

Association Between System Usage Pattern and Impact of Web-Based Telerehabilitation in Patients with Multiple Sclerosis

In cheol JEONG ^{a,1}, Jiazhen Liu ^a and Joseph FINKELSTEIN ^a

^a*Icahn School of Medicine at Mount Sinai, New York, NY, USA*

Abstract. Patients with multiple sclerosis (PwMS) increasingly use online services for managing their healthcare. The objective of this study was to investigate web log data (weblogs) generated by PwMS in the process of web-based telerehabilitation and correlate them with rehabilitation progress. The weblogs from 17 patients (female: 15, male 2; mean age: 60.1±11.4 years) were tracked for an average period of 153.6±38.3 days with the total number of log events and page visit records of 1,457 and 37,030, respectively. The time and frequency of patients' web visits were investigated as well as their adherence to prescribed exercise regimen. Rehabilitation progress was gauged by changes in quality of life, mobility, and sleep ascertained by measuring MSQOL, 2MWT and PSQI respectively. The changes in these metrics were correlated with system usage patterns. On average, PwMS visited 30 pages a day for 26.5 minutes, with a single login amounting for 27 pages in duration of 22.0 minutes. The average exercise program comprised 6.9 sets and 29.1 repetitions with average set and repetition completion rates of 46.5% and 72.6% respectively. A statistically significant association has been found between time spent in the online exercise mode and clinical improvements. The results of the study demonstrate that the patients had more pronounced outcome improvements when they increased the time of using the telerehabilitation system for home-based exercise. The results of this study could contribute to the development of more efficient home-based telerehabilitation systems.

Keywords. Telerehabilitation, weblogs, multiple sclerosis

1. Introduction

Demand for online disease management by patients with multiple sclerosis (PwMS) using web services at home has been increasing [1, 2]. The need for disease management in an open space outside the hospital [3] creates a variety of functions of the system and subsequent complex operational requirements. Using a system that combines the functions of patient education, exercise management and performing interactions requires understanding of the factors in the patient's system operation to lead to the best clinical outcomes, and it is essential that optimal operational patterns are identified. However, association between system usage pattern and impact of web-

¹ Corresponding Author, In cheol JEONG, Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, New York, NY 10029, USA; E-mail: Incheol.Jeong@mssm.edu.

based telerehabilitation in PwMS has not been systematically studied. The goal of this study was to analyze web usage logs generated by PwMS during home-based telerehabilitation.

2. Methods

We conducted a retrospective analysis of web logs generated by PwMS in the course of using the MS HAT system [4] for online home-based telerehabilitation. In the analysis, the patient identifier has been de-identified. The data was stored in a relational database called “va_ms-test.” It was a Microsoft SQL Server database located on a AWS EC2 instance.

The typical patterns for patient use of the system is defined as in Table 1. During the total period of use between time at beginning (BL) and end (FU) of the study, and when logging in once, we wanted to investigate information about how patients used the system. We also wanted to see how the conditions of exercise prescribed by the healthcare provider affect the patient. Next, we wanted to evaluate how well a patient performed the prescribed exercise, and finally we investigated information about how much the patient wanted to communication with the healthcare provider. In order to find above-mentioned concerns, we took log-in time, exercise access time, exercise set completed, and log-out time from the server log of MS HAT web page. The exercise repetition number was saved by the patient in the web page, so it was taken from MS HAT database.

Sociodemographic information was measured at BL. The Pittsburgh Sleep Quality Index (PSQI) [5], the Multiple Sclerosis Quality of Life (MSQOL) [6], and the Two Minutes Walk Test (2MWT) [7] were measured at BL and FU. Comparisons were made with these outcomes and the items mentioned in 'Parameter Definition' section. All statistical analyses were performed with bivariate Pearson Correlation analysis method using IBM SPSS Statistics 26 for Windows. The results provided the correlation coefficient and the 2-tailed statistical significance.

Table 1. Definition of system usage pattern

Parameter Name	Definition
Total system usage time	cumulative system usage time from BL to FU
Total page number	cumulative number of visited pages from BL to FU
Day usage time	average system usage time for at least 1 log-in day
Day page number	average number of visited pages for at least 1 log-in day
Day number	average number of days that the patient log-in at least 1 time
Visit usage time	average system usage time on a single log-in
Visit page number	average number of visited pages on a single log-in
Visit number	average number of log-ins
Exercise set number	cumulative number of exercise sets
Exercise repetition number	cumulative number of exercise repetitions
Average set completed	average number of exercise sets completed when at least 1 set was finished
Average percent set completed	average percent of exercise sets completed when at least 1 set was finished
Total exercise time	cumulative exercise page stay time from BL to FU
Message	cumulative number of messages from BL to FU

BL: at beginning of the study, FU: at end of the study

3. Results

Seventeen PwMS aged between 39 and 76 years old used a telerehabilitation system for 153.6±38.3 days. The range of time how long the patient has MS was between 2.5 and 50.8 years and the average of education was 15.5 ± 2.7 years. The white was 70.6% and the Hispanic was 11.8%. The answers of 11.2% of severe MS severity and 29.4% of progressing disease were investigated. The average of day difference between BL and FU was 153.6±38.3 days. The total time patients spent using with MS HAT system were ranged between 6 and 68 hours with 30.7 ± 19.8 hours (mean ± SD). The average of total log-in was 86, patients visited 30 pages a day on average for 26.5 minutes, and once visited 27 pages for 22.0 minutes. The average 6.9 sets and 29.1 repetitions of exercise provided to the patient had average completion set and repetition rates of 46.5% and 72.6% respectively, and the average total time stayed in the exercise page was 13.5 hours. The patients also sent an average of 8.5 messages. The p-values of <0.01 were found the relationships between ‘Total system usage time’ and ‘PSQI sleep efficiency (FU-BL),’ ‘Visit page number’ and ‘Exercise repetition number,’ ‘Visit page number’ and ‘Day page number,’ ‘Average percent set completed’ and ‘2MWT (30sec),’ ‘Total exercise time’ and ‘Total system usage time,’ ‘Total exercise time’ and ‘Visit number,’ ‘Total exercise time’ and ‘Day number,’ and ‘Total exercise time’ and ‘PSQI sleep efficiency (FU-BL).’ Additional significant association was found between system usage pattern and impact of telerehabilitation on mobility, sleep and quality of life (Table 2).

