European Journal of Physical and Rehabilitation Medicine
EDIZIONI MINERVA MEDICA

**ARTICLE ONLINE FIRST**
**This provisional PDF corresponds to the article as it appeared upon acceptance.**
**A copyedited and fully formatted version will be made available soon.**
**The final version may contain major or minor changes.**

# Telecommunication and rehabilitation for patients with multiple sclerosis: access and willingness to use: a cross-sectional study

Caroline REMY, Maxime VALET, Gaetan STOQUART, souraya EL SANKARI, Vincent VAN PESCH, Alice DE HAAN, Thierry LEJEUNE

*European Journal of Physical and Rehabilitation Medicine* 2020 Apr 15
DOI: 10.23736/S1973-9087.20.06061-X

Article type: Original Article

© 2020 EDIZIONI MINERVA MEDICA

Supplementary material available online at http://www.minervamedica.it
Article first published online: April 15, 2020
Manuscript accepted: April 14, 2020
Manuscript revised: April 8, 2020
Manuscript received: October 26, 2019

**Subscription: Information about subscribing to Minerva Medica journals is online at:**
**http://www.minervamedica.it/en/how-to-order-journals.php**
**Reprints and permissions: For information about reprints and permissions send an email to:**
**journals.dept@minervamedica.it - journals2.dept@minervamedica.it - journals6.dept@minervamedica.it**

**EDIZIONI MINERVA MEDICA**

COPYRIGHT© EDIZIONI MINERVA MEDICA

# Telecommunication and rehabilitation for patients with multiple sclerosis: access and willingness to use: a cross-sectional study

Caroline Remy [a], Maxime Valet [a,b], Gaëtan Stoquart [a,b], Souraya El Sankari [c], Vincent Van Pesch [c], Alice De Haan [c], Thierry Lejeune [a,b,*].

[a] Cliniques universitaires Saint-Luc, Service de Médecine Physique et Réadaptation, Avenue Hippocrate 10, B-1200 Brussels, Belgium.

[b] Université catholique de Louvain, Secteur des Sciences de la Santé, Institut de Recherche Expérimentale et Clinique, Neuromusculoskeletal lab (NMSK), Brussels, Belgium.

[c] Cliniques universitaires Saint-Luc, Service de Neurologie, Avenue Hippocrate 10, B-1200 Brussels, Belgium

e-mail addresses of authors: caroline.remy@student.uclouvain.be; maxime.valet@uclouvain.be; gaetan.stoquart@uclouvain.be; souraya.elsankari@uclouvain.be; vincent.vanpesch@uclouvain.be; alice.dehaan@uclouvain.be; thierry.lejeune@uclouvain.be

*Corresponding author :
T. Lejeune, Service de Médecine Physique et de Réadaptation, Cliniques universitaires Saint-Luc, Avenue Hippocrate 10, B-1200 Brussels, Belgium.

E-mail address: thierry.lejeune@uclouvain.be

Word count: 3809

Abstract word count: 345

References: 39

Table: 1

Figures: 4

Supplementary file: 1

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA


## Abstract

**Background**: Telerehabilitation is a promising approach for patients with multiple sclerosis (MS), but uncertainties regarding patients' access and preferences remain.

**Aim**: To investigate the access to telecommunication technologies and rehabilitation services of patients with MS, and their willingness to use these technologies for rehabilitation.

**Design**: Cross-sectional survey.

**Setting**: Outpatient neurological facility.

**Population**: Patients with MS.

**Methods**: Patients with MS attending consultations in the Neurology department were asked to fill in a paper questionnaire. This anonymous questionnaire was designed to gain information about needs and access to rehabilitation and telecommunication technologies, as well as interests and perspectives of telerehabilitation among these patients. Descriptive statistics, chi-squared tests and logistic regressions were used to describe the sample and survey answers.

**Results**: Two hundred patients completed the questionnaire. Mean age was 44.41(±12.52) years. Seventy-one percent were women, and 49% were unemployed. Ninety-one percent of the patients regularly used internet and 73% used apps. Most patients were interested in using telecommunication technologies to receive a program of physical exercises (62%), for information and personalized advice about physical activity and MS (69%), and to communicate with caregivers (75%). Patients with EDSS>4 were less interested than patients with EDSS≤4 in communicating with the caregivers via apps (33%vs52%,Δ19%[CI-36%;-2%],p=0.04) but expressed greater interest in receiving information and personal advice about physical activity and MS via the internet (70%vs51%,Δ19%[CI+2%;+36%],p=0.03). One third


This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

of the patients was not interested in receiving telerehabilitation interventions (32%), notably patients with EDSS>4 and non-workers.

**Conclusions**: Patients with MS are mainly interested in using telecommunication technologies for rehabilitation services, and most of these patients have access to the required technology. Being mildly disabled and having a professional activity are associated with a greater interest in telerehabilitation. In contrary, patients with moderate-to-severe disability and non-workers have reportedly less access and ease in using the required technologies.

**Clinical rehabilitation impact**: Telerehabilitation is feasible and wished by patients with MS, specifically in patients with low EDSS scores and workers. Given the strong need for rehabilitation in more disabled patients, the barriers to its access, the lower access and ease of use of telecommunication technologies, a special effort is needed to facilitate their use in these patients.

**Keywords**: telerehabilitation, multiple sclerosis, rehabilitation, telecommunication

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

# Introduction

Multiple sclerosis (MS) is a chronic and incurable disease of the central nervous system, affecting around 2.4 million persons worldwide.[1] The diagnosis is most frequently made during the third or fourth decade of life.[2] The healthcare needs in this population are complex and require long-term multidisciplinary management to preserve central nervous system integrity.[3] There is strong evidence that multidisciplinary rehabilitation in patients with MS has positive short-term effects on functional capacity and long-term effects on quality of life.[4] A recent systematic review of systematic reviews shows that strong evidence supports the use of physical therapeutic modalities to improve functional outcomes (especially ambulation and muscle strength), reduce fatigue and improve quality of life.[5] Recently, many rehabilitation interventions have been assessed in patients with MS. For example, constraint-induced movement therapy is effective in patients with MS to improve muscle strength and dexterity[6] and whole-body vibration training promotes strength and endurance of their core muscles, which impairment can limit patients' functioning[7]. Another example is a task-oriented upper limb training program that lead to several significant functional benefits among patients with MS.[8]

Many patients have limited access to rehabilitation services, and many are physically inactive. Use of rehabilitation services is often limited because of lack of energy, reduced mobility, transportation costs, service costs and/or restricted availability.[4,9] A cross-sectional survey reported that the total mean annual cost per patient was 26 400€ for mildly-disabled patients, 45 300€ for patients with moderate disability, and 62 000€ for patients with severe disability, in Belgium.[10] This recent study also showed that the use of health services and its cost has considerably increased. With growing financial constraints on healthcare systems, alternative cost-effective and efficient methods of rehabilitation should be a priority. In this context, telerehabilitation could be an interesting solution.

