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PHEEZEE™ FINDINGS OF UPPER LIMB IN HEMIPLEGIA PATIENT DURING PHYSIOTHERAPY SESSIONS: A CASE STUDY

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Abstract

Hemiplegia is one of the major outcomes of stroke in which the delayed recovery of upper limb is seen. Because of this, it is crucial to perform relative periodic assessments to track the progress along with the treatment procedures. The aim of this case study was to discuss the findings of motor performance using a novel device Pheezee™ in a 69-year-old female patient diagnosed with Hemiplegia while undergoing physiotherapy treatment sessions. The outcomes recorded using Pheezee™ were the muscle activity of Deltoid, Biceps Brachii, Flexor Carpi Radialis, and Extensor Digitorum and joint range of motion (ROM) for relative movements; shoulder abduction, elbow flexion, wrist flexion and extension. Results show detailed information on muscle activity changes in relation to the treatment and patient's condition in the analytical data generated by Pheezee™. The challenges faced in using traditional assessment methods in physiotherapy settings while treating serious health conditions can be addressed using Pheezee™ which is an affordable device, less tedious to use and requires less time to assess and comes as a feasible solution in this digital era of healthcare practices in the world.

Keywords: Electromyogram (EMG), Hemiplegia, Motor performance, Physiotherapy, Range of motion (ROM), Rehabilitation, Stroke, Evidence based practice.

1. Introduction

Stroke is one of the most serious health problems prevailing in the world. According to the survey of Global Burden of Diseases (GBD) stroke is one of the leading causes of disability[1, 2, 3, 4]. One of the major outcomes of stroke is Hemiplegia, where the effected side of the body which includes the upper and lower limbs is paralyzed[5]. The paralysis after stroke causes motor deficits in limbs which in turn results in functional limitations in everyday life[6, 7]. The recovery of motor deficits is delayed more for the upper limb[8, 9]. Therefore, it is mandatory to implement early effective intervention methods focusing on the recovery of the upper limb.

An effective intervention method should include not only the strategic treatment approach but also distinctive assessments and patient progress tracking methods. Adapting such protocols helps physiotherapist (PT) to design the treatment targeting the underlying impairments and also to see if a specific technique is effective in treating specific motor deficit[6]. The most widely used clinical parameters that predict the motor deficits are muscle strength[10, 11] and joint range of motion (ROM)[12, 13, 14, 15, 16, 17, 18, 19]. These assessment tools are important as they provide information on treatment progression[20]. But, for implementation of these assessment procedures there are certain difficulties faced by the physiotherapists in practical settings with regard to ease and time taken, especially for stroke patients who are either bed ridden or wheel chair bound[21]. The guidelines for Manual Muscle Testing (MMT) and joint Range of Motion (ROM) require constant changing of the patient position for each respective grading of muscle and joint movement[22, 23]. Therefore, a low-to-moderate additional effort will be placed on the patient and the physiotherapist as well. Implementing feasible scheduled assessment methods into an effective intervention plan is the need of the hour and is one of the prospective solutions to the aforementioned problems in existing practice of physiotherapy.

Another important contribution to an effective intervention plan is to include methods for tracking of patient prognosis (WCPT)[24]. This is usually done by documenting and archiving the assessment reports of physiotherapy sessions and comparing them with their previous performance at the end. This practice is important because tracking of prognosis provides information on the treatment effectiveness to modify the plan if needed any for faster patient recovery status[6]. Additionally, this information about the treatment effectiveness of an illness allows provision for evidence-based practice in physiotherapy settings[25], where the similar treatment regimen can be used worldwide for better outcomes. Furthermore, the documentation technique is considered as a professional requirement for a physiotherapist[26, 27]. In current practice, the physiotherapists save the assessment reports on computer excel files or in the hand written paper-based file folders. This method of archiving the important assessment reports lack the credibility, reliability and patient confidentiality. Hence, lack of availability of safe ways to assess show that there are technical gaps in physiotherapy field to deliver a smooth intervention plan for a stroke patient.

