekov M, Saliev T, Bukeyeva Z, Almabayeva A, Zhanaliyeva M, Aitenova N, *et al.* The Recent Progress and Applications of Digital Technologies in Healthcare: A Review. Int J Telemed Appl 2020;2020:1-18.

23. Kerr A, Smith M, Reid L, Baillie L. Adoption of Stroke Rehabilitation Technologies by the User Community: qualitative Study. JMIR Rehabil Assist Technol 2018;5:e15.

24. Li L, Tyson S, Weightman A. Professionals' Views and Experiences of Using Rehabilitation Robotics With Stroke Survivors: A Mixed Methods Survey. Front Med Technol 2021;3:780090.

25. Eckert M, Gómez-Martinho I, Meneses J, Martínez JF. New Approaches to Exciting Exergame-Experiences for People with Motor Function Impairments. Sensors (Basel) 2017;17:354.

26. Kaimara P, Oikonomou A, Deliyannis I. Could virtual reality applications pose real risks to children and adolescents? A systematic review of ethical issues and concerns. Virtual Real (Walth Cross) 2022;26:697–735.

27. Kickbusch I, Piselli D, Agrawal A, Balicer R, Banner O, Adelhardt M, *et al.*; Secretariat of the Lancet and Financial Times Commission. The Lancet and Financial Times Commission on governing health futures 2030: growing up in a digital world. Lancet 2021;398:1727–76.

28. Eide AH, Ofstad D, Støylen M, Hansen E, Høiseth M. Participation and Inclusion of Children and Youth with Disabilities in Local Communities. Int J Environ Res Public Health 2022;19:11893.

29. Demont A, Gedda M, Lager C, de Lattre C, Gary Y, Keroulle E, *et al.* Evidence-Based, Implementable Motor Rehabilitation Guidelines for Individuals With Cerebral Palsy. Neurology 2022;99:283–97.

30. Ferron A, Robert MT, Fortin W, Bau O, Cardinal MC, Desgagné J, *et al.* Virtual Reality and Active Video Game Integration within an Intensive Bimanual Therapy Program for Children with Hemiplegia. Phys Occup Ther Pediatr 2024;44:410–26.

Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
Javier de la Cruz and Christelle Pons contributed equally. Johanne Mensah-Gourmel, Saranda Bekteshi, Javier De La Cruz and Christelle Pons performed the data analysis and wrote the original draft. All authors contributed to the data acquisition, were regularly consulted upon data analysis, and contributed to the critical revision of the manuscript. All authors read and approved the final version of the manuscript.

Congresses
Preliminary analyses were presented at the 35th congress of EACD, May 2023, Ljubljana; at the 77th annual meeting of the American Academy for Cerebral Palsy and Developmental Medicine, September 2023, Chicago; and at the 38th congress of the French Society of Physical Medicine and Rehabilitation, October 2023, Le Havre; but the whole results have not been presented yet.

Acknowledgements
The authors wish to thank those who participated in creating and revising the survey, circulated it, and everyone who took the time to answer. They are also grateful to the EACD and the EACD national coordinators for the support in the creation and diffusion of this survey. Lastly, they would also like to thank Johanna Robertson for providing language assistance.

History
Article first published online: October 10, 2024. - Manuscript accepted: September 23, 2024. - Manuscript revised: July 11, 2023. - Manuscript received: April 17, 2024.

Supplementary data
For supplementary materials, please see the HTML version of this article at www.minervamedica.it