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

Telerehabilitation is defined as "the use of information and communication technologies as a medium for the provision of rehabilitation services to sites or patients that are at a distance from the provider".[11] It constitutes one of the components of telehealth, which denotes the use of telecommunications technologies in a health care perspective.[12] There seems to be room for telehealth, including telerehabilitation, as communication technologies are thriving. In 2015, in Belgium, 82% of households had internet access. Eighty-four percent of Belgians and 76% of Europeans connect to the internet at least once a week. Moreover, mobile devices, especially cell phones, smartphones and tablets, occupy a growing proportion of a household's connected devices.[13] Based on this data from the general population, technological basis for telerehabilitation seems widely available, supporting the feasibility of such an approach. Furthermore, as more participants can be involved simultaneously, telerehabilitation can provide fairer access to individuals separated by geographical distance, or with physical or economical constraints.[14]

Given the age at diagnosis of the majority of the patients with MS, they are likely to be familiar with modern technology. Consequently, these patients seem to be a privileged target population for telerehabilitation interventions. Thus, the recent boom in the integration of telecommunications technologies in studies involving patients with MS was expected. Studies involving a wide range of telecommunication technologies in a healthcare perspective among patients with MS have been recently reviewed elsewhere.[15]

Telerehabilitation has been widely studied in patients with various disorders of the central nervous system. [16] This approach seems feasible and effective in many neurologic diseases (*e.g.*, stroke[17], Parkinson's disease[18], …). Nevertheless, there is a lack of evidence for the effectiveness of telerehabilitation in MS. [19] There is low quality evidence concerning short-term improvement in fatigue and quality of life, and long-term improvement in disability. The cost-effectiveness of telerehabilitation and preferred intensity and type of program are still unknown.

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

However, telerehabilitation trials have shown encouraging results in improving functioning of patients with MS. It is therefore worthy to encourage research regarding telerehabilitation in MS to improve this approach and optimally implement it in clinical settings.

Access and willingness to use telecommunication technologies are essential prerequisites to benefit from telerehabilitation interventions. While the Internet constitutes the first source of information for a large proportion of patients with MS [20], acceptance of app-based interventions for disease management remains variable among these patients, depending on a wide range of personal and environmental factors. [21, 22] In a rehabilitation strategy, patients' access, ease to use and perspectives should be incorporated into every therapeutic program, to ensure adherence and effectiveness, however, this is often overlooked. [19] A better understanding of the technological preferences and access of patients with MS is essential. The main aim of this study was to investigate, among patients with MS, the perceived needs, access and barriers to rehabilitation, as well as the access to telecommunication technologies and willingness to use them to receive rehabilitation services. The secondary aim was to explore potential differences among patients depending on disease severity.

## Materials and Methods

### *Study design and participants*

This cross-sectional study was performed in the Department of Physical and Rehabilitation Medicine and in the Department of Neurology of the Cliniques universitaires Saint-Luc, Brussels, Belgium. Patients attending a follow-up visit received an informed consent form, briefly presenting telerehabilitation. After they signed it, they were given an anonymous questionnaire. They were asked to fill out the questionnaire while sitting in the waiting room before the consultation. If a patient had difficulty with any part of the questionnaire, the

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

consulted neurologist (VVP or SES) could clarify the questions during the consultation. Consultants were not involved in the analyses of the data. Only patients with sufficient cognitive and linguistic abilities to correctly understand the questionnaire were included in this study. All the patients were recruited between February and May 2017. Our study was approved by the Ethics Committee of the "Cliniques universitaires Saint-Luc" on January 13th, 2017 (B403201526348). We followed the STROBE guidelines while reporting this study. [23]

### *Measures*

A French-language paper questionnaire was developed to collect data about needs, access, interests and perspectives of telerehabilitation among patients with MS. The questionnaire was designed to assess patients' self-reported perception of current rehabilitation services, access and ease in using telecommunication technologies, and willingness to use rehabilitation interventions. It was similar to a questionnaire which was used among patients with stroke. [24] Subsequently, the questionnaire was tested on healthy volunteers and adapted for comprehensibility.

The EDSS scale was used to quantify the neurologic disability of the participants. This scale, ranging from 0 to 10, is based on a neurological examination. A score of 4 or less indicates so-called mild neurological disability without walking distance limitation, while scores higher than 4 indicate moderate-to-severe disability with walking distance limitation. [25] Patients filled the questionnaire by themselves and the EDSS score was completed by the Neurologist (VVP or SES). The first part of the questionnaire explored the perceived time invested in rehabilitation, access and perceived barriers to rehabilitation. Questions about access and use of telecommunication and consumer-based monitoring technologies were also included, in the second part of the questionnaire. The third part addressed the patients' interest in using these technologies in a telerehabilitation purpose. The last few questions dealt with elements that

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

could increase interest in practicing a physical activity. The questionnaire is available as a supplementary material.

### *Data analysis*

Data was processed using Excel 2016 (Microsoft Corporation, USA) and SigmaPlot V13.0 (Systat Software, USA). Univariate descriptive statistical analyses were used to characterize the sample and the response rate. Missing data was reported. Bivariate descriptive statistical analyses and chi-squared tests were carried out to compare difficulties in access to rehabilitation, access to technology and interest in using telerehabilitation, depending on working status and disease severity (EDSS score). These tests were also carried out to explore differences in the practice of sport and prescription of physiotherapy in different groups of patients. Z-tests were also used to obtain confidence intervals on absolute difference between subgroups. Chi-squared tests were performed to explore the relationships between physical activity participation and physiotherapy (dichotomous outcome: participation versus non-participation). We conducted a logistic regression analysis to identify variables predictive of an interest in using telecommunication technologies. For all analyses, the threshold of statistical significance was set at $p=0.05$.

## Results

### *Sample characteristics*

Two hundred patients completed the questionnaire. The number of responses for each item ranged from 172 (86%) to 199 (99.50%), with an overall response rate of 97%.