2. Objectives of the study

The main objective of the study was to understand the use of Pheezee^{TM}, as an assessment and patient's recovery progress tracking device, in a hemiplegic patient undergoing physiotherapy. This was also to provide an overview of few difficulties faced while using traditional assessment methods and to see if these can be addressed using the novel digital intervention - Pheezee^{TM}.

3. Methods

This is a clinical investigation case report that presents the findings of motor performance of upper limb. The study was conducted at Ucchvas Neuro Rehabilitation Center, Telangana, India. A study plan was documented and submitted at the rehabilitation facility for approval. The selection of subject was done by the word of mouth at the facility, during admission. After meeting the inclusion criteria, the patient was recruited and given an informed consent that was signed. The superficial muscles recruited for strength assessment were Deltoid, Biceps brachii, Flexor carpi radialis (FCR), and Extensor Digitorum (ED) and joint movements included the shoulder abduction, elbow flexion, and wrist flexion and extension respectively.

3.1 Inclusion & Exclusion Criteria:

The inclusion criteria set were as follows; i) Patient diagnosed with Hemiplegia, ii) Patient in sub-acute or chronic stage of stroke, and iii) Patients with good cognitive skills. The exclusion criteria set were as follows; i) Patients who are critically ill, ii) Patients in acute stages of post-stroke, iii) Patients with active implanted devices, and iv) Patients who are receiving palliative care. After meeting the afore-mentioned criteria, an informed consent was given by the patient for participation in the study.

3.2 Participants

Initially 5 participants were recruited for the study, however 4 participants had to withdraw from the study after given the consent due to unforeseen reasons like restrictions imposed by global pandemic Covid-19, limited stay of the patients in the facility, to name a few. Finally, it was decided to do the study on one patient, as it was considered to be sufficient to bring out the needed pointers using data generated by

Pheezee™.

3.3 Patient Presentation

A 69-year-old female was diagnosed with acute hemorrhagic stroke in the month of February 2021, and medical investigations found a hemorrhagic infarct in the right middle cerebral artery (MCA) along with mild involvement of anterior cerebral artery (ACA) resulting in left hemiplegia. The patient's past medical history comprises of recent diagnosis of Hypertension and more than 20 years history of Diabetes Mellitus. After the patient was treated conservatively for the infarction, she has been referred to the facility in April 2021, with the complaints of being unable to use her affected (left) upper limb in carrying out her activities of daily living (ADL). On observation, the patient was found to have poor muscle properties such as muscle wasting and loss of motor function in the upper limb. The patient was wheel chair bound for the ambulation and was on Foley's catheter.

3.4 Initial Assessments

The patient was classified with good cognitive skills using Montreal Cognitive Assessment (MoCA). Assessment tool Brunnstrom Recovery Stages of stroke (BRS) was used to understand the presence of the movement in the patient[28] which indicated that the patient was in stage 2 recovery of stroke. The Modified Ashworth Scale (MAS) manual grading was used to examine the spasticity[29] which showed fluctuations from 0 and 1 at the initial stages, but was maintained at 1 during the study duration. The questionnaire Barthel Index (BI) was used to assess functional ability.

4 Pheezee™ Device Information

Pheezee™ is a novel wearable prognostic device which aims to record a patient's activity while undergoing physiotherapy sessions. The device comprises of two wearable modules; upper and lower for joint movement sensing, surface EMG (sEMG) electrodes to pick up signals generated during the muscle activity from the surface of the skin, in a non-invasive manner. Pheezee™ device displays the movement information in real-time on the custom designed mobile app dashboard that connects wirelessly over the Bluetooth®. The subsequent process and analysis of ROM and EMG signals are done in the secured remote server. After the session ends, a detailed session report is generated in the android app running in the phone. The report is analyzed by the physiotherapist to conclude on the patient's condition. This report can be shared electronically or can be printed and attached to the patient reports and clinical case notes.

Additionally, information on few other clinical parameters is also available in the report related to movement which includes rate of movement, repetitions, activity duration, and hold angle to name a few.

