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Home rehabilitation using android-based system as booster on the independences of stroke patients in local government hospital in Aceh, Indonesia

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Abstract. *Background and aim:* The independence of stroke patients played the main role in not only preventing the asymptomatic attacks which delayed assistance but also enhancing their quality of life by reducing their dependence on family members or caregivers. However, the inaccessibility and expense of treatment prevented stroke patients from continuing their rehabilitation and exercise after returning home. Thus, the purpose of this study was to provide an efficient system for alternative home rehabilitation to boost the self-care Independence of stroke patients by designing Android-based home rehabilitation. *Methods:* The quantitative research was conducted using a non-randomized trial where the patients were purposively sampled. 70 participants were joined and divided into two groups: the control and intervention groups. The intervention group will have SIMTROKE application on their smartphone as the home rehabilitation process where control group would not have SIMTROKE installed. The effect of home rehabilitation was assessed by univariate, bivariate analysis, and the correlation matrix to analyze home rehabilitation effect to the participants' self independences. *Results:* The result showed that the independent intervention in post-stroke patients has a significant effect on increasing the independence of stroke patients to improve their quality of life of stroke patients. The highest improvements were found in urination and toileting followed by defecation, dressing, active and phase motion range, self-care, stepping to stairs, mobilization, showering, and eating abilities. *Conclusions*: The result proved that home rehabilitation utilizing an Android-based system could be employed as an alternate method to assist stroke patients in improving their independence and quality of life. (www.actabiomedica.it)

Key words: Independence, self-care, rehabilitation, stroke disease, Aceh

Introduction

Stroke is reported as a global epidemic disease that attacks asymptomatically and leaves patients at risk and potential for movement disabilities due to post-stroke deficits and complications (1). The post-stroke effects could initiate a further stroke attack or worsen the complications if the individual does not follow the healthy lifestyle factor such as proper diet, physical activities, etc (2). The World Health Organization (WHO) reported stroke as the second non-communicable disease which could cause a spontaneous death worldwide and the third most common cause of disability-adjusted life-years in the world (1). In Indonesia, Stroke was the most common cause of mortality and disability (3). The prevalence of stroke in Indonesia increased from 7 in 2013 to 10.9 in 2018 with the highest stroke prevalence recorded in East

Kalimantan Province (14.7) (4). Indonesia is also reported as highest number of stroke patients in Asia the fourth in the world for stroke incidence after India, China, and the United States (5).

The primary mechanism of stroke attack was triggered by an abnormal condition of cerebrovascular disease which was characterized by the formation of an embolus or thrombosis causing bleeding in the brain or by clogging the arteries and ischemia of brain tissue supplied blood vessels in the brain (6). The fatty buildup (plaque) generates vessel blockage leading and ischemic stroke, whereas rupture or leakage in the arteries could initiate hemorrhagic stroke (7). Both strokes could result in permanent disability for the patient where the early handling and treatment played the main roles to save the patient. Advani (2017) reported that the early handling of a stroke attack within 60 minutes (golden hour) leads the stroke patient to complete recovery shown by the health stroke scale to zero (patient completely recovered) (8).

On the other hand, the prevention of stroke could be started by understanding the stroke symptom. Most stroke patient has paralysis or impaired motor control, sensory disturbances and pain, impaired language and understanding, impaired thinking and memory, and emotional disturbances (6, 9). The stroke initiation generates neurological disability and paralysis on one and both sides of the body and often requires the involvement of another person for treatment (10). The sign of stroke was also hemiplegia or the weakening of body parts and hemiparesis or paralysis on one side of the body which limits the patient's mobility (11). This immobilization condition could further complicate the physical and mental disorder of the patient due to the inability for doing daily activities (11).

In general, all stroke patients need full support from medical staff, families, and the neighborhood. All the support stimulates the emotions of the patient which further increases the intention to recover after the stroke (12). The empowerment and adaptation of post-stroke patients can improve the functional status of post-stroke patients, increase adaptability, and extend life expectancy (13). Thus, the patient individual independence is very important to prevent stroke recurrence and improve quality of life.