Demographic and MS-related data are presented in Table I. The mean age of this mostly female (71%, sex ratio: 2.43) sample was 44.41(±12.52) years. Forty-nine percent of the patients were unemployed, of whom 75% were on sick leave. The median EDSS score was 2.50[1;4]; 77%

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

of the patients were classified as mildly-disabled (EDSS≤4). Among these mildly-disabled patients, the mean age was lower and the average duration of disease was shorter than patients with moderate-to-severe disability (EDSS>4) (41.39 vs 54.52 years; 11.70 vs 21.29 years). It should be noted that, according to their reports, 83% of the patients did not follow the global recommendations on physical activity for health (*i.e.*, a minimum of 150 minutes per week of moderate physical activity). [26]

### *Access to rehabilitation services and difficulties with access*

Ninety-eight percent of the sample consulted a neurologist on a regular basis, three times a year, on average. Thirteen percent of all the patients visited a specialist in Physical Medicine and Rehabilitation at least once a year. Forty-four percent of the patients were benefiting from physiotherapy. Fifty-two percent practiced recreational physical activity. There was no relationship between benefiting of physiotherapy and reporting any physical activity (p=0.48).

However, a greater proportion of patients with mild disability reported practicing a sport (61%) than individuals with moderate-to-severe disability (36%, Δ25% [CI +8%;+42%], p<0.01). A smaller proportion of patients with mild disability reported receiving physiotherapy (29%) than individuals with moderate or severe disability (88%, Δ59% [CI -76%;42%], p<0.01). Nineteen percent of patients benefited from home-based physiotherapy, while the remainder of the cohort travelled an average of 6.66 km for physiotherapy. Seventy-four percent of all the participants reported some difficulty in accessing rehabilitation. People with mild disability reported more difficulty accessing rehabilitation sessions (81%) than those with moderate-to-severe disability (63%, Δ18% [CI +4%;+33%], p=0.03). Difficulties were reported as being mainly because of fatigue (77%), limited mobility or pain due to MS (78%). These limitations of mobility and pain were more pronounced in unemployed (90%) than in employed patients (60%, Δ30% [CI +18;+42%], p<0.01). Difficulties were also reportedly due to lack of motivation (50%), cost of rehabilitation sessions (45%), and transport issues (40%), especially among non-workers than

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

among workers (49% vs 26%, Δ23% [CI +10%;+37%], p=0.03). A busy schedule was reported as a limiting factor for 34% of the patients, more frequently among workers (60%) than among non-workers (16%, Δ44% [CI +30%;+58%], p<0.01). Approximately one-fifth of the participants reported that the time invested in non-pharmacological treatment of their disease was not sufficient, regardless of whether they were receiving physiotherapy (21%) or not (18%, p=0.61).

### *Use of communication technologies*

Ninety percent of the sample reported that they owned at least one computer, with 73% of respondents owning at least one laptop and 38% owning at least one desktop. These percentages were similar across the range of neurological disability. Ninety-six percent of the sample had access to a cell phone. Smartphone use (73%) was higher in individuals with mild disability (79%) than in individuals with moderate-to-severe disability (46%, Δ33% [CI +18%;+49%], p<0.01) and among workers (88%) than among non-workers (54%, Δ34% [CI +21%;+47%], p<0.01). The ownership and use of communication and physical activity-related technologies are presented in Figures 1 and 2.

### *Patients' perspectives of telerehabilitation*

More than half of the patients reported an interest in receiving a program of physical exercises (62%), information and personalized advice about physical activity and MS (69%), and in communicating with their caregivers (75%) via telecommunication technologies. Figure 4 shows the interest in receiving rehabilitation services by the mean telecommunication. Patients expressed more interest in using the internet (52%) and apps (44%) for these activities than short text messages, telephone and television. For communicating with their caregivers, the patients expressed an interest in using short text messages (28%) or the telephone (31%). Patients with mild disability were as interested as people with moderate-to-severe disability in

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

receiving a program of physical exercises (61% vs 65%, p=0.72), receiving information and personalized advice about physical activity and MS (66% vs 80%, p=0.10), and communicating with their caregivers (74% vs 75%, p=0.95) via communication technologies. Patients with moderate-to-severe disability were less interested in communicating with the caregivers via apps (33% vs 52%, Δ19% [CI -36%;-2%], p=0.04) but expressed greater interest in receiving information and personal advice about physical activity and MS via the internet (70% vs 51%, Δ19% [CI +2%;+36%], p=0.03) than patients with mild disability. Similarly, workers did not differ from non-workers in their interest in receiving a program of physical exercises (66% vs 56%, p=0.18), in receiving information and personal advice about physical activity and MS (72% vs 64%, p=0.26) or in communicating with the caregivers (80% vs 68%, p=0.07) via telecommunication technologies.

Thirty-eight percent of the patients replied that having external goals (e.g., running the '20 km of Brussels') could enhance their interest in practicing a physical activity. Fifty-one percent of the patients said that receiving personalized exercises in paper form or via an app may increase their interest in practicing a physical activity. Thirty-six percent of the participants reported that joining group sessions, on a regular basis, could motivate them to be physically active. However, 70% of the participants reported that practicing exercises by themselves (individually, without time restriction), could increase their interest in practicing a physical activity. Figure 3 illustrates the reported interest in practicing a physical activity.

In the logistic regression analysis, working status and disease severity were predictors of the interest in using telecommunication technologies for rehabilitation. There was no confounding effect of age or other demographic variables. Individuals with moderate-to-severe disability were 3.33 times less likely to be interested in receiving a program of physical exercises via communication technologies, than individuals with mild disability, regardless of occupational status. Patients in work were 2.64 times more likely to be interested in receiving a program of

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

physical exercises via communication technologies, than non-workers, regardless of EDSS status.

## Discussion

This study explored the perceived needs and barriers to rehabilitation for patients with MS, their access to telecommunication technologies and willingness to use these technologies to receive rehabilitation interventions. About three-quarters of the respondents reported that they had difficulty accessing the rehabilitation interventions they needed. This study showed that many patients with MS are interested in using telerehabilitation. Indeed, more than half of the participants reported an interest in receiving internet- or application-based telerehabilitation programs. These two technologies were reportedly used at least once a week by the majority of the patients. Two thirds of our sample reported that the opportunity to perform sessions of exercises by themselves, guided and monitored by the means of telecommunication technologies, would increase their interest in practicing a regular physical activity. On the other hand, only a third reported that joining a group would motivate them to practice that activity.

The main barriers to physical exercise for people with MS were reported to be fatigue, impaired mobility and time constraints. [27] Telerehabilitation could constitute an optimal approach to facilitate adaptation of physical exercise interventions according to lifestyle and needs of patients with MS, and, consequently, to improve physical activity participation among patients with MS. Dlugonski et al. showed that physical activity was significantly improved in patients with MS using a web-based video-coaching intervention. [28] Learmonth et al. showed that patients with MS expect exercise materials to facilitate planning, goal-setting and exercise accountability (e.g., activity trackers, mobile phone applications with exercise diaries). [29] In our survey, although very few patients possessed consumer-based activity trackers and sport-centered connected devices, a large proportion of these patients expressed an interest in using

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

telecommunication technologies to interact with caregivers. These technologies could therefore be used to inform patients about the benefits of exercise, as well as providing them with strategies to initiate and maintain exercise behavior.

