Feasibility of a 10-week community-based mobile health rehabilitation program using the WalkWithMe application in late sub-acute and chronic stroke survivors in a low resource setting: A pilot study

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ABSTRACT

Physical functioning can be increased in people with stroke by using a mobile health application. The purpose of this study was to investigate the feasibility of a 10-week community-based program using the WalkWithMe (WWM) application in people with late sub-acute and chronic stroke in Benin. An interventional pilot study with mixed methods research design was used examining the application of ~~with~~ an unsupervised individualized mobile Health (mHealth) instructed training program consisting of overground walking in the community.

Main outcome included the application usage, safety, adherence, perceived enjoyment, mHealth quality, patient experiences to use the application and pre-post efficacy measures. Nine adults with late sub-acute and chronic stroke, five males, median age of 60 years and time since stroke of 12 months participated in this study. For most participants adherence with the application was over 70%. However, some usability problems were observed due to incorrect understanding and use by participants and technical problems. The application was very fun, stimulating and enjoyable. Significant improvements were found with median (pre/post measures) of locomotors skill (1.4/3.4); impairments (38/40), Barthel Index (85/95), activity limitation (2.1/3.1), and quality of life (194/218). A trend towards significant improvement was found with 6 minutes walking test (6MWT) (181/220, p=0.06). The WWM application is perceived as a potential approach to increase physical activity and functioning among people with late sub-acute and chronic stroke in Benin.

KEYWORDS: stroke; mobile health application; rehabilitation; physical activity; walking performance.

MANUSCRIPT WORD COUNT: 4944

LIST OF ABBREVIATIONS

1	6MWT	:	Six-minute walk test
2	app		Application
3	BI	:	Barthel Index
4	CBR	:	Community-based rehabilitation
5	CSI-D	:	Community Screening Instrument for Dementia
6	FAC	:	Functional Ambulation Category
7	IPAQ	:	International Physical Activity Questionnaire
8	LMICs	:	Low- and middle-income countries
9	MARS	:	Mobile App Rating Scale
10	mHealth	:	mobile health
11	MRS	:	Modified Rankin Scale
12	PA	:	Physical activity
13	PACES-8	:	Physical activity enjoyment scale
14	PM-Scale	:	Participation Measurement-Scale
15	SIAS	:	Stroke Impairment Assessment Set (SIAS)
16	SSQoL	:	Stroke Specific Quality of Life Scale
17	UHasselt	:	University of Hasselt
18	WWM	:	WalkWithMe
19	ABILOCO	:	Ability of locomotion
20	ACTIVLIM	;	Activities limitations

INTRODUCTION

Stroke is the second most common cause of death, third leading cause of long term disability worldwide and its burden is still rising in low- and middle-income countries.[1,2] Regarding Benin, a lower middle-income country in Western Africa, the age standardized prevalence of stroke is almost double in comparison to many western European countries.[2]

The adherence of stroke survivors to physical activity (PA) recommendations continues to decrease after two years post-stroke,[3] although PA is important to improve health and quality of life in patients with stroke.[4] PA helps to maintain functional autonomy and reduces the risk of a new stroke.[5] In addition, PA is an easy and low-cost mean to decrease disability and mortality.[6,7] Therefore, PA recommendations and exercise training should be incorporated into the stroke rehabilitation especially in low resource settings.[8]

A recent systematic review indicated that community-based rehabilitation (CBR) can be used in many forms or in combination with an exercise program or task-oriented training to benefit people with chronic stroke.[9] Everywhere, the majority of stroke survivors deal with walking problems.[6,10,11] Walking is the most important factor for independent daily life in the community.[12] In particular, community walking is defined as a complicated and challenging activity requiring the ability to walk at a given speed for a minimum requisite distance and to adapt to changes in various environments.[3,12] Also, walking time and number of steps per day of stroke survivors can be significantly improved by applying a mobile, home-based intervention.[13] Due to the rapid increase of smartphone usage in common daily life even in low resource countries, interest in using a mobile health (mHealth) application has also increased in healthcare and rehabilitation services.[14] In addition, the COVID-19 pandemic has reinforced the use of mHealth for PA after stroke.[15] In order to provide alternative health-related interventions, recent innovations allow healthcare professionals to provide services remotely through communication technologies (for example, smartphone or video call via computers with Internet access), known as telehealth.[16] Lai et al.[17] found high acceptability for an aerobic exercise program, which was attributed to its accessibility, convenience and interpersonal interaction with the professional. Moreover, home-based rehabilitation technologies improve stroke patients' physical functioning, the performance of daily activities[18] and adherence to rehabilitation.[19] In this way, a mHealth application can be a successful approach to increase access to health care in low-and middle-income countries[20] mHealth technologies has been defined as the use of "wearable, portable, or domestic-integrated devices that can provide objective measures and that include digital applications, as well as body-worn (adhered to a body surface, mainly inertial measurement units) or frequently used patient-centered devices (e.g., smartphone and keyboard).[21]