To increase the independence of stroke patients, well-designed rehabilitation with easy understanding of knowledge was subjected. In Indonesia, stroke rehabilitation could be done through a clinical service such as a hospital, or traditional therapy such as acupuncture or traditional massage (14). However, both therapies either clinical service or traditional therapy need lots of money, and some services are located in big cities where the patient could be in remote areas. Therefore, easy access to stroke therapy which could access by any patient, especially in Indonesia needs to be developed.

In this modern era, advanced technologies have revolutionized medical rehabilitation. Telerehabilitation has been applied to provide rehabilitation services to people remotely in their homes or any specific place or environment (15). However, most telerehabilitation required video conference platforms and telephones which required tele-support and specific equipment such as a laptop, computer, or tablet. These technologies limit the use for people in the middle and low income since they might hard to fulfill this equipment. Thus, further rehabilitation needs to be cheap but provide an effective service like telerehabilitation.

The phone-based rehabilitation become a popular approach since almost everyone uses at least one phone today. This fact opens the possibility to apply the use of phone-based rehabilitation to do stroke rehabilitation. The present study aims to design a phone-based rehabilitation that contains a basic knowledge and rehabilitation approach to increase patient independence and allows patients to become independent, take care of themselves, and learn to do so through applications downloaded to their mobile phones. By giving the application, the stroke patient could have a better understanding of stroke and how to handle their daily activities by themselves after a stroke attack. The main goal was to give knowledge to the stroke patient that the stroke can be completely recovered, and the patient could do their activities independently. Thus, the stroke patient could enhance their confidence and independence which further rises the possibility of fully recovering.

Methods

Research design and period

This present research uses a non-randomized experimental research design where there are two groups designed as (1) an intervention group and (2) a control group. The intervention group or treated group is the group that had the Android-based application for their home rehabilitation treatment. As a control group, the patients will not have SIMTROKE installed in their phone meaning that there would be no routine treatment based on SIMTROKE materials. However, both intervention and control would have any treatment as needed from the health care provider.

70 participants of a stroke patient from the government hospital of Banda Aceh joined the research and were divided into two groups with a specific 35 participants for each group. The participant was choosen based on the inclusion criteria where all the participant have satisfied the criteria. Furthermore, every participant has agreed to be part of this research and has passed a nursing ethics test and ethics committee from the ethics committee of the Faculty of Nursing, Syiah Kuala University on June 4, 2021 (Code Research: 113001210521). The research period was started from February 2021 to August 2021. To obtain the sample and divide into two groups, the purposive sampling was used based on the age of the patient where each sample should meet the sampling criteria (shown below) and be characterized by the demographic and classification in Table 1. Both control and intervention groups will have the close proportions or percentages of each age categorization to ensure that both group will have a quite similar sample condition. The demographic study will be conducted by doing the interviewing with each patient to obtain the information.

Furthermore, the sample inclusion criteria are:

1. The respondents should have been diagnosed with stroke by confirming the patient data with the hospital record
2. The respondents should have a family or caregiver to control the rehabilitation and research process. The roles of caregiver or family was to ensure the rehabilitation process run as the plan and the patient could access the application without any technical delays.
3. The respondent and caregiver should know the basic knowledge of how to operate the Android phone to ensure that the patient could do the rehabilitation without any technical delays
4. The respondent agreed to provide the daily record data as the input for the study
5. The family or caregiver should support the respondent to do daily independence exercises at home based on the phone-based rehabilitation approach

Where the exclusion criteria of this study are:

1. The respondents could not join the research if they experience an impaired consciousness
2. The respondents could not join the research if they did not have any family or caregiver who can support and monitor the patient's status and treatment.

Table 1. The demographics variables and classification.