Recently, Tallner et al. studied the implementation of a web-based intervention among patients with MS. [30] Although participants reported high acceptance and satisfaction with the programs, compliance was a major issue. However, the question of willingness and perspectives in using technologies for rehabilitation interventions has seldom been studied among patients with chronic neurological conditions. A Canadian study analyzed interest in receiving specific rehabilitation services, such as delivery of physical exercise programs or information and personal advice, via various telecommunication tools among patients with stroke. [24] Although they concluded that telerehabilitation is desirable by post-stroke patients, this population seems less prone to use such an approach than patients with MS. In that study, 20% of patients did not own a computer (10% in our sample), 30% did not have access to a cell phone (5% in our sample) and 39% of the participants were not interested in receiving telerehabilitation (32% in our study). These differences could be explained by a higher mean patient age compared to that of our sample (67.6 years vs 44.41 years), reflecting the mean ages of the populations with these two diseases. Furthermore, most of the participants in the latter study had severe disabilities, whereas most of our patients had mild neurological disability. MS could therefore be a privileged context within the field of neurology to develop and implement telerehabilitation.

Our findings, among a large sample representative of the European population with MS, suggest that many patients are interested in receiving telerehabilitation. We observed that patients with mild disability and patients who work are the most interested in telerehabilitation. The use of technologies to provide rehabilitation services is both feasible and desirable by these groups of patients. They could constitute a privileged target for such interventions to increase patient compliance and rehabilitation intensity. It would be suitable to prioritize the development of

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

telerehabilitation programs for the needs of these patients. Nevertheless, it remains necessary to develop facilitation and/or alternative strategies to enable non-workers patients and~~/or~~ those with moderate or severe disability to also benefit from this type of program. Indeed, these latter groups have less access to telerehabilitation technologies and seem less comfortable using it. Given their high needs for and strong barriers to accessing rehabilitation, special effort should be taken to promote and facilitate the use of telerehabilitation in this subgroup of patients. It is then plausible that if the technological devices were adapted for people with physical and functional deficits, there would be greater interest in telerehabilitation. To date, telerehabilitation should be considered as a complementary approach in the management of patients with MS.

It would be opportune to encourage the development of web-based programs for the implementation of telerehabilitation by patients with MS. Among individuals with moderate or severe disability, apps were of less interest than the internet. Within this group, fewer patients used smartphones. This observation may be explained by a more severe neurological impairment in this group, because of visual, motor or ataxic deficits, as well as their higher mean age. A previous study carried out among moderately-disabled patients with MS, demonstrated their interest in web-based rehabilitation. Participants mainly reported that the website was easy to use, practical and rewarding. [31] Web-based interventions have been suggested as an effective medium for delivery of exercise interventions to patients with MS. [30] Furthermore, the use of smartphones is constantly growing worldwide. It is estimated that in 2020 there will be 6.1 billion smartphone users, which will represent approximately 80% of the world population. [32, 33] App-based interventions could be an interesting complementary approach.

Clinical manifestations of MS should be considered when implementing telerehabilitation interventions. For example, an enlarged keyboard or audio signals could simplify use of

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

technological devices for patients with visual disorders. [24] Symptoms linked to MS, such as fatigue, limited mobility and pain, represent significant barriers to accessibility of in-person rehabilitation. These symptoms should be considered when designing telerehabilitation approaches, to allow patients to perform their exercises at the most suitable time. It is also essential to consider cognitive impairments during implementation of telerehabilitation for patients with MS. Indeed, up to 70% of these patients have impaired cognition, essentially episodic memory, attention, verbal fluidity and information processing. [34] Although these factors can limit use of telerehabilitation programs, studies have shown that implementation of telerehabilitation is feasible for patients with cognitive disorders. [35, 36] Preliminary training, continued until the techniques are mastered by the patient and adapted to the patient's learning rhythm, is necessary for patients with cognitive disorders. [37] Validated neuropsychological tests are available for patients with MS, widely accepted and could enable to identify patients with cognitive disorders so that preliminary steps could be undertaken when considering telerehabilitation in those patients. [38]

Finally, strategies are needed to increase the motivation of patients with MS for using telerehabilitation programs. Implementation of game-design elements has been successful to increase compliance to internet-delivered interventions. [39] In addition, integration of social networks seems to be a promising strategy, especially among individuals with moderate or severe disability. Moreover, online support (goal setting, exercise promotion, feedback) through a personal healthcare provider may result in greater long-term adherence to the programs. [29, 40]

A non-negligible proportion of our sample did not possess a computer (10%) or a smartphone (30%). Furthermore, one third of participants are not interested in using telecommunication technologies to receive a program of physical exercises, to receive information and personalized advice about physical activity and MS, or to communicate with caregivers. This suggests that

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

a substantial proportion of patients with MS would not be able to access telerehabilitation services or willing to receive rehabilitation using technology. Consequently, to date, telerehabilitation is not a candidate to entirely replace face-to-face rehabilitation but is rather a complementary approach in the healthcare setting. Therefore, encouraging research regarding telerehabilitation in MS to improve this approach and optimally implement it in clinical settings are key areas for future research.

### *Limitations*

Some limits to our work must be mentioned. The self-reported nature of our data acquisition could result in bias related to the patients' cognitive state. Indeed, cognitive disorders are frequent in MS and vary according to sex, duration and clinical form of the disease, psychiatric comorbidities, as well as genetics. [41] However, our questionnaire was based on a questionnaire previously used among patients with stroke, and slightly adapted to our population. A testing phase among healthy subjects allowed us to ensure its understandability. [42] Irrelevant answers were removed during analysis. Consequently, cognitive deficits should not have interfered in a significant manner with the acquisition of our data. To limit selection bias, the questionnaire was given to participants in paper form, and not via internet or other telecommunication techniques. This allowed inclusion of patients who had less access to technological devices. The Neurologists could potentially bias the patients' answers. However, they met the patients after they had filled the questionnaire. They interfered as less as possible, not at all in the vast majority of the cases, and never answered in place of the patients. It is then unlikely that caregivers significantly influenced patients' answers. EDSS cut off of 4 might represent a potential bias in evaluating sport participation in that individuals with moderate-to-severe disability reported that they had more difficulty practicing a sport than did individuals with mild disability. However, this difference could be explained by a higher functional limitation in patients with moderate-to-severe disability.