4.1 Pheezee^{TM} Recordings

The device was used by an experienced physiotherapist who has been trained to use Pheezee^{TM} device. A total of 3 assessment sessions were done during the patient's stay in the sequence of day 1, day 30, and day 45. All the recordings were taken while the patient was positioned seated on a wheel chair. Based on the selected joint, the modules of the Pheezee^{TM} device were strapped in a manner - the upper module goes above the joint and the lower module below the joint, as also shown in Figure 1. The SENIAM recommendations were followed for skin preparation, electrode fixation, and inter-electrode distance of electrodes[30]. After the skin preparation, the electrodes were placed on the major portion of the muscle belly to acquire signals[31]. Once the device is placed on the specific joint and muscle, it is turned on and connects wirelessly to the Pheezee^{TM} application running on android mobile phone or an android tablet computer. Pheezee^{TM} device transmits the acquired data about the ROM and sEMG, wirelessly using Bluetooth® protocol. Later, the details of the patient were entered manually in the phone app and the session was started for each respective joint movement and the muscle sequentially. The sequence of the muscles that were tested has been kept uniform throughout the study which was Deltoid, Biceps, Flexor Carpi Radialis, and Extensor Digitorum. The readings for both muscle activity and joint's range of motion were taken simultaneously by performing the respective movement of the muscle. For example, readings of biceps were taken when the joint ROM was recorded for elbow flexion movement (Fig. 1). The same procedure was followed the rest of the Pheezee^{TM} readings respectively. Practice trials were performed on the patient to ensure the proper understanding of the movement prior to recording, by the physiotherapist. The examiner monitored activity of the patient which was displayed in real time in the dashboard of the app. The same protocol was followed for all the muscles and joints chosen for this study. After the readings were taken, the needed data was retrieved from the session report generated in the app and entered on Microsoft Excel sheets[32] for further analysis on the patient's motor status. Along with session report (which shows how well the individual physiotherapy session was performed), an overall report was also generated after the end of all the sessions. But the session report included the data of Pheezee^{TM} trial movements which was an attempt to ensure the patient's understanding of the movement. As the data from practice trials may impact overall results, the overall report is not withing the scope of this paper. The summary of movements performed are shown in figure 2, which has been extracted from the Pheezee^{TM} report of first session. The data retrieved was used to draw conclusions based on the findings from the Pheezee^{TM} generated data.

Fig 1: Pheezee^{TM} device placement to record Biceps EMG and Elbow Flexion ROM.

Report Details

Session Date: **Apr 09 2021, Fri, 12:09 PM** Session Duration: **1m:6s** Previous Session Date: **-**

No.	Joint	Movement	Muscle	Side	EMG (uV)	ROM (°)
1	Shoulder	Abduction	Deltoid	Left	7uV	9°
2	Shoulder	Abduction	Deltoid	Left	7uV	8°
3	Shoulder	Abduction	Deltoid	Left	7uV	23°
4	Elbow	Flexion	Biceps	Left	56uV	81°
5	Elbow	Flexion	Biceps	Left	23uV	9°
6	Elbow	Flexion	Biceps	Left	189uV	36°
7	Elbow	Extension	Tricep	Left	21uV	84°
8	Elbow	Extension	Tricep	Left	280uV	79°
9	Wrist	Flexion	Flexor Carpi Radialis	Left	93uV	15°

Fig. 2: Summary as per Pheezee^{TM} session report.

5. Results

The muscle activity values are presented in table 1 for both Pheezee^{TM} and MMT grades. The Pheezee^{TM} generated values for joint range of motion are given in table 2 for all the sessions. The rate of movement which was expressed in terms of speed was mentioned for all the trials in table 3. The ROM graphs from Pheezee^{TM} report for wrist flexion are presented in the figures 3, 4, and 5 while the EMG of FCR were given in figures 6 and 7. The comparison graphs for EMG of Flexor carpi ulnaris and ROM of wrist flexion were shown in the figures 8 and 9.

Table 1: shows MMT grades and Pheezee™ sEMG values of left upper limb muscles.

