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Handheld Devices Utilization for Cognitive Rehabilitation and Medical Assessment Based on Navstar Global Positioning System: Towards Brain-Rehabilitation

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ABSTRACT: There is less than a third of clinically competent brain patients in developed and developing countries utilizing brain rehabilitation through exercise. The lack of hospital-based rehabilitation services and long travel times impede participation. As a consequence, calls have been made for the creation of more adaptable substitutes. The creation of a system that enables the transmission of a patient's unique EEG, sample rate, N-GPS based speed, and position, as well as walking-based brain rehabilitation. A programmed handheld mobile device (HMD) transmits these data to a secure server where an exercise scientist can view them in real-time. To evaluate the viability of this approach, 134 brain patients who were unable to engage in hospital-based rehabilitation underwent remotely supervised exercise assessment and exercise sessions. Completion rates, technical participation, the ability to spot EEG changes, and the six-minute walk test conducted both before and after the participation. The device's efficiency and speed were praised. The participants were able to finish a six-week exercise-based rehabilitation program while they were on the go or close to their homes or places of employment. The bulk of sessions went off without a hitch or technical issues, however sporadic signal loss in underserved areas occasionally caused issues. There were many post-workout and exercise-related EEG abnormalities found. In all countries with data available, less than a third of clinically competent patients use exercise-based brain rehabilitation.

Keywords: Navstar Global Positioning System (NGPS), Electroencephalogram (EEG), Handheld Mobile Devices (HMD), Cognitive Rehabilitation System

1. INTRODUCTION

Descriptive analyses have shown decreased rates of all-cause brain deaths, fewer episodes of epilepsy, fewer readmissions, and shorter durations of stay, and it is well accepted that BR is essential to fostering recovery in BR patients. Additionally, it has been shown that BR is a very affordable method of secondary prevention. Unfortunately, there are ongoing difficulties in almost every country where BR is offered because to restricted accessibility and poor participation rates [1]. The Framework of the National Services has set a target of 85% of Kuala Lumpur residents being invited to participate in BR, but only about one out of five Kuala Lumpur residents do so, according to statistics. Recently, a number of studies have outlined the factors that influence nonparticipation. Participation in services is often discouraged by poor referral procedures, but more immediate access constraints have also often been observed [2] [3]. The percentage of patients who participate in or finish programs is lower for those who are older, female, or have more clinical difficulties. Residents living far away from a program, those having a longer commute, and those unable to drive are examples of these obstacles. There has been a dramatic decrease in research presenting numerous remedies to help overcome participation hurdles despite this increased knowledge. This persists despite strong recommendations that BR programs investigate their flexibility, including the statement that "fresh methodologies and the latest technology are rarely used in BR programs," and the fact that cerebral morbidity and death are more common in rural and isolated areas with limited access to conventional rehabilitation than in metropolitan areas [4] [5]. There is a potential benefit to home-based BR for such individuals. RCTs have produced equivalent results to center-based programs on a variety of parameters for a lower or comparable cost. These programs may have little to no risk factor and brain function observing, despite the fact that they vary greatly in terms of delivery method, content, and supervision. A lack of functional observing may make it more difficult to make timely adjustments to clinical care in addition to generating safety concerns. There were 24% of patients with low- and 34% with high-and medium -risks who experienced an "untoward event" from 3,877 BR exercise sessions conducted in hospitals. The majority of these events occurred within the first two weeks, with 58% of these resulting in changes in medical management [6] [7].

The transmission of baseline or exercise EEG via the telephone is one technique to provide functional observing during home-based rehabilitation. When this technology was first tested 25 years ago, the reports were mostly positive. An issue with the present systems is that users are restricted to exercising indoors in a certain location and to landlines. Exercise rehabilitation techniques need to be more adaptable, inexpensive, and customized so that they may be used wherever is most practical. Here, we present the creation of a system to address this requirement along with a preliminary assessment of its effectiveness and viability [8] [9]. Patients engaged in scheduled outdoor walking exercises near their homes, places of employment, while visiting friends, on vacations, or while traveling. Aside from the fact that it may impose a sufficient and easily adaptable effort and is typically seen as pleasurable, outdoor walking is especially excellent for BR since it plays a significant role in the return to work and everyday life. The single lead EEG and position of the patient during a reported exercise session were observed remotely by a university-trained exercise scientist [10] [11].

2. RESEARCH METHODS AND MATERIALS

2.1 AN ANALYSIS OF A POPULATION SAMPLE

Patients with certain brain problems who were qualified but unable to participate part in traditional BR did exercise sessions. Participants had had a Cerebral Arterial Catheterization procedure and/or experienced a coronary episode before being released from the hospital. Clinical personnel at Pantai Kuala Lumpur Hospital provided referrals of eligible patients [12].