Table 2. Parameters that were shown significant correlations.

Parameters	Correlation	p-value	n
Total system usage time			
PSQI sleep efficiency (FU-BL)	0.757	0.000	17
PSQI total (FU-BL)	-0.507	0.038	17
Total page number			
Exercise repetition number	0.507	0.038	17
Visit page number			
Exercise set number	0.895	0.000	17
Day page number (for only log-in days)	0.931	0.000	17
Exercise repetition number			
PSQI sleep efficiency (FU-BL)	0.532	0.028	17
PSQI total (FU-BL)	-0.536	0.027	17
Average set completed			
MSQOL physical health (FU-BL)	0.503	0.047	16
Average percent set completed			
2MWT (30 sec)	-0.835	0.005	9
2MWT (120 sec)	-0.729	0.026	9
Total exercise time			
Total system usage time	0.886	0.000	17
Visit number	0.702	0.002	17
Day number	0.614	0.009	17
Exercise repetition number	0.494	0.044	17
PSQI sleep efficiency (FU-BL)	0.814	0.000	17
PSQI total (FU-BL)	-0.702	0.002	17
Messages			
MSQOL cognitive function (FU-BL)	0.486	0.048	17
2MWT (30 sec)	0.721	0.028	9

BL: at beginning of the study, FU: at end of the study, FU-BL: difference data between FU and BL

4. Discussion

The study of the enhancement of clinical outcomes related to a healthcare provider's response for patients is constantly being carried out [8-10]. However, studies involving patient behavior patterns, particularly those used in the home disease management system, are limited. This study used MS HAT system weblogs to perform validation for typical usage pattern analysis that improves the clinical outcomes of PwMS. In our results, we could confirm that an increase in the patient's system usage time affected the improvement of sleep quality of patients represented by an increase in PSQI sleep efficiency and a decrease in PSQI total. It was also found that the self-paced walking ability and functional capacity of the patient were improved with the increased distance of 2MWT.

Extensions to the use of each page will help to find more detailed patterns of patient's system usage. In addition, the aggregation of information about the interaction of healthcare provider will enable pattern analysis that will lead to improve clinical outcomes. More detailed and accurate optimal system operating patterns will be found when dynamic analyses, such as sequences of system operations, are induced over static analyses. More detailed analyses for further analysis of system weblogs and patient outcomes in a larger study sample is warranted.

References

- [1] Darkins A, Ryan P, Kobb R, Foster L, Edmonson E, Wakefield B, Lancaster AE, Care Coordination/Home Telehealth: the systematic implementation of health informatics, home telehealth, and disease management to support the care of veteran patients with chronic conditions. *Telemedicine and e-Health* 14(10) (2008), 1118-1126.
- [2] Farzanfar R, Finkelstein J, Friedman RH, Testing the usability of two automated home-based patient-management systems. *Journal of Medical Systems* 28(2) (2004), 143-153.
- [3] Matthew-Maich N, Harris L, Ploeg J, Markle-Reid M, Valaitis R, Ibrahim S, Gafni A, Isaacs S, Designing, implementing, and evaluating mobile health technologies for managing chronic conditions in older adults: a scoping review. *JMIR mHealth and uHealth* 4(2) (2016), e29.
- [4] Finkelstein J, Liu J, Usability of Telerehabilitation System Supporting Multipronged Exercise in Patients with Multiple Sclerosis. *Studies in health technology and informatics* 251 (2018), 281-284.
- [5] Buysse DJ, Reynolds III CF, Monk TH, Berman SR, Kupfer DJ, The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry research* 28(2) (1989), 193-213.
- [6] Vickrey B, Hays R., Harooni R, Myers LW, Ellison GW, A health-related quality of life measure for multiple sclerosis. *Quality of life research* 4(3) (1989), 187-206.
- [7] Scalzitti DA, Harwood KJ, Maring JR, Leach SJ, Ruckert EA, Costello E, Validation of the 2-minute walk test with the 6-minute walk test and other functional measures in persons with multiple sclerosis. *International journal of MS care* 20(4) (2018), 158-163.
- [8] Finkelstein J, Cha E, Wood J, Wallin MT, Predictors of successful acceptance of home telemanagement in veterans with Multiple Sclerosis. *Conf Proc IEEE Eng Med Biol Soc* 2013 (2013), 7314-7317.
- [9] Lewin S, Skea Z, Entwistle VA, Zwarenstein M, Dick J, Interventions for providers to promote a patient-centred approach in clinical consultations. *Cochrane database of systematic reviews* (12) (2012), Art. No.: CD003267.
- [10] Jeong I, Liu J, Finkelstein J, Factors Affecting Adherence with Telerehabilitation in Patients with Multiple Sclerosis. *Stud Health Technol Inform* 257 (2019), 189 - 193.