THE MUSICGLOVE AND THE FITMI AND THEIR POTENTIAL IN TELEREHABILITATION AFTER STROKE: A CASE STUDY

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ABSTRACT

Motor impairments are a common sequalae of stroke and a major cause of disability. Rehabilitation remains the primary intervention in improving motor function and independence in activities of daily living. Accessibility of rehabilitative care is limited by provider and resource availability, geographical constraints and travel costs. Telerehabilitation is a care modality that seeks to overcome these obstacles, as well as unpredictable disruptions such as the COVID-19 pandemic, by conducting therapy remotely using telecommunication technology. Here we provide a case study of a 76-year-old stroke survivor that utilized the MusicGlove and FitMi instead of conventional rehabilitation and a review of the current literature pertaining to the effectiveness of these devices and that of telerehabilitation.

INTRODUCTION

Stroke is the leading cause of long-term disability in developed world with motor deficits, being the most common impairment[1,2]. Generally upper limb function is more affected than that of the lower limb with 9/10 stroke survivors suffering some degree of upper limb impairment[3,4]. Because of the importance of arm and hand function in performing activities of daily living (ADLs), upper limb motor impairment is a strong predictor of poor functional recovery[5]. Upper limb dysfunction post-stroke can also be linked to a decreased perception of subjective well-being and quality of life, and increased anxiety[1]. While affected individuals may experience some spontaneous recovery of function within the first month after insult, this recovery is highly varied with 50% experiencing some degree of motor improvement at 6 months and only 5-20% of individuals fully regaining arm function[1,6,7]. Thus, increasing upper limb motor function is important in improving patient outcomes and is a major focus of stroke rehabilitation[8].

Rehabilitation is the primary intervention in regaining functional capacity after experiencing a stroke[9]. Provision of this service is highly variable but is traditionally provided initially in health facilities through the combined efforts of occupational therapists, physiotherapists and physicians, and may continue with prescribed exercises completed by caregivers and patients at home[1,10]. While most patients are offered rehabilitation after stroke, access continues to be limited by availability of providers and resources, geographic isolation, transportation limitations and variance in adherence[11]. Though duration and frequency of rehabilitative therapy are major determinants of its success, therapy is often decreased over time leaving 43% of patients and caregivers reporting they feel they would have continued to see improvement with further care according to a study in the UK[1,4]. Telerehabilitation, the use of telecommunication technologies to transmit health information and provide rehabilitative care, seeks to overcome the barriers of traditional care by allowing continued consultation, assessment and monitoring to occur within the homes of patients[12]. A number of telerehabilitation models have been trialed and communication between healthcare professionals and patients has been achieved through a variety of methods from telephone calls and video conferencing to remote monitoring of activities through robotic, virtual reality (VR) and other data collection devices[13].

The MusicGlove and the FitMi are two devices designed and marketed by the company FlintRehab to be used in neurorehabilitation to improve motor function. The MusicGlove is comprised of a glove that has sensors on each of the fingertips as well as one on the lateral aspect of the second digit. The associated software uses non-immersive VR to prompt the patient to perform gripping movements between the thumb and the sensors on the other digits in time with music much like the popular videogame Guitar Hero. The FitMi consists of two pressure-sensitive discs that are used in a variety of exercises aimed at increasing strength and motor function to the core and upper and lower limbs. The accompanying software includes videos demonstrating the exercises and progressively increases the number of repetitions of each exercise as the user progresses. Both systems monitor the user's progress, provides real time feedback and allows the user to tailor the exercises to their needs[10].

CASE PRESENTATION

A 76-year-old male with a past medical history of hyperaldosteronism, a stable right carotid artery dissection, hypertension and ORIF to left leg presented to a rural emergency room after experiencing a headache followed by slurred speech, diplopia and right-sided weakness, precipitating a fall. On assessment by the emergency room physician, he exhibited mild left-sided facial droop, deficits in lateral movement of the right-eye, left-sided weakness with pronounced left arm dysmetria, an inability to ambulate and continued to experience diplopia. On an MRI performed later that day, the patient was found to have experienced an acute right paramedian pontine infarct. He was later seen by occupational and physiotherapy for mobility testing and functional training who noted the patient continued to experience left-sided weakness and incoordination with decreased balance however was then able to ambulate with assistance and the diplopia was subsiding. When disposition planning the patient and family had a strong preference to be discharged home in light of the COVID-19 pandemic. The patient and his spouse received instruction on safe transfer practices and returned to their home community.