Ten patients were initially referred; five men and five women completed the research, while one man withdrew before the first round of activity testing. This modest sample size allowed for the feasibility assessment to be based on more than 100 observed exercise sessions. Figure 1 shows the trial protocol and recruiting process. The Scientific Research Ethics Committee (SREC) of the Faculty of Art, Computing, and Creative Industry (FSKIK), University of Pendidikan Sultan Idris (UPSI), gave ethical approval for this study [13] [14].

2.2 THE PROCESSING AND UTILIZATION PROGRAM

A typical six-week walk outside involved three sessions each week. Using N-GPS technology, a modified six-minutes' walk check was conducted in two different sessions that were remotely monitored before and after the exercise participation in order to determine the suggested exercise duration and intensity. In addition to adding distance, incorporating hills, increasing pace, and adding short bursts of running to two of the participants who were deemed acceptable, the programs were regularly modified based on performance and symptoms.

The participant inserted the electrodes and switched on the machinery at the appointed session time. The patient was called, the After receiving the EEG signal at the base station, we assessed the signal quality and confirmed our session objectives. In the event cerebral symptoms arise during testing, data is interrupted uncomfortably, or significant changes in the EEG are observed, follow-up measures will be taken (stopping excessive exercise, modifying exercise, or consulting a physician). Patients' current locations and conditions can be disclosed to local emergency services if necessary.

2.3 NAVSTAR GLOBAL POSITIONING SYSTEM (N-GPS)

It consists of ground stations and satellite control stations and uses satellites as its source of positioning information. An array of 31 N-GPS satellites orbits the Earth at an altitude of 11,000 miles and provides accurate information about the location, speed, and time of users regardless of the ground conditions. The Department of Defense manages N-GPS. (DoD). A civil-military technology project began with N-GPS in 1973. Globally, N-GPS is used for a variety of applications since its capabilities can be accessed with small, inexpensive equipment [15].

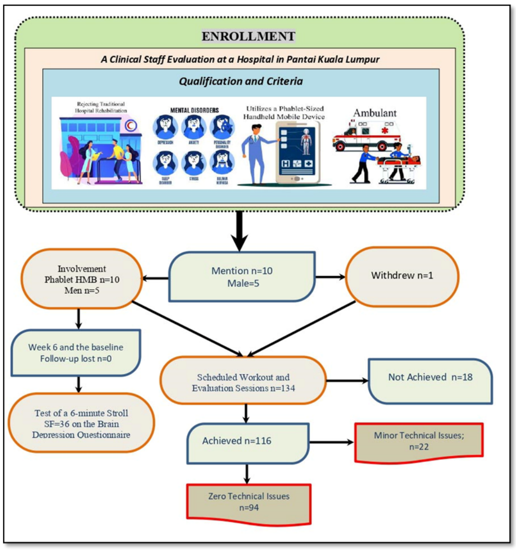

FIGURE 1. **System Methodology**

2.4 PHABLET-TYPE HANDHELD MOBILE DEVICES (PHABLET HMB)

HMB that combines or crosses the dimensions of both smartphones and tablets is referred to as a "Phablet". The portmanteau is a mashup of the words "phone" and "tablet." Phablets have huge screens that are ideal for screen-intensive activities like multimedia watching and mobile web surfing. Software designed for an integrated self-storing pen that makes it easier to doodle, take notes, and annotate may also be included [16] [17]. Although some Phablet HMBs feature flagship specifications, Phablet HMBs are recognized for having "budget-specs-big-battery" with large low-resolution displays and midrange CPUs. Android 4.0 and later releases of Android were suitable for both big and small screen sizes, and elderly users prefer larger screen sizes on smartphones owing to failing eyesight. Phablet HMBs have also grown popular for a number of other reasons. Devices with comparable form factors from the past date back to 1993 [18]. From 2012 to 2014, the word "phablet" expanded across the industry, however, its utilize has subsequently decreased as tiny tablets with screen sizes up to 6.9 inches gradually replaced normal smartphone sizes. However, by 2020, the majority of Android smartphones will have a Phablet HMB form factor with a minimum 6.5-inch screen size in addition to a height of 160 mm or more [19] [20].