Parameters/ Variable	Classification	Age intervals:
Age	I 2 3 4	Young adult = 36 – 45 Middle-age Adults = 46 - 55 Old Adult = 56 – 65 Senior = >65
Sex	I 2	Male Female
Education Level	1 2 3	Elementary School High School Higher Education
Smoking Status	1 2 3	Non-active Passive Active
Health Background	1 2 3 4	Diabetes Mellitus Hypertension Coronary heart Complication (Combination of 1-3)
Stroke Attack	1 2	1st Attack 2nd Attack

3. The respondents could not join the research if they have mental disorders
4. The respondent who had blood pressure more than 180/90 mmHg (high risk) could not join the research

Android-based rehabilitation for stroke patient

The University of Syiah Kuala in Banda Aceh created a system called SIMTROKE for a phone-based rehabilitation program. The application was created using a single code base system using React Native to develop the applications. However, SIMTROKE support only an Android-based operating system device where the other operating system was still under development. There was no specialization in using the Android operating system compared to other operating systems. The only reason was based on the fact that most Indonesian uses Android as the phone operating system (16). SIMTROKE contained basic materials about stroke including the definition of stroke, etiology of stroke, and risk of stroke. The application also contained self-care and rehabilitation materials including standard operational procedure (SOP) of eating, showering, dressing, self-care including combing and self-cleaning, defecation and urination, toileting, active and passive motion range, mobilization, and stepping/walking on the stairs. All the material was the basic rehabilitation for stroke patients which was based on literature (7, 17).

Moreover, with the installation of smartphones for the patients and their families, the rehabilitation procedure for the treated group got underway. Then, provide basic instructions for operating or utilizing the SIMTROKE application. In the first week of treatment, the patient was instructed to read material on stroke fundamentals and self-care. When engaging in everyday activities, patients receiving the given treatment could benefit from regular instruction in basic self-care. In addition, family members or caregivers will assist the patient in ensuring that the patient is able to utilize the application during therapy and will check daily to see if the individual is reading the information. The patient or caregiver must provide a daily report on the patient's confidence and ability to do everyday activities. The Barthel index scale was measured on the initial day of treatment and the last day of treatment, which was three months following the first day (18).

Statistical analysis

All the obtained data including demographic and Barthel index scales were processed by Google Collaboratory and SPSS (SPSS, Chicago, IL, US) to perform the Correlation Matrix and the univariate and bivariate analysis, respectively. The correlation matrix was subjected to identify the collinearity between independent variables which measured between -1 and 1. The result will be a heatmap using color intensity shown in Figure 1. The correlation between each variable becomes the result where the diagonal was the comparison between a variable itself which had the value of 1 along the downward right diagonal. The value of correlation could become negative or positive which depended on how the correlation between the variables (19).

The univariate analysis was conducted to provide an overview or description of each of the variables studied. The numerical data were presented as mean, median, standard deviation, minimum value, and maximum value. For categorical data, the data will be calculated by frequency and percentage. Each variable including age, sex, education, smoking status, illness history, and stroke history will be presented using a table and interpreted based on the results obtained. To analyze the effect of the Android model application on the independence of stroke patients, the bivariate analysis was used with the *t*-test formula with a two-mean difference test. The statistical significance was determined by *p*-value where *p*-value ≤.05 was considered significant throughout the study.

Results

Demographic characteristics of the population

The demographic characteristics of the participant who joined the present study were chosen from the total participant consisting of 35 stroke patients in each group. All the participants fulfilled the required