Two weeks post-stroke the patient followed-up with his family doctor and it was found that his balance and gait had returned to baseline and there were persisting speech disturbances and fine motor deficits that were slowly improving. In their research the patient and his spouse found and purchased the FitMi and the MusicGlove. Beginning at one-month post-stroke, the patient utilized each of the systems daily for approximately 45 minutes in addition to walking on a treadmill for approximately one mile a day. After a month of this regimen, therapy with the FlintRehab devices was decreased to 15-minute sessions three times a week while continuing daily treadmill training. According to dexterity test of the MusicGlove system, the patient's performance in completing the prescribed gripping motions increased from an initial 34% to 94% after two months of using the device. At 19-weeks post-stroke the patients upper and lower extremity motor function was evaluated using the Fugl-Meyer assessment according to the protocol from the University of Gothenburg derived from Fugl-Meyer *et al.*, 1975[14]. The assessment revealed no hemiparesis or dysmetria with all measures of the affected side equalling that of the unaffected side. In the same visit, an unstructured interview was conducted on the usability and functionality of the two devices. For both systems, he reported that their design was intuitive and experienced no technical problems allowing from easy use. He was motivated by the game-like aspects of the MusicGlove and enjoyed the challenge the real-time feedback and performance tracking that it provided. As for the FitMi he found that the exercises were not difficult enough and that he had reached the highest difficulty level of the system too quickly. Overall, while the devices provided him adequate instruction and monitoring, he felt that he would have benefited from goal setting and counselling as to how the scores related to his recovery and functional goals.

LITERATURE REVIEW

Efficacy of the MusicGlove

A literature search was conducted using the PubMed database between July 14 and July 21, 2020. A key word and MeSH term search was performed to extract articles relating to the use of the MusicGlove and FitMi in stroke rehabilitation with no filters applied (Table 1). This search produced three records with publication dates ranging from 2011 to 2016, all of which were included. All three publications, found in Table 2, pertained solely to the MusicGlove and were produced by the research group that designed the system.

The first of the articles, Friedman *et al.,* 2011, is a trial that consisted of 10 participants who have experienced a stroke within 3 years undergoing single session of using the MusicGlove with and without music. An assessment of dexterity of the affected hand was done before and after therapy using the commonly used Box and Block Test where the participant is required to pick up and drop as many blocks as they can over a barrier over 1 minute. This study found that: 1) a higher percentage of 'notes' were hit when completing the therapy with music while there was no difference in the accuracy of the timing of the movement, 2) the presence of music also increased the subjective measure of motivation measured by a participant survey, 3) the Box and Block scores had a linear relationship to the performance measured by the MusicGlove and 4) participants with low to moderate hand impairment, that is a Box and Block score of 7 or more, were able to utilize the MusicGlove[15].

The group later conducted a pilot study, Friedman *et al*., 2014, with 12 stroke survivors with mild to moderate upper limb impairment. The participants underwent 6 hours of treatment using the MusicGlove, the IsoTrainer, another sensor device used in a similar way to the MusicGlove, or conventional table-top exercises in two-week blocks in varying orders. It was found that 2 weeks of using the MusicGlove produced a statistically significant increase in Box and Block Test and the Nine Hole Peg Test scores compared to conventional therapy. As in the previous study it was also found that there was a significant linear relationship between Box and Block scores and performance using the MusicGlove. In a survey following undergoing the three therapies participants reported that the MusicGlove was more effortful, provided more benefit tin terms of ADLs and was more interesting compared to traditional exercises[16].

Most recently a randomized control trial was conducted, Zonderman *et al*., 2016, comparing self-guided therapy using either the MusicGlove or a booklet of conventional hand exercises. 18 participants were asked to complete 3 hours of therapy a week for 3 weeks and were contacted by a therapist or nurse of the research team weekly to manage any technical difficulties and monitor for adverse outcomes. At 1 month post-therapy it was found that there was no significant difference in the primary outcome, Box and Block score improvement, but there was significant increase in the self-reported Quality of Movement (QOM) and Amount of Use (AOU) subscales of the Motor Activity Log (MAL) in the MusicGlove group compared to the control group after therapy.

Table 1. Detailed Search Strategies
Use of the MusicGlove and FitMi in stroke rehabilitation
PubMed: "Stroke Rehabilitation" [Mesh] AND (FitMi OR MusicGlove) Filters: None
Effectiveness of telerehabilitation
PubMed: "Stroke Rehabilitation"[Mesh] AND "Telerehabilitation"[Mesh] Filters: Article Type: Review, Meta-analysis, Systematic Review
Cochrane Library: MeSH descriptor: [Stroke rehabilitation] explore all trees) AND (MeSH descriptor: [Telerehabilitation] explore all trees) Filter: Article Type: Review