2.5 COGNITIVE REHABILITATION (CEREBRAL REHABILITATION)

Cognitive Rehabilitation (or Cerebral Rehabilitation) offers training for thinking, making judgments, and making decisions. Our program focuses on memory (brain), concentration, attention, perception, learning, planning, sequencing, and judgment. The goal of cognitive rehabilitation is to help patients process and interpret information, as well as improve their ability to function within their families and communities [21]. It may be necessary to restore, strengthen, and sharpen cognitive functions after a brain injury, stroke, or another medical incident. Patients learn and translate cognitive strategies into everyday life by completing cognitive exercises, participating in bridging activities, and having discussions with their clinicians [22].

3. REMOTE SURVEILLANCE SYSTEM DEVELOPMENT

The small non-differential 1 Hz N-GPS receiver, a programmable HMD, and a tiny brain signals screen and brain activity observe that are worn via a hat on the patient’s head and record single lead EEG at 300 Hz were all included in the remote surveillance system developed for this research (Figure 2) [23].

4. FINDINGS MEASUREMENTS

Before and after participating, participants completed A Questionnaire for the Assessment of Brain Depression, A Short Questionnaire on the Quality of Life Concerning General Health, and walked six minutes. The effectiveness of the equipment was assessed in 14 distinct ways, and six technical issues were identified. As well as providing qualitative

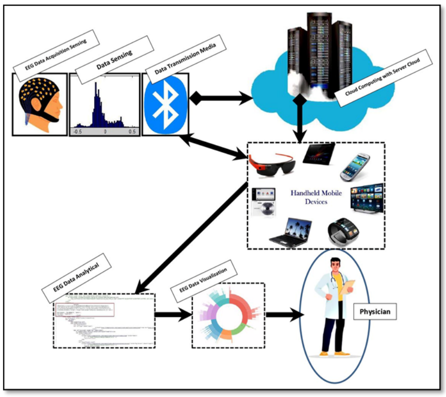

FIGURE 2. **Surveillance System Components**

comments, they estimated the setup and takedown times for the equipment. Pair-wise t-tests were previously used for comparison of these metrics.

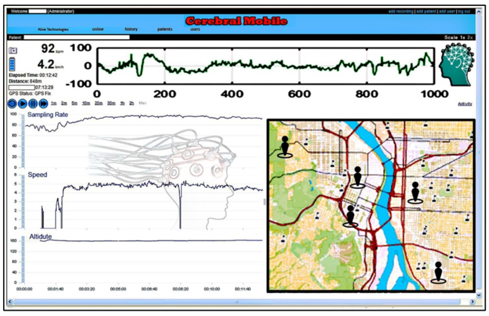

FIGURE 3. **Patient's N-GPS data, sampling rate data, walking speed data streamed by HMD**

5. FINDING SIMULATION AND DISCUSSION

This study illustrates a technologically viable method of supervised brain rehabilitation for patients without access to hospital-based programs, using a walking-based approach with real-time remote EEG monitoring. Portable electronic devices may be unfamiliar to target audiences, making easy operation vital. There are 10 participants were included in this study. These 10 participants, who ranged in age from 42 to 67, had an average BMI of 25.9 (19.6-33.4) and declined hospital-based BR due to job obligations, travel for work-related purposes, distance to the hospital, or lack of transport. Walking-based exercise sessions were scheduled 134 times, of which 120 were completed (84.4%), and 18 were postponed (15.6%). A customized six-week rehabilitation program was completed by all participants; 134 appointments were scheduled, 120 were completed (84.4%), and 18 appointments were postponed (15.6%). (Table 1). There were never any symptoms reported or EEG findings that called for immediate management. Two times, asymptomatic EEG alterations required the study team to speak with the patient's neurologist before the patient could resume exercising. More than 80% of finished sessions were free of technical issues. The most frequent issue in the remaining sessions was periodic signal disruption brought on by poor mobile phone coverage, followed by battery drain. Table 1, shows a technical issues and session status. Participants rated its usability favorably: According to the ease of use rating, it is 4.8; 96.7 percent confidence interval, and 4.6-5.0. Based on a 96.7 percent confidence interval, the frequency of technical problems is rated as 4.; 4.1-4.9 (4 = less than once a week and 5 = never). Their average time for putting on and taking off the equipment was 3.9 minutes. The program resulted in improved physical and psychological functions. A short form of the health questionnaire showed significant improvements in 36 quality-of-life questionnaires, walking distance, brain depression, and physical (but not mental) health. Throughout the test, the distance walked increased by 113 meters, which is comparable to published studies on the effects of brain rehabilitation on six-minute walks.