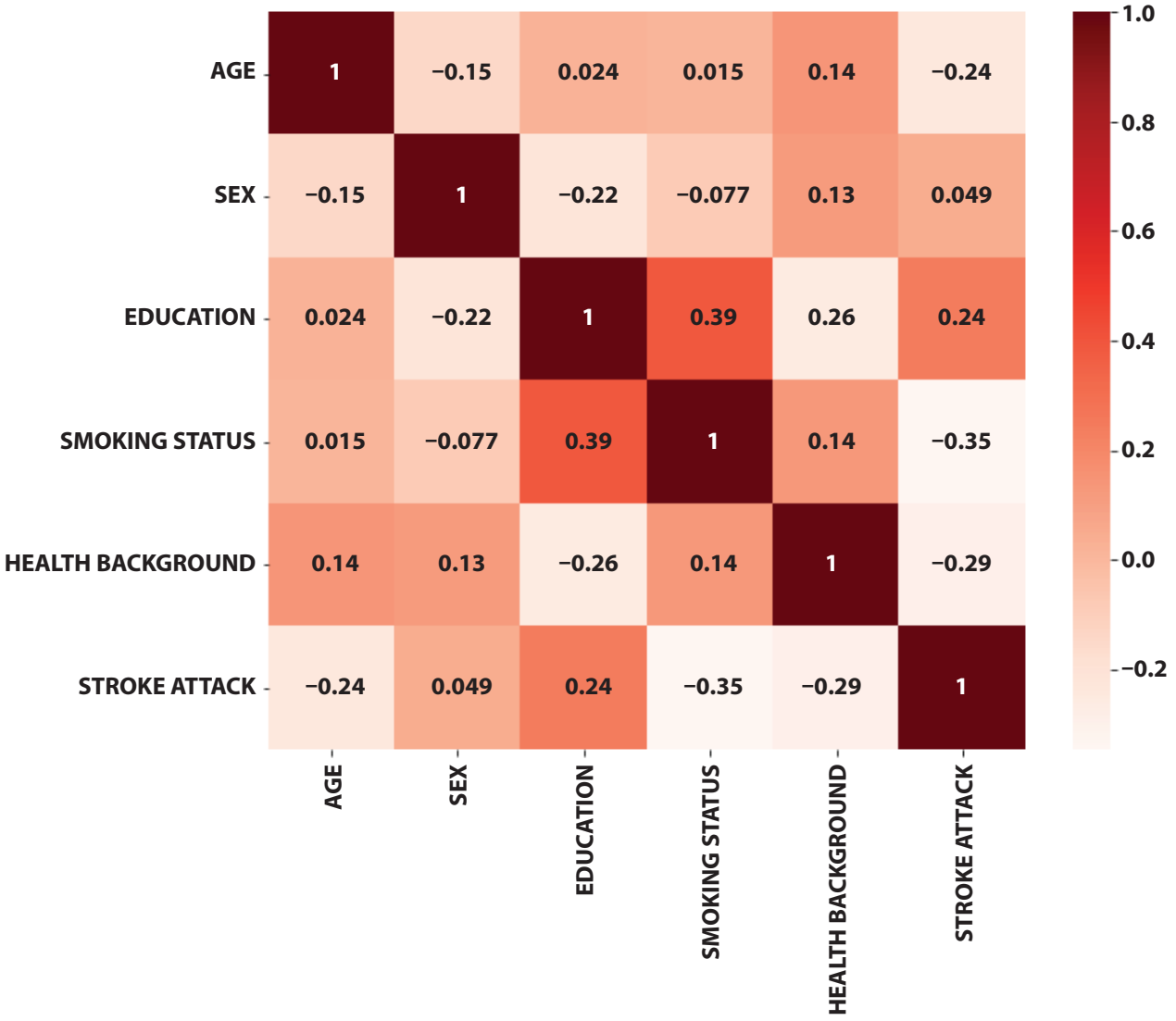

Figure 1. Heatmap of the correlation matrix of all the data features obtained from the present studies.