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

Finally, although there is a risk of bias related to the inclusion of patients from the Department of Neurology of the "Cliniques universitaires Saint-Luc", our sample is representative of the European population with MS in terms of demographic- and disease-related characteristics, which supports the external validity and thus the generalizability of our results.

## Conclusion

Patients with MS support the use of technologies to provide rehabilitation services and most patients have access to the necessary technology. However, patients with moderate-to-severe disability and non-workers have, on average, less access and ease in using these technologies for a rehabilitation purpose. Given their high need of and strong barriers to rehabilitation, special effort is necessary to promote and facilitate the use of telecommunication in this setting.

## Conflicts of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

## Funding

This research was partly financed by the ARSEP, FRS-FNRS, the Bourse de mobilité Allergan-SOFMER and the Fondation Saint-Luc.

## Acknowledgements

We wish to thank Louise Declerck for her assistance in copyediting the English text.

## Authors' contribution statement

Caroline Remy participated to the design of the study, assisted with data collection, participated in data analysis and interpretation of results, did literature searches, and drafted the manuscript.

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

Maxime Valet was the initiator of the study, participated in the design of the study, assisted with data collection, participated in data analysis and interpretation of results, did literature searches, and drafted the manuscript. Gaëtan Stoquart and Thierry Lejeune oversaw and coordinated study activities, provided advice and input to methodological and theoretical issues, participated in the interpretation of results and revised the manuscript. Souraya El Sankari, Vincent Van Pesch and Alice De Haan participated to the design of the study, assisted with data collection and interpretation of results, and revised the manuscript.

This study was orally presented at the Congress of the ISPRM-SOFMER, Paris, 8-12 July 2018 by Caroline Remy.

## Supplementary files

Additional information regarding methods and results could be obtained by contacting the corresponding author.

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

# References


1. Organization WH. Atlas: country resources for neurological disorders 2004: results of a collaborative study of the World Health Organization and the World Federation of Neurology. 2004.
2. Ramagopalan SV, Sadovnick AD. Epidemiology of multiple sclerosis. Neurologic clinics 2011;29:207-217.
3. Giovannoni G, Butzkueven H, Dhib-Jalbut S, et al. Brain health: time matters in multiple sclerosis. Mult Scler Relat Disord 2016;9 Suppl 1:S5-s48
4. Khan F, Gray O. Disability management and rehabilitation for persons with multiple sclerosis. Neural Regeneration Research 2010;5:301-309.
5. Khan F, Amatya B. Rehabilitation in Multiple Sclerosis: A Systematic Review of Systematic Reviews. Arch Phys Med Rehabil 2017;98(2):353-367.
6. de Sire A, Bigoni M, Priano L, Baudo S, Solaro C, Mauro A. Constraint-Induced Movement Therapy in multiple sclerosis: Safety and three-dimensional kinematic analysis of upper limb activity. A randomized single-blind pilot study. NeuroRehabilitation 2019;45(2):247-254.
7. Abbasi M, Kordi Yoosefinejad A, Poursadeghfard M, Parsaei Jahromi F, Motealleh A, Sobhani S. Whole body vibration improves core muscle strength and endurance in ambulant individuals with multiple sclerosis: A randomized clinical trial. Mult Scler Relat Disord 2019;32:88-93.
8. Lamers I, Raats J, Spaas J, Meuleman M, Kerkhofs L, Schouteden S, Feys P. Intensity-dependent clinical effects of an individualized technology-supported task-oriented upper limb training program in Multiple Sclerosis: A pilot randomized controlled trial. Mult Scler Relat Disord 2019;34:119-127.
9. Rasova K, Martinkova P, Pavlikoma M, et al. Physical therapy provision in multiple sclerosis across Europe: a regional lottery? European journal of physical and rehabilitation medicine 2015;51:850-852.
10. Dubois B, Kobelt G, Berg J, Capsa D, Gannedahl M. New insights into the burden and costs of multiple sclerosis in Europe: Results for Belgium. Mult Scler 2017;23:29-40.
11. Brennan DM, Mawson S, Brownsell S. Telerehabilitation: enabling the remote delivery of healthcare, rehabilitation, and self management. Studies in health technology and informatics 2009;145:231-248.
12. Dorsey ER, Topol EJ. State of Telehealth. 2016;375:154-161.
13. SPF Economie PME, Classes moyennes et Energie. Baromètre de la société de l'information 2018 [online]. Available at: https://economie.fgov.be/fr/publications/barometre-de-la-societe-de. Accessed 03/01/2019.
14. Hailey D, Roine R, Ohinmaa A, Dennett L. Evidence of benefit from telerehabilitation in routine care: a systematic review. Journal of telemedicine and telecare 2011;17:281-287.
15. Marziniak M, Brichetto G, Feys P, Meyding-Lamade U, Vernon K, Meuth SG. The Use of Digital and Remote Communication Technologies as a Tool for Multiple Sclerosis Management: Narrative Review. JMIR rehabilitation and assistive technologies 2018;5:e5.
16. Agostini M, Moja L, Banzi R, et al. Telerehabilitation and recovery of motor function: a systematic review and meta-analysis. Journal of telemedicine and telecare 2015;21:202-213.
17. Laver KE, Schoene D, Crotty M, George S, Lannin NA, Sherrington C. Telerehabilitation services for stroke. The Cochrane database of systematic reviews 2013:Cd010255.
18. Seidler KJ, Duncan RP, McNeely ME, Hackney ME, Earhart GM. Feasibility and preliminary efficacy of a telerehabilitation approach to group adapted tango instruction for people with Parkinson disease. Journal of telemedicine and telecare 2016.
19. Amatya B, Galea MP, Kesselring J, Khan F. Effectiveness of telerehabilitation interventions in persons with multiple sclerosis: A systematic review. Mult Scler Relat Disord 2015;4:358-369.
20. Marrie RA, Salter AR, Tyry T, Fox RJ, Cutter GR. Preferred sources of health information in persons with multiple sclerosis: degree of trust and information sought. Journal of medical Internet research 2013;15:e67.