	Deltoid		Biceps		Flexor Carpi Radialis		Extensor Digitorum	
	MMT (grades)	Pheezee™ (microvolts)	MMT (grades)	Pheezee™ (microvolts)	MMT (grades)	Pheezee™ (microvolts)	MMT (grades)	Pheezee™ (microvolts)
Reading 1	1	0	1	0	1	32	1	0
Reading 2	1	606	1	10	3	612	3	304
Reading 3	1	82	1	310	3	199	3	661

Table 2: shows Pheezee™ ROM values of left upper limb movements

Pheezee™ - ROM readings of left upper limb in degrees				
	Shoulder Abduction (degrees)	Elbow Flexion (degrees)	Wrist Flexion (degrees)	Wrist Extension (degrees)
Reading 1	8	9	26	6
Reading 2	21	36	66	54
Reading 3	30	60	59	77

Table 3: shows Pheezee™ generated rate of movement of left upper limb movements

	Pheezee™ - Speed variable			
	Shoulder Abduction (reps/seconds)	Elbow Flexion (reps/s)	Wrist Flexion (reps/s)	Wrist Extension (reps/s)
Reading 1	0	0	0	0
Reading 2	0.12	0.25	0.16	0.14
Reading 3	0	0.02	0.03	0.007

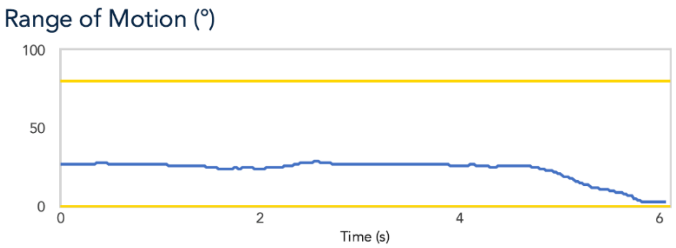

Fig. 3: Pheezee™ ROM graph of Wrist Flexion on day 1 of rehabilitation.

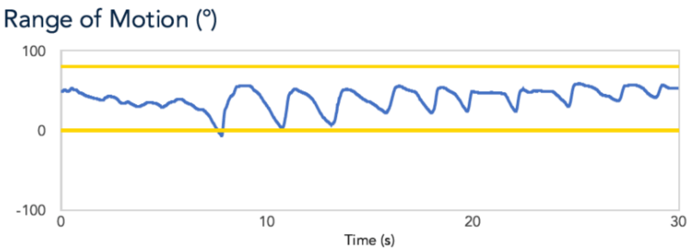

Fig. 4: Pheezee™ ROM graph of Wrist Flexion on day 30 of rehabilitation.

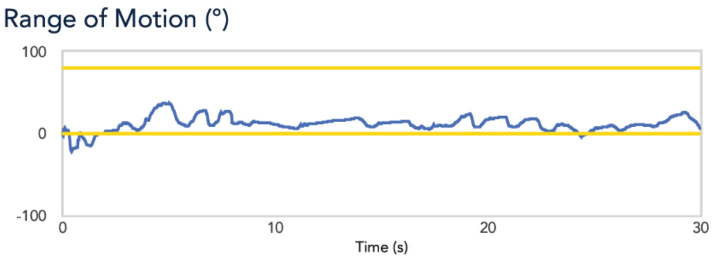

Fig. 5: Pheezee™ ROM graph of Wrist Flexion on day 45 of rehabilitation.

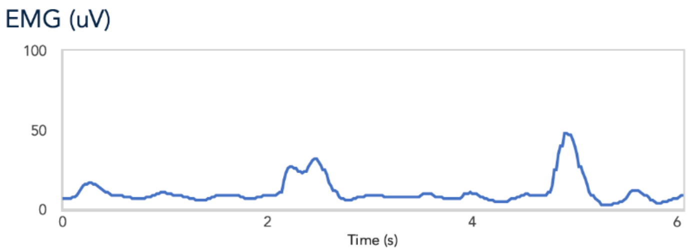

Fig. 6: Pheezee™ EMG graph of FCR on day 1of rehabilitation.