characteristics either in the control (n=35) or treatment (n=35) group (Table 2). The demographic study would be combined with heatmap analysis to correlate the result. Age become the first parameter in the demographic study where most of the stroke patient in both groups was old adult followed by middle-aged adult, senior, and young adult. However, the correlation matrix using heatmap analysis found that the increasing age number would not affected the number of stroke attacks showed by the negative result in heatmap of correlation matrix. There were two main possible reasons: (i) the data size was small which could not cover all the correlation second and (ii) the number of stroke incidents in middle-aged adult and old adult cover approximately 80% of stroke incidence which further affect correlation matrix. Furthermore, the effect of age on the demographic analysis provided effects to the health background where the complication and coronary heart were increased with the increase of age. A bad health background especially complications where diabetes mellitus, hypertension, and coronary health could be combined become the most risk factor for stroke incidents (20). The detail of the health background would be discussed in the next paragraphs.

Table 2. Demographic Characteristics of the Respondents in the Intervention Group (n=35).

Characteristics	Control Group n=35	Percentage (%)	Treated Group n=35	Percentage (%)
Age				
Young adult	1	2.9	2	5.7
Middle-aged adult	6	17.1	8	22.9
Old adult	24	68.6	21	60.0
Senior	4	11.4	4	11.4
Gender				
Female	17	48.6	12	34.3
Male	18	51.4	23	65.7
Education				
Elementary	5	14.3	5	14.3
High School	20	57.1	18	51.4
Higher Education	10	28.6	12	34.3
Smoking Status				
Non-smokers	12	34.3	10	28.6
Passive	14	40.0	12	34.3
Active	9	25.7	13	37.1
Illness History				
Diabetes mellitus	20	57.1	10	28.6
Hypertension	10	28.6	10	28.6
Coronary Heart	2	5.7	4	11.4
Complications	3	8.6	11	31.4
History of stroke				
First	23	65.7	30	85.7
Second and more	12	34.3	5	14.3

Sex characteristics found that most of the stroke survivor in both groups was found as men. In education background, most of the patients had a good education background and only five patients in each group have graduated from elementary school. Most stroke patient has high school degree in which higher education results in lower percentages. Furthermore, the education level could differentiate the smoking activities of stroke patients that higher education level potentially becomes non-active or passive smokers (21). However, the heatmap analysis showed that education level had a strong correlation the smoke activities.

The health background played the main role in stroke occurrences. The demographic result showed that hypertension and diabetes mellitus and complications are the most comorbidities that affected the stroke attack in the present studies. Those three comorbidities had slightly similar percentages in the treated group where the control had diabetes mellitus and hypertension as the most comorbidities that affected the stroke. The heatmap analysis showed negative results indicating that the lower characterization number (diabetes mellitus and hypertension) affects the most stroke attack.

Statistical analysis of the Independence of stroke patients

The statistical analysis was used to assess the effect of Android-based rehabilitation on a stroke patient. The standardized questionnaires in questions about independent variables such as mobility activities were recorded. Table 3 showed the average values of the independence ability of stroke patients before and after being treated with Android-based rehabilitation. The result showed that most of the independent variables showed higher independence after being treated with a *p*-value close to 0 indicating the Android-based system has a large influence on the independent variables. The highest effects of Android-based rehabilitation were found on urination and toileting (0.900)

Table 3. Distribution of the average value (*mean*) of independence of stroke-patients.

Independent Variable Patient	**Types of Groups**	**Mean**	**SD**	**SE**	**n**	***p*-value**
Eating	Intervention	*0.486*	0.612	0.103	35	0.000
	Control	0.400	0.553	0.093	35	0.000
Showering	Intervention	*0.400*	0.490	0.084	35	0.000
	Control	0.200	0.400	0.069	35	0.006
Self-care	Intervention	*0.743*	0.500	0.085	35	0.000
	Control	0.200	0.406	0.069	35	0.006
Dressing	Intervention	*0.886*	0.530	0.090	35	0.000
	Control	0.200	0.406	0.069	35	0.005
Defecation	Intervention	*1.057*	0.684	0.116	35	0.000
	Control	0.370	0.490	0.83	35	0.000
Urination	Intervention	*1.057*	0.680	0.116	35	0.000
	Control	0.140	0.355	0.060	35	0.223
Toileting	Intervention	*1.029*	0.664	0.112	35	0.000
	Control	0.143	0.355	0.060	35	0.025
Active and passive motion range	Intervention	*0.657*	0.482	0.81	35	0.000
	Control	0.021	0.160	0.024	35	0.234
Mobilization	Intervention	*0.314*	0.583	0.98	35	0.003
	Control	0.029	0.169	0.029	35	0.324
Stepping stairs	Intervention	*0.486*	0.562	0.95	35	0.000
	Control	0.029	0.169	0.029	35	0.324