Turning on and off devices was the limit of operational responsibilities. Rural areas were mostly affected by GPRS coverage issues. A rehab participant regularly exercised at unfamiliar places that could not be tested during his rehabilitation between Tanjung Malim and Johor. Rural and remote areas have been greatly relieved by utilizing Australia's 850 mHz

Table 1. Status of the Session and Technical Issues

%	n	Status of the Session	%	n	Findings
72.1	96	Having no technical issues			
9.5	12	Periodic signal loss of less than 15s			
6.5	8	Battery discharges near the conclusion	84.4	120	Achieved
3.5	4	Other sporadic technological issues			
5	6	A weak EEG signal			
6.5	8	Severe Weather			
5	6	Additional technical issues			
4.2	5	Patient NOT present			
3.5	4	A lack of phone coverage	15.6	18	Not Achieved
3.5	4	No recharging of the battery			
2.7	3	A weak EEG signal			
100.0	156		100.0	134	Total

3G network. Future wireless network developments like TDMA will improve performance. Less commonly, a participant failed to charge their phone, so after-exercise reminders were added. EEG signal quality was typically acceptable and facilitated wave alterations, although it was sometimes sufficient or bad. Electrode leads were adjusted to eliminate pulling and movement artifacts, or the skin was prepared again and electrodes were replaced [24] [25]. A brain arrest occurs every 1.3 million patient hours during conventional brain rehabilitation, and one occurrence occurs every 49,565 patient hours. Since emergency services aren't immediately accessible, patients with home-based CR may benefit from surveillance and supervision in two ways. Despite the need for medical evaluation for two participants, both were approved for completion of the program. When a patient exercises without supervision or surveillance, there is a high risk of significant anomalies being detected, voice contact being made, and N-GPS location is recorded [26] [27]. Whenever rehabilitation occurs far from emergency treatment, future studies should consider patient safety. In situations where risks are high and safety risks are high (such as traffic hazards, unsafe walking surfaces, a lack of public safety), safety benefits and risks must be carefully balanced. As important as the physical support that such surveillance can provide is the psychological support that can accompany this recovery process [28] [29]. Several brain patients believe exercise rehabilitation is detrimental, according to a UK study. Study participants reported feeling more confident about exercising because of being observed, and that the intensity and amount of exercise were appropriate [30] [31]. As a result, participants may be more likely to participate, comply, and perform better. It may be beneficial to monitor EEGs during the first few weeks of treatment as a motivational and therapeutic tool, but after that, it should be tapered off to avoid becoming too dependent [11] [24]. An experiment conducted at a hospital-based BR center found that patients who exercised off-site after one month were more motivated to exercise and had higher exercise self-efficacy six months after EEG monitoring had been removed. A six-minute walk assessment was conducted remotely using N-GPS. Encephalitis patients' maximum walking distance has been assessed using this method. The physiological effort was calculated using an accurate system utilized in this study [31]. By using accurate location data, exercises can be tailored to individuals' physical capacities and progressions based on changes in physiological characteristics (sample rate) [28].

Table 2. Outcome of performance measures

Unit	Pre-participation		Post-participation		P (Pre) & P(Post) (t-test for dependent scores with two tails)
	Mean	96.7% CI	Mean	98.73% CI	
Test of a 6-minute walk	526	422 to 657	639	567 to 728	2.009
Brain Depression	56	42.40 to 73.00	46.60	34.00 to 62.40	2.007
Physical Health SF36	52	38.00 to 69.50	80.40	59.90 to 105.90	2.03
Mental Health SF36	69.4	46.40 to 98.30	73.50	56.60 to 94.80	2.5

6. RESTRICTIONS

Research in this area is limited by two major drawbacks. Compared with hospital-based BR, it provides comparable results in walking distance, depression, and physical health; however, since the feasibility trial did not include a control group, participants cannot be compared to each other. As a result, the improvements cannot solely be attributed to the participants. Researchers in the study were primarily men and had a small sample size [31] [18]. It appears that, despite these limitations, 120 sessions were successfully completed and observed, the technology was widely used, compliance was high, and encouraging results were obtained. A cost-benefit analysis should be performed on studies that evaluate long-term clinical, functional, and quality-of-life outcomes for patients, along with safety and effectiveness [28]. To determine the effectiveness of the intervention, comparisons must be made between conventional therapy (hospital-based rehabilitation) and customary care, which is not an official rehabilitation program for the target population. If this technology proves to be safe, beneficial, and economically feasible, it may resolve a well-known problem with healthcare access (in many countries) that is particularly acute in remote areas and rural areas [29].

7. CONCLUSIONS

A feasible and highly flexible alternative to hospital-based brain rehabilitation programs was offered to patients unable to participate in hospital-based programs. Many nations may benefit from this solution because it might help solve a problem. A larger sample size, including a range of conditions and severity levels, would be needed to evaluate its long-term reliability, financial viability, and safety.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

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