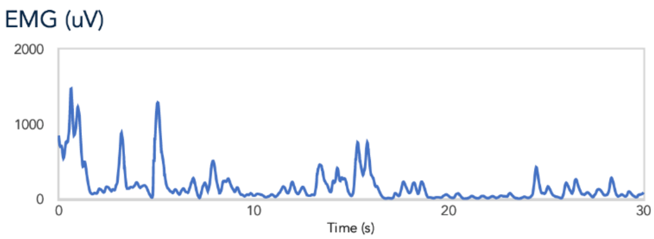

Fig. 7: Pheezee™ EMG graph of FCR on day 30 of rehabilitation.

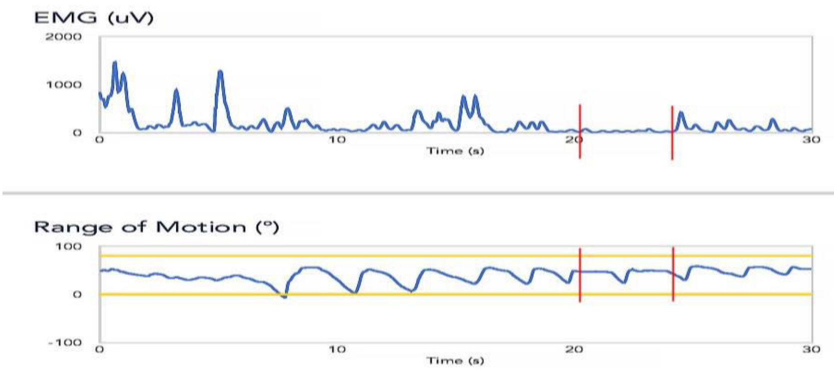

Fig. 8: Pheezee™ ROM & EMG graphs of FCR on day 30 of rehabilitation.

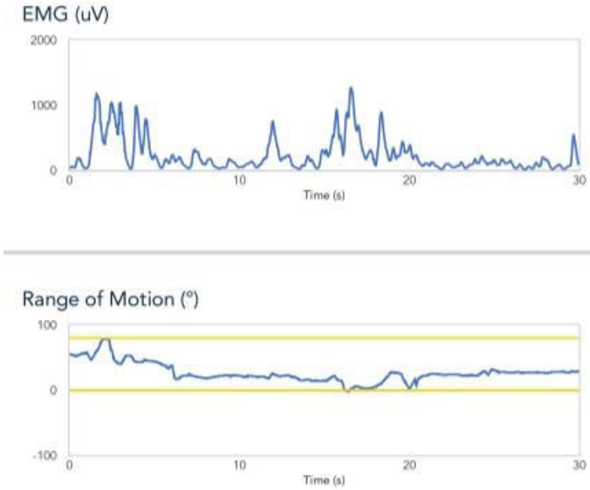

Fig. 9: Pheezee^{TM} ROM & EMG graphs of FCU on day 30 of rehabilitation.

6. Discussions

The main objective of the study was to understand the role of Pheezee^{TM} as a movement and muscles' activity monitoring tool to predict the patient recovery status in female 69-year-old stroke survivor undergoing physiotherapy. It was also to provide an overview of simple challenges faced during rehabilitation phase of a stroke patient and if these can be resolved using Pheezee^{TM}.

6.1 Findings from Pheezee^{TM} session reports

6.1.1 Wrist Flexion- Flexor Carpi Radialis (FCR)

From Figure 3, it was seen that during first session recording, the graph was stable with no spike, indicating very weak joint performance similar to the sEMG graph (figure 6) that shows weak muscle firing. But the graphs for both ROM and sEMG acquired as seen in the figure 4 and figure 7 show that the patient was responding positively to the facility's physiotherapy sessions where the muscle firing has become almost adequate to move the joint during the first 30 days (figures 4, 7). Another unique finding noted from the day 30 session report was, the muscle firing for FCR was gradually decreased which was even at the lowest between 20 to 25 seconds whereas the consistency of joint performance has not changed at all (figure 8). On observation, the patient's left wrist was in ulnar deviation even at rest (figure 10) which suggests FCR muscle was not strong enough to oppose the activity of FCU. Therefore, it was understood that the wrist flexion movement was compensated by flexor carpi ulnaris muscle whenever FCR was unable to carry out the wrist flexion. The readings taken for FCU muscle show a gradual decrease in the muscle firing that was related to decreased wrist joint flexion as well (figure 9). This information can be used to modify the exercise regimen to increase the strength of FCR while to stretch or limit the FCU muscle work.