This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

21. Apolinario-Hagen J, Menzel M, Hennemann S, Salewski C. Acceptance of Mobile Health Apps for Disease Management Among People With Multiple Sclerosis: Web-Based Survey Study. JMIR formative research 2018;2:e11977.
22. Giunti G, Kool J, Rivera Romero O, Dorronzoro Zubiete E. Exploring the Specific Needs of Persons with Multiple Sclerosis for mHealth Solutions for Physical Activity: Mixed-Methods Study. JMIR mHealth and uHealth 2018;6:e37.
23. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. International journal of surgery (London, England) 2014;12:1495-1499.
24. Edgar MC, Monsees S, Rhebergen J, et al. Telerehabilitation in Stroke Recovery: A Survey on Access and Willingness to Use Low-Cost Consumer Technologies. Telemedicine journal and e-health : the official journal of the American Telemedicine Association 2016.
25. Kurtzke JF. Rating neurologic impairment in multiple sclerosis: an expanded disability status scale (EDSS). Neurology 1983;33:1444-1452.
26. Organization WH. Global recommendations on physical activity for health. 2015.
27. Asano M, Duquette P, Andersen R, Lapierre Y, Mayo NE. Exercise barriers and preferences among women and men with multiple sclerosis. Disabil Rehabil 2013;35:353-361.
28. Dlugonski D, Motl RW, McAuley E. Increasing physical activity in multiple sclerosis: replicating Internet intervention effects using objective and self-report outcomes. J Rehabil Res Dev 2011;48:1129-1136.
29. Learmonth YC, Adamson BC, Balto JM, et al. Identifying preferred format and source of exercise information in persons with multiple sclerosis that can be delivered by health-care providers. Health expectations : an international journal of public participation in health care and health policy 2017;20:1001-1010.
30. Tallner A, Streber R, Hentschke C, et al. Internet-supported physical exercise training for persons with multiple sclerosis—a randomised, controlled study. International Journal of Molecular Sciences 2016;17.
31. Paul L, Coulter EH, Miller L, McFadyen A, Dorfman J, Mattison PG. Web-based physiotherapy for people moderately affected with Multiple Sclerosis; quantitative and qualitative data from a randomized, controlled pilot study. Clin Rehabil 2014;28:924-935.
32. Ericsson. The Ericsson Mobility Report [online]. Available at: https://www.ericsson.com/en/mobility-report. Accessed 03/01/2019.
33. De Wulf M. Population Pyramids of the World from 1950 to 2100. 2016.
34. Chiaravalloti ND, DeLuca J. Cognitive impairment in multiple sclerosis. The Lancet Neurology 2008;7:1139-1151.
35. Torsney K. Advantages and disadvantages of telerehabilitation for persons with neurological disabilities. NeuroRehabilitation 2003;18:183-185.
36. Jelcic N, Agostini M, Meneghello F, et al. Feasibility and efficacy of cognitive telerehabilitation in early Alzheimer's disease: a pilot study. Clinical interventions in aging 2014;9:1605.
37. Diamond BJ, Shreve GM, Bonilla JM, Johnston MV, Morodan J, Branneck R. Telerehabilitation, cognition and user-accessibility. NeuroRehabilitation 2003;18:171-177.
38. Rocca MA, Amato MP, De Stefano N, et al. Clinical and imaging assessment of cognitive dysfunction in multiple sclerosis. The Lancet Neurology 2015;14:302-317.
39. Primack BA, Carroll MV, McNamara M, et al. Role of video games in improving health-related outcomes: a systematic review. American journal of preventive medicine 2012;42:630-638.
40. Webb TL, Joseph J, Yardley L, Michie S. Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. Journal of medical Internet research 2010;12.
41. Benedict RH, Zivadinov R. Risk factors for and management of cognitive dysfunction in multiple sclerosis. Nature reviews Neurology 2011;7:332-342.
42. Kramer JM, Schwartz A. Reducing barriers to Patient Reported Outcome Measures for people with cognitive impairments. Archives of Physical Medicine and Rehabilitation.

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

# Table

| | |
|---|---|
| Age (years) (not reported= 2), mean ± SD | 44.41(±12.52) |
| Sex (not reported = 1) | |
| Male | 58 |
| Female | 141 |
| Marital status (not reported = 9) | |
| Married | 76 |
| Cohabitant | 38 |
| Divorced or separated | 30 |
| Single | 47 |
| Employment status (not reported = 1) | |
| Full time | 67 |
| Part time (more than half time) | 15 |
| Half time | 16 |
| Part time (less than half time) | 4 |
| Sick leave | 73 |
| Job searching | 9 |
| Retired | 15 |
| Education (not reported = 2) | |
| Primary | 12 |
| Lower secondary | 27 |
| Upper secondary | 48 |
| Higher non-university | 56 |
| University | 55 |
| Clinical form of MS (not reported = 9) | |
| RR (relapsing-remitting) | 149 |
| SP (secondary progressive) | 28 |
| PP (primary progressive) | 14 |
| EDSS (Expanded Disability Status Scale) (not reported = 9), median [IQR] | 2.50 [1;4] |
| Duration since the first symptoms of MS (years) (not reported = 8), mean ± SD | 13.85 ± 9.91 |
| Duration since the last attack of MS (years) (not reported = 28), mean ± SD | 6.52 ± 9.44 |

Table I. Demographic and MS-related data of participants. SD (standard deviation), [IQR] (interquartile range)

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

## Figures

Figure 1. Ownership of technologies.

Percentage of patients with MS reporting to own these technologies.

Figure 2. Use of technology among patients with MS.

Frequency to which patients reported to use each technology.