Telerehabilitation Effectiveness

In order to gain a general appreciation of the current literature regarding the effectiveness of telerehabilitation, a literature search of the PubMed and Cochrane Library databases was conducted between July 14 and July 21, 2020 using the search strategy found in Table 1 with results limited to reviews, systematic reviews and meta-analyses. Systematic reviews and meta-analyses selected were those that evaluated the current literature comparing the outcomes of rehabilitation therapies conducted in the patients' home with use of some form of telecommunication technology to no therapy, in-clinic rehabilitation, or self-guided therapies. Of the 14 records produced, 7 were found to meet the inclusion criteria (Table 3); a detailed overview of the screening process can be found in Appendix 1. Of the articles selected, 5 analyzed studies that compared the results rehabilitation efforts conducted in patients homes remotely to conventional in-person therapy or no therapy[17–21], 1 evaluated studies evaluating the effect of commercially available VR devices when used at home[22] and 1 included studies comparing impact of use of telerehabilitation with the help of monitoring devices to traditional in-clinic therapies or no therapy[23].

In comparing the results therapy conducted by telerehabilitation methods to in-clinic or no therapy, by a majority of measures there was low to moderate quality evidence that there was no significant difference between telerehabilitation and controls. 5 studies found that there was no significant difference in improvements in ADLs and motor function[17,19–21,23], 2 studies found that there was no significant difference in rates of depression[18,21], 3 studies found that patients were generally satisfied with telerehabilitative care[19–21], and 2 studies found that there was no significant difference in caregiver quality of life[18,21]. Differences in other measures, when found, were inconsistent between studies included in the reviews and often were not statistically significant. One review found that 7 out of 18 studies included reported an increased improvement in motor function in favor of the intervention group[18], Chen *et al*., cited one study that indicated those in the telerehabilitation group on a measure of health-related quality of life[17] and Rintala *et al.,* found that in 2 of 3 studies favoured the control group when measuring improvements in walking ability[23]. In terms of cost-effectiveness multiple reviews cited a study by Llorens *et al*., that found a $654.72 decrease per patient receiving care remotely compared to conventional in-clinic care[24], and Laver *et al.,* cited 1 study that found there was a significant decrease in doctor visits in the intervention group at 3 months post-stroke[20]. When reviewing the literature evaluating use of VR devices within a telerehabilitation model, Schröder *et al*., found that there was data to support that use of the devices was as feasible at home as in-clinic, use of VR devices have positive effects in the chronic stroke population and there is good adherence to VR therapy at home[22].

The reviews and meta-analyses cited some common limitations in the current literature surrounding telerehabilitation. The reviews found few studies that met their inclusion criteria[17,22] and the studies included had small sample sizes[17,18,20–22] and used a variety of telerehabilitation models[19,20,22,23] and effectiveness measures[21]. A definitive evaluation of telerehabilitation will require larger randomized control trials, standardized data reporting and more studies evaluating its cost-effectiveness[18,20,21].

Table 2. Publications extracted from the PubMed database relating to the efficacy of the MusicGlove in stroke rehabilitation.

Authors	Title	Reference
Friedman, Chan, Zondervan, Bachman, Reinkensmeyer	MusicGlove: Motivating and quantifying hand movement rehabilitation by using functional grips to play music	[15]
Friedman, Chan, Reinkensmeyer, Beroukhim, Zambrano, Bachman	Retraining and assessing hand movement after stroke using the MusicGlove: Comparison with conventional hand therapy and isometric grip training	[16]
Zondervan, Friedman, Chang, Zhao, Augsburger, Otr, Reinkensmeyer, Cramer	Exercise ProgramHome-based hand rehabilitation after chronic stroke: Randomized, controlled single-blind trial comparing the MusicGlove with a conventional exercise program	[10]

Table 3. Publications extracted from the PubMed and Cochrane Library databases relating to the effectiveness of telerehabilitation in stroke rehabilitation.

Authors	Title	Reference
Chen, Jin, Zhang, Xu, Liu, Ren	Telerehabilitation Approaches for Stroke Patients: Systematic Review and Meta-analysis of Randomized Controlled Trials	[17]
Tchero, Teguo, Lannuzel, Rusch	Retraining and assessing hand movement after stroke using the MusicGlove: Comparison with conventional hand therapy and isometric grip training	[21]
Sarfo, Ulasavets, Opare-Sem, Ovbiagele,	Tele-Rehabilitation after Stroke: An Updated Systematic Review of the Literature	[18]
Appleby, Gill, Hayes, Walker, Walsh, Kumar	Effectiveness of telerehabilitation in the management of adults with stroke: A systematic review	[19]
Schröder, Criekinge, Embrechts, Celis, Schuppen, Truijen, Saeys	Disability and Rehabilitation: Assistive Technology Combining the benefits of tele-rehabilitation and virtual reality-based balance training: a systematic review on feasibility and effectiveness	[22]