Fig 10: Patient wrist in ulnar deviated position at rest with Pheezee™ device placement.

6.1.2 EMG muscle activity

The EMG values presented in table 1, shows gradual increase in the muscle activity noticed in Biceps and Extensor digitorum throughout the sessions. The Pheezee™ device was able to detect a sudden decrease for Deltoid and Flexor carpi radialis in the last session compared to previous sessions. To understand this sudden significant change in EMG values, the information on the patient's therapy sessions was discussed with the practitioners in the facility. Because of the COVID-19 induced weakness[33, 34], the patient was unable to participate in the existing physiotherapy sessions and was given a new therapy regimen where primary goal was to clear airways and preserve endurance. Therefore, it was noted that sudden decrease of the EMG values might have been associated with covid-19. Another important aspect that was observed while studying the raw data captured using Pheezee™ showed that there was a delay in muscle response noted to initiate the movement for biceps and extensor digitorum during the first session. This information went unnoticed using traditional MMT grading and Pheezee™ was able to detect, which was later found to add great value in the assessment of recovery status of the patient. Therefore, it can be understood that Pheezee™ provides more information in analyzing the motor status and assists the physiotherapists in modifying the treatment protocol as per the patient needs.

6.1.3 Joint ROM

The ROM gained for the joints increased gradually with the physiotherapy sessions compared to day one of treatment. Using Pheezee™ was easier to record patient's activity compared to the traditional methods like using goniometer. Therefore, Pheezee™ can be a reliable device that can measure joint angle efficiently for the bed or wheel chair bound patients. The quality of movement in Pheezee™ was expressed in three parameters; consistency, control and smoothness of the patient's movement. It has been seen that the consistency for elbow flexion and the control for wrist extension improved while the smoothness was maintained normal for other joint movements. The parameter 'activity time' also increased gradually indicating the increase in ability to perform movement. Lastly the parameter 'rate of the movement' increased in second reading obtained, however decreased fairly in final session because of afore-mentioned reasons. This overall information gathered from the parameters generated by Pheezee™ device assists in precise understanding of the patient's recovery status while undergoing physiotherapy in terms of progression. Because, the same information cannot be achieved from using the traditional assessment methods, it can be concluded that Pheezee™ serves as a great addition to physiotherapists in rehabilitation settings.

Even though the goniometer, which is considered one of the easily accessible measuring tools, it has its fair share of limitations of being less reliable that requires professional expertise[13, 16, 35, 36, 37, 38]. Because the Pheezee™ device offers detailed understanding of the joint movement, it can be used as an assessment tool in stroke patients to limit the challenges discussed before in this paper. Therefore, Pheezee™ is the best choice for feasibility[39, 40], ease of administration, tracking of prognosis, and quantification of recovery to include in the treatment of stroke patients. The patient information presented in the form of electronic generated report will benefit the physiotherapist in terms of more time spent on treatment and less on frequent assessment sessions.

6.2 Conclusions

Pheezee™, being a small pocket-sized product, functions as an effortless prognostic tool in rehabilitation. The reports generated at the end of session are archived in the mobile app and server, which are later easily accessible by the therapist and the patient as well. Pheezee™ reports can be used in evidence-based practice to see the effectiveness of a treatment and share the same information. From the results of our study, we conclude that it offers as reliable source to document and archive recovery information of the patient. Furthermore, as a simple wearable device, Pheezee™ can be useful as a tele-rehabilitative tool where patients can be able to perform the therapy protocol at home.

Limitations

Since this is our pilot clinical investigation report using Pheezee^{TM}, we came across a few limitations. The data presented was not compared with the traditional assessment methods to establish correlation as this was not our primary motive. This study presents the data of a single patient hence external validity was not provided. The least number of Pheezee^{TM} sessions performed was another limitation because of the patient's duration of stay in the facility.

Future Research

The findings from the current study need to be further analyzed by recruiting a greater number of participants with hemiplegia.

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