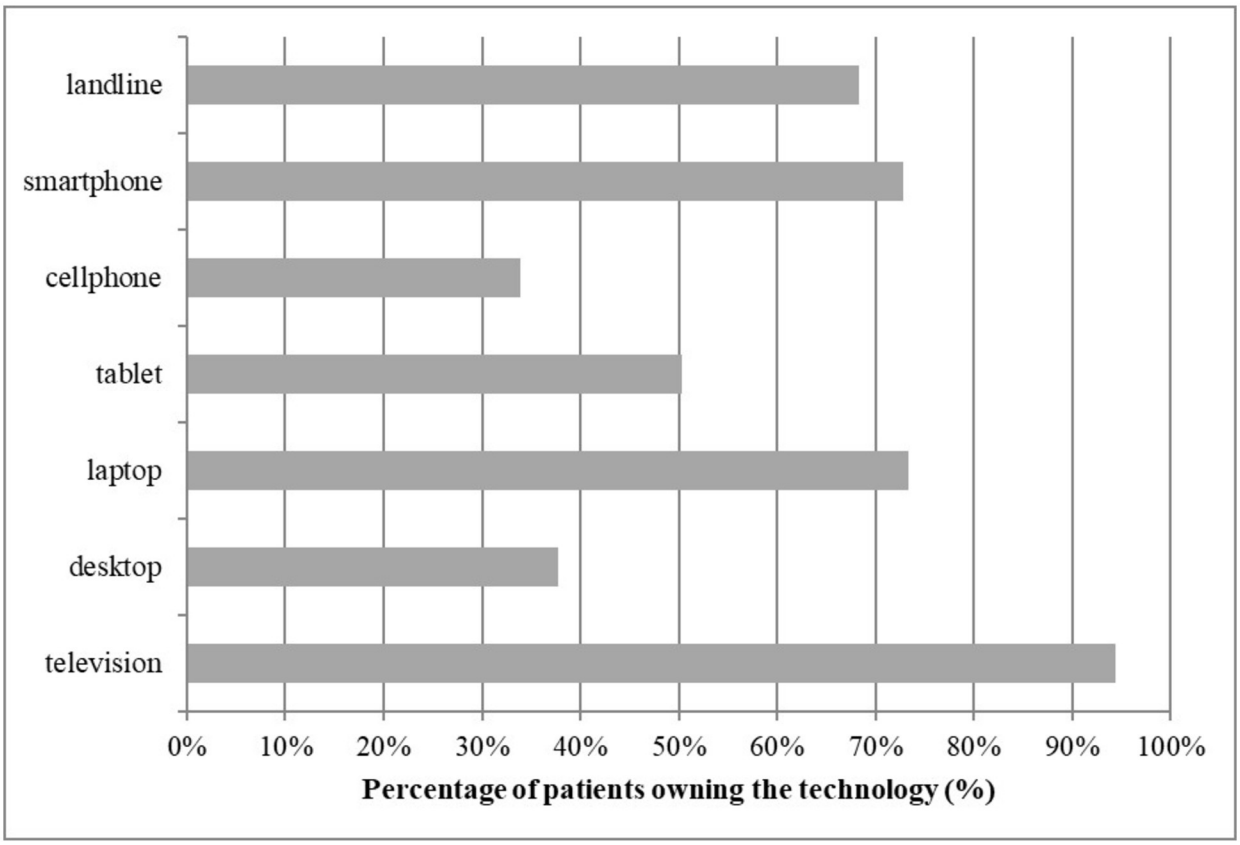
Figure 3. Reported motivating factors to practice a physical activity.

Percentage of patients reporting that they would be interested by each physical activity setting/approach.

Figure 4. Interest in receiving rehabilitation services via a technological device

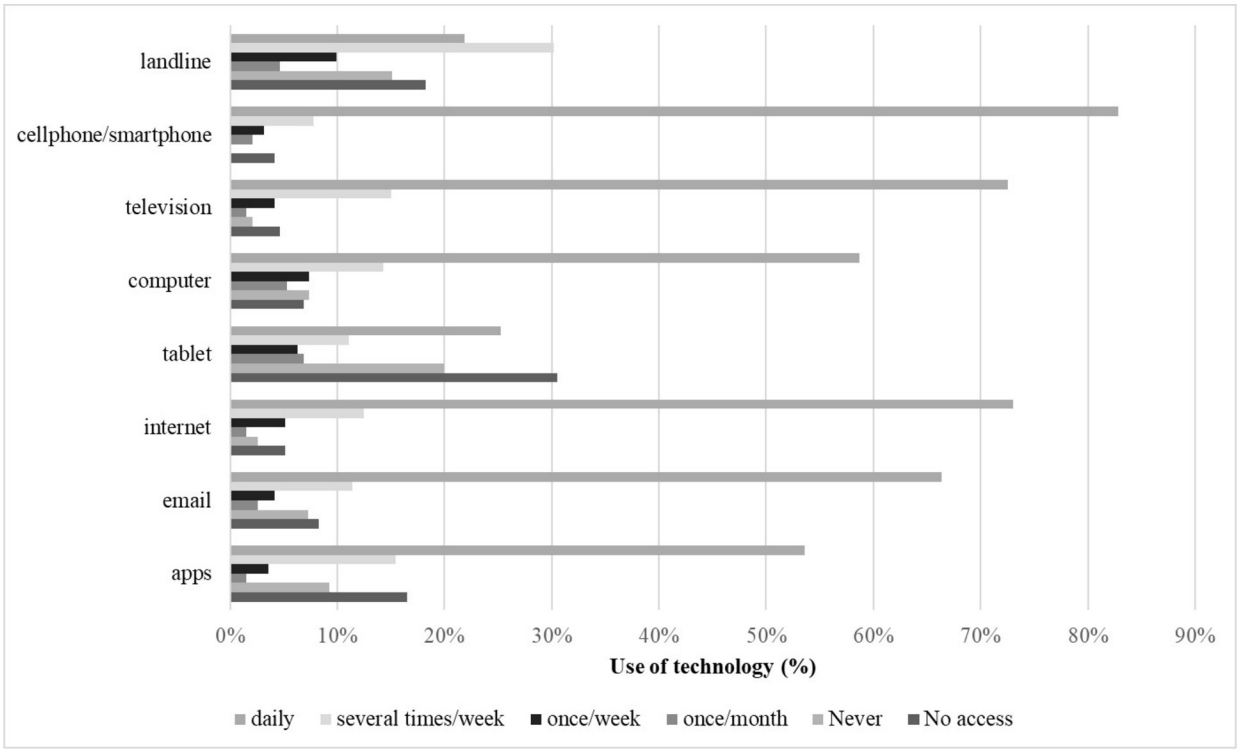
This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA



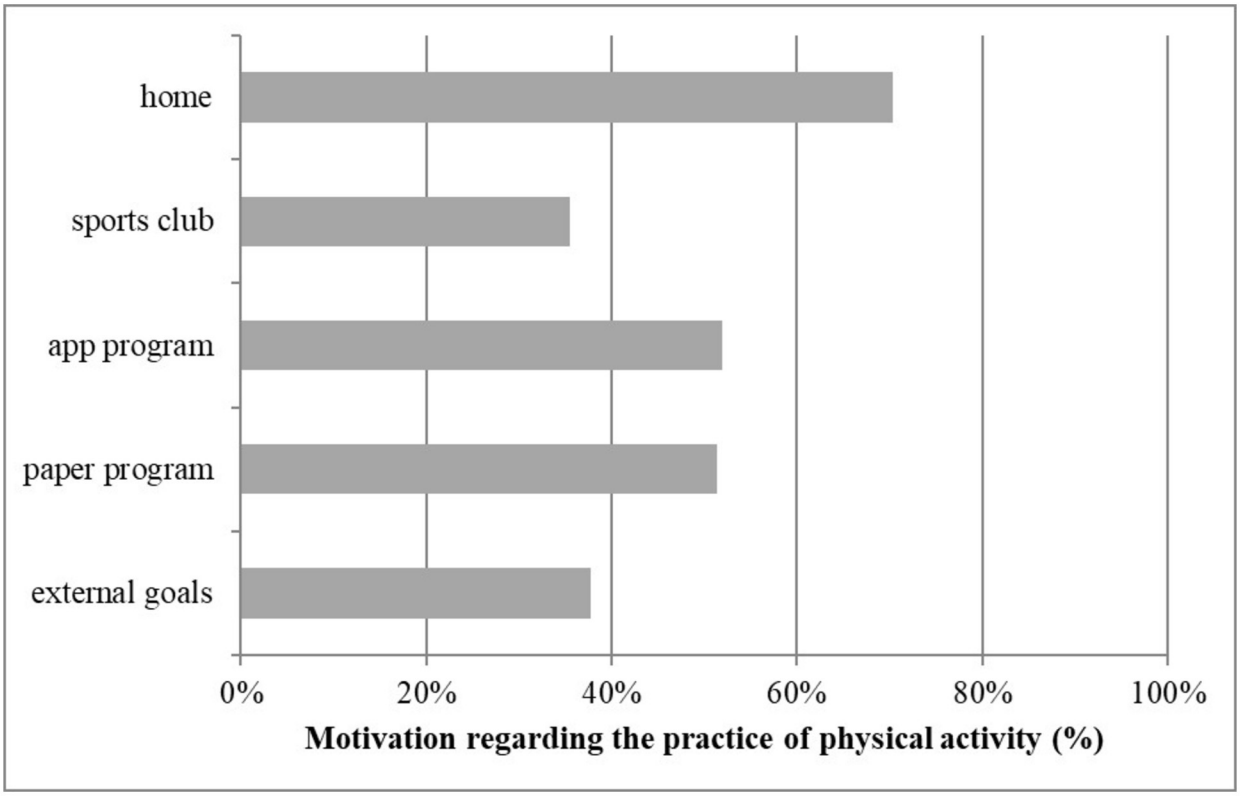

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA



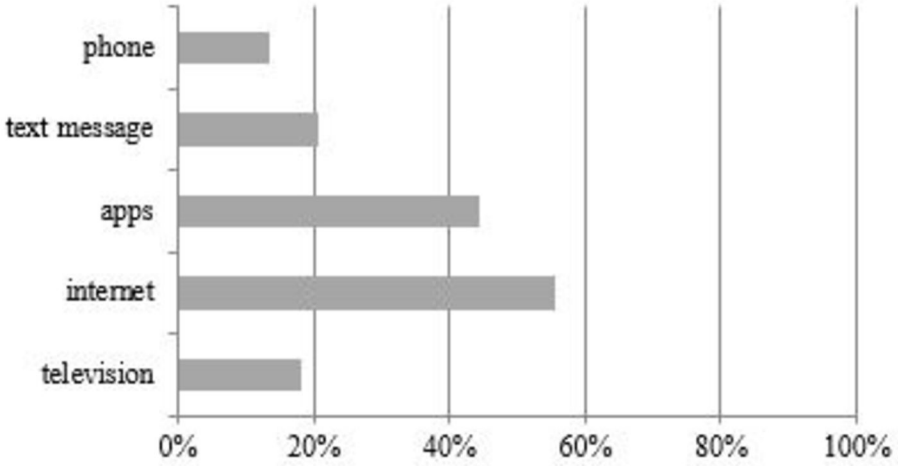

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

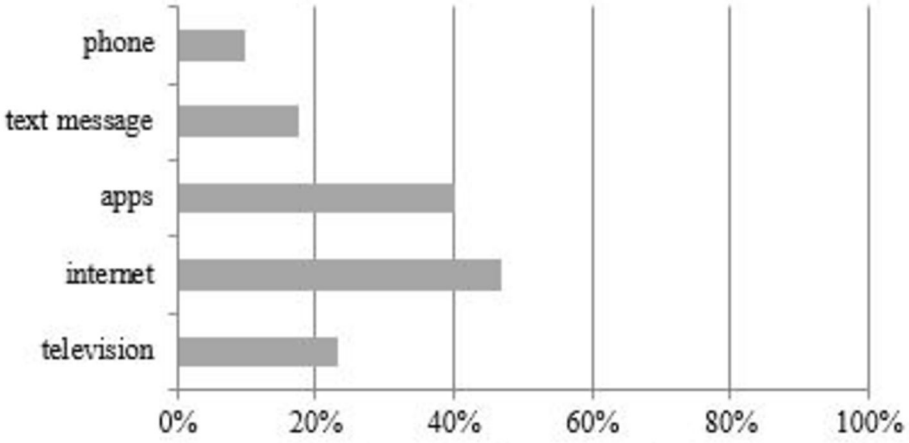



This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

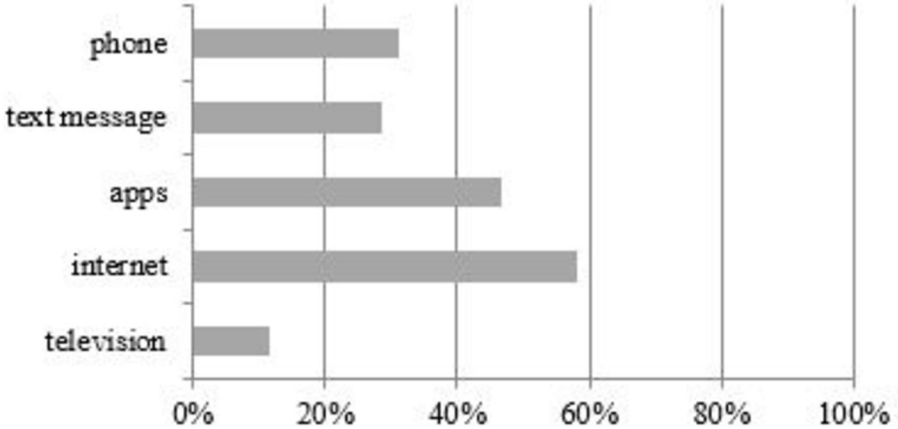
COPYRIGHT© EDIZIONI MINERVA MEDICA




**Interest in using technology to receive information and personalized advice about physical activity and MS (%)**




**Interest in using technology to receive a program of physical exercises (%)**




**Interest in using technology to communicate with the caregivers (%)**

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

COPYRIGHT© EDIZIONI MINERVA MEDICA

# Supplementary Digital Material

Download supplementary material file: Eur J Phys Rehabil Med-6061_2_V1_2019-10-26.docx

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The creation of derivative works from the Article is not permitted. The production of reprints for personal or commercial use is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.