followed by defecation (0.687), dressing (0.686), active and phase motion range (0.636), self-care (0.543), stepping to stairs (0.457), mobilization (0.285), showering (0.200), and eating (0.086).

Discussions

Demographic characteristics of control and intervention groups have a quite similar proportion where the middle-aged and old adult patients with the age above 45 years old dominated more than 60 percents of samples. The demographic results showed showed that that most of the stroke patient in both control and intervention group was relatively old ages indicating that aging is considered the most robust non-modifiable risk factor of stroke (22).

Based on the sex characteristic, men dominated the stroke patient joined in the study compared to women where the intervention group have more number of men compared to the control group. The result was different from Reeves (2009) who reported that women have higher stroke events compared to men (23). However, the result could not be used to conclude that men dominated the stroke patient in Indonesia or in Aceh province since the present data only covered the patient who qualified and joined the study.

The correlation metrix from demographic characteristics found that education played the main role in the stroke occurances and it has a strong correlation to smoking status. It showed that most of patient who become the active or passive smoker have lower education level. The result also proved that education become one of the important ways to lower the smoker number in Aceh which would be further lowering the number of stroke occurances in Aceh (24, 25). The importances of education also become the idea to improve the self independence of stroke patient through educate the stroke patient using android-based rehabilitation.

The Android-based rehabilitation differentiated the value of independence of stroke patients. The study proved that the dependence of people on phones or

smartphones could provide a good impact on the health treatment process. The success of stroke rehabilitation in the present study could increase the quality of life of stroke patients since most stroke patients were dependent on caregivers or family and could not do their daily activities on their own. The successful independence improvement was important since the majority of stroke patients who return home after treatment (post-stroke) have motor impairment in the upper and lower extremities, especially in the distal joints such as the hands and feet (10, 26). As a result, the stroke limited the stroke patient in performing their daily activities and worsened due to persistent symptoms that cause the patient to experience resistance to mobilization and cardiorespiratory ability, limited physical activity can contribute to the patient's poor quality of life after stroke (27).

Toileting and urination have the highest impact on the independency of stroke patients followed by defecation using home rehabilitation in the present study. The abilities of those activities were important since urination, toileting, and defecation were considered private activities which come with no schedule. To be more specific to urination, improper urination potentially initiated a urinary tract infection (UTI) (28). UTI was a common complication of stroke affecting up to two-thirds of stroke patients. Post-stroke UTI is associated with an increase in patient mortality and morbidity and can be used as an independent predictor for an increase in days in the hospital. Thus, most patients should be taught to perform toileting and urination on their own to prevent UTIs. Sometimes, the patient was not well trained since it was conducted in a short period during staying in the hospital and most of the training required full support and understanding from the family of the stroke patient. Therefore, the success of Android-based therapy may reduce UTIs and increase stroke patients' confidence in urinating and using the toilet independently.

The other intense improvement in independence variables in the present study was dressing which was found as the fourth most improvement in independence variable. The dressing was a daily activity in which the success of improvement of independencies could improve the confidence of stroke patients. The other followed variable was motoric activities such as active and phase motion range, self-care, stepping to stairs, and mobilization. Motoric activities were found as the most problem for stroke patients since those problems were experienced by 80% of patients after having a stroke (29). This condition might worsen if the patient does not practice mobility and movement. To prevent contractures, the patient should engage in some light daily physical activity.