Table 2 Continued		
Authors	Title	Reference
Rintala, Päivärinne, Hakala, Paltamaa, Heinonen, Karvanen, Sjögren	Effectiveness of Technology-Based Distance Physical Rehabilitation Interventions for Improving Physical Functioning in Stroke: A Systematic Review and Meta-analysis of Randomized Controlled Trials	[23]
Laver, Adey-Wakeling, Crotty, Lannin, George, Sherrington	Telerehabilitation services for stroke	[20]

DISCUSSION

This case demonstrates an instance where a patient experienced excellent motor restoration within the first 19 weeks of recovery after stroke while using the MusicGlove and FitMi and training on a treadmill. Most patients that experience a pontine infarct recover a fair amount motor function at 3 months after the insult and there is limited evidence that shows that those that undergo rehabilitation have better outcomes[25]. Due to the variability in spontaneous recovery of motor function after stroke, no comment can be made about the effectiveness of these devices in this case. Instead our case demonstrates that their use was feasible and acceptable to the patient and allowed for physical therapy to be conducted without the presence of therapist while the patient was in their home community. Currently there is no literature available regarding the efficacy of the FitMi and a small amount of research pertaining to the effectiveness of the MusicGlove. In three studies conducted by the research group that designed the MusicGlove, it was found that its use is feasible in individuals with low to moderate hand impairment, performance using the device is correlated to other measures of hand function and while there is no significant difference in motor function recovery when using the MusicGlove compared to conventional self-guided therapy, there may be an increase in self-reported function in ADLs following rehabilitation using the device[10,15,16]. There are however features of these studies that limit the quality of evidence produced and generalizability to patients in need of stroke rehabilitation. All three studies had small sample sizes and short intervention periods. The average age of participants was 58 years and there is recent research that 70% experience their first stroke while greater than 65 years of age[19].

Despite the limitations of the current literature regarding the MusicGlove its effectiveness in stroke rehabilitation is plausible. It relies on the same premise as task-specific practice, that practicing activities results in relearning and improved performance of that activity. Task-specific training has been shown to be effective in regaining hand and arm function after stroke[7] and is recommended under current American Stroke Association guidelines with the stipulations that tasks are to be performed repeatedly, tailored to challenge an individual's capabilities and increase in difficulty frequently[9]. While the MusicGlove allows for difficulty to be increased, it does not train entire functional movements and instead focuses solely on gripping motions and thumb opposition used in a variety of activities[10]. Depending on the functional goals of the patient, improvement in these movements may be favourable. Its use of music and virtual reality may also be beneficial in encouraging participation as has been found with other VR and game-like therapeutic devices[9].

While the MusicGlove and FitMi may provide adequate instruction and immediate feedback, these devices do not fulfill all the functions of trained therapists such as assistance in goal setting and creating exercise regimens for reaching these functional goals; this care, however, may be offered through use of telecommunication technology. According to the reviews and meta-analyses reviewed, there is low to moderate quality evidence that telerehabilitation models produce comparable outcomes in ADLs and motor function and health-related quality of life as conventional therapy. Telerehabilitation also has the potential to reduce the costs associated with stroke rehabilitation[24], improve access to rehabilitation services and increase the dose of therapy[13]. Use of telecommunication technology could be especially useful in rural and remote areas of Canada allowing for stroke survivors to return to their home communities and support systems while recieving rehabilitation therapy. However, implementing telerehabilitation models may be limited by technological infrastructure, the technological expertise of patients and their caregivers and the financial cost of equipment required[13,21].

CONCLUSION

The COVID-19 pandemic led to disruptions to outpatient rehabilitation services and a reluctance of the patient presented to remain in hospital. The MusicGlove and the FitMi are two commercially available devices that can be used in stroke rehabilitation. There is no data available on the efficacy of FitMi and there is a small amount of low-quality evidence that the MusicGlove is as effective as self-guided exercises in improving hand function in patients with chronic stroke. In this case both devices were used for 15 weeks and were found to be easy to use and motivating but left the patient still desiring assistance in goal setting and performance monitoring provided in rehabilitation with a trained therapist. This aspect of care potentially could have been provided remotely using telecommunication technology. Telerehabilitation using models such as this, has been shown to be as effective as conventional rehabilitative care and has great potential in confronting barriers to stroke survivors receiving care especially in rural and remote settings. Devices such as the MusicGlove and the FitMi may be valuable in conducting rehabilitative care remotely and are currently available to patients and clinicians. However, their effectiveness as well as that of telerehabilitation still requires further elucidation.

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Appendix 1: Detailed literature search strategy on the effectiveness of telerehabilitation.