The other success of Android-based rehabilitation was the independence of stepping on the stairs. It is significant because the majority of houses in the investigated area lacked handicap-accessible equipment and accessories, requiring stroke patients to enter on their feet. The stepping activity of going up and down stairs requires close supervision by family members so that injuries do not occur causing repeated strokes. Therefore, the improvement in the ability of stroke patients in the stepping activity enhances the independency of the stroke patient.

In general, increasing physical activity could improve cognitive function (30). The activities such as active and phase motion range, self-care, stepping to stairs, and mobilization enhanced muscle strength and bone density (30). Nursiswati (2017) reported that the provision of care for independence in stroke patients was reduced from the time the patient was admitted to treatment until the patient got discharged from the hospital (31). This shows that patients get good outcomes of care during treatment. Based on the general standard that is targeted at the care of stroke patients, there should be functional improvement after one week in ischemic stroke and two weeks in hemorrhagic stroke (7). Therefore, nurses have a good opportunity to optimize nursing care within the 1-2 week span.

The other achievement obtained in the present study was the short period of rehabilitation of stroke patients. Most of the improvement in the ability and independence was conducted in three months. In comparison, the early rehabilitation of stroke required at least 6-10 weeks and the complete rehabilitation could be a couple of months (18, 32, 33). The easy access and available resource from Android-based rehabilitation made the rehabilitation process could be accessed in every place and at every time which further increase the fast improvement for the stroke patient. The use of Android-based rehabilitation also provided a sustainable rehabilitation program that could prevent relapse and activate neuroplasticity in patients with chronic poststroke conditions and provide clinically improved

outcomes (34). Furthermore, the recovery of extremity function after a stroke depends on intense and repetitive exercise in weakness or paralysis by optimizing voluntary motor effort and minimizing compensatory movements of muscle coordination.

Android-based rehabilitation was considered as a cheap rehabilitation where the main technical problem of post-stroke rehabilitation was the high cost of rehabilitation service. By providing a free access application, every patient or person could have a better understanding of stroke to handle or even prevent the stroke. Affordable and easy access to home rehabilitation was important, especially in developing countries like Indonesia. On the other hand, the smartphone was everywhere and most people nowadays used the smartphone as a daily need. Tablet or mobile-based programs containing therapeutic content should be carefully considered according to post-stroke patients to minimize barriers and maximize therapeutic response (35).

However, the study also has a limitation which could become the further step to develop the stroke rehabilitation. Technically, the SIMTROKE still use a single operating system (Android) and only available in Bahasa Indonesia (National Language of Republik of Indonesia). SIMTROKE is still not available in online which limits the people especially people from other countries to access the application. SIMTROKE could only be installed after transferring the app source to the patient smartphone and could not be installed by online system. Furthemore, the limitations of result are:

1. The rehabilitation process still need a major assistant from caregiver or family member where the successful of rehabilitation in the study depended on the full support of assistant and willingness of patient to learn and study the materials. The SIMTROKE application is only the media for the patient to improve their self independences and do not the key for the successful of rehabilitation.
2. The home rehabilitation could only support the patient with a minor post-stroke syndrome where the patient with mayor post-stroke syndrome who hard to move would not have a significant progress in the same rehabilitation period.

Conclusions

Advanced mobile technology of Android-based rehabilitation has been proven as a breakthrough approach in the modern era to provide cheap and easy-to-access handling stroke rehabilitation for a stroke patient in Indonesia. The Android-based rehabilitation could facilitate the stroke patient to access the basic information and standard operational process which was safe and proper to be applied for the stroke patient. The application has succeeded in boosting the independence of stroke patients and reducing the burden of stroke patients on family members and preventing patients from experiencing contractures in the future. This application was considered the best practice for a stroke patient who has limited access to facilities for rehabilitation, especially for people in developing countries like Indonesia.

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