In the body of literature, mHealth applications have so far been mainly investigated in high-income countries.[22,23] In contrast, there is currently a lack of research about mHealth rehabilitation programs among stroke survivors in low-and middle-income countries. In this study, the WalkWithMe application, a personal mHealth application stimulating PA and walking performance in one's community setting[24] was applied in Benin Republic, a lower-middle income country. The feasibility of the WalkWithMe application was demonstrated previously in persons with Multiple Sclerosis.[25] The latter study provided a proof-of-concept that, when using the WalkWithMe application, improvements are possible on walking capacity, perceived walking ability, and physical activity.[25] The present study investigated the feasibility of a ten-week community-based walking program using the WalkWithMe (WWM) application in people with late sub-acute and chronic stroke living in Parakou, Northern Benin. In addition, the study explored the effects of the program on walking performance of participants.

METHODS

Study design

A mixed method design with both quantitative and qualitative data was used in this feasibility pilot study. An independent interpretation of both data was made to evaluate the feasibility of the WWM application (app).

Setting and ethical considerations

The intervention took place at [information retracted to maintain the integrity of the review process], from May 15th to August 30th 2022. All participants were recruited and data collected during this period. The study received approval from the Ethics Committee of biomedical research of the University of Parakou, Benin, approval number 0520/CLERB/-UP/P/SP/R/SA of 04th October 2021. Before starting the intervention, the objectives of the study were explained to the participants and caregivers and the participants signed an informed consent.

Participants

Participants were recruited from the admission records of University Hospital of Parakou and were selected based on the eligibility criteria. The inclusion criteria were: (1) stroke in late sub-acute and chronic stage, at least three months after stroke onset, (2) adult person, age ≥ 18 years, (3) absence or minimal disability with a Modified Rankin Scale (MRS) score ≤ 3, (4) absence of major cognitive impairment and dementia with a Community Screening Instrument for Dementia (CSI-D) score ≥ 7, (5) ability to walk independently with/without an assistive device for at least ten minutes, (6) ability of the participant or a family caregiver to use a smartphone application, and (7) availability of an Android smartphone for using the WWM app. The exclusion criteria were: (1) contraindication to physical exercise and (2) other conditions interfering with walking, such as hip prosthesis or rheumatoid arthritis.

Intervention

The intervention was an individualized unsupervised training consisting in over ground walking in the community, based on goal setting with personal training schedule. Participants had to walk independently in their own community, at least twice a week during 10-weeks.

Before starting the study, the participants received detailed information about the intervention and about the WWM app. At a first visit in the rehabilitation department of the University Hospital of Parakou, the WWM app was installed on the participants' smartphones. The participants and the physiotherapist (researcher) practiced the use of the application together. Thereafter, the participants could practice the application in their community for one week (so called week 0), the pre-intervention. Participants were asked to walk at a comfortable speed without a goal set. In order to define a reasonable and objective end goal, an average of walking time performance during this week 0 was calculated and the result was considered as the baseline walking activity.

Then, at the second visit in the hospital, the participants and the researcher determined together their individual walking end-goal as **e**nd goal = average (session durations of week 0) + 45 minutes which was set as a parameter in the application. So the first session (Week 1) had the baseline walking activity as session duration for the walking activity, and to determine the length of the following sessions, five (5) minutes were automatically added by the application each week (until it reached the set goal) and the session duration of the last week corresponded to the set goal (Table 1).

The step rate of the participants was determined during a walk at a comfortable walking pace for 20 seconds. This step rate was set as a minimal baseline steps/minute for configuring the WWM app. As well, the participants were asked about possible problems with the application during their practice in their community. Thereafter, participants were instructed to walk in their community using the WWM app minimal twice a week. A WhatsApp group was created with the participants and the researcher to contact each other in case of problems during the intervention (WhatsApp, California, USA). Also, weekly motivation was given by the physiotherapist using the WhatsApp group and the participants were encouraged to stimulate each other by sending screenshots of their walking activities and to facilitate especially non-written communication between all. Moreover, participants received two weekly notifications from the WWM app to stimulate adherence to the walking program. An overview of the WWM application options and screens is presented in the Supplementary Material 1.

Variables and outcome measures

Participant characteristics

At baseline the participants' characteristics and clinical data were collected. Clinical data were collected before and immediately after the intervention as well and contained the modified Rankin Scale (mRS)[26], the Community Screening Instrument for Dementia (CSI-D)[27] and the Functional Ambulation Category (FAC)[28]. The mRS, which determined the severity of the disability and CSI-D, which screened for cognitive impairments, were both conducted to screen for eligibility criteria. The FAC determines the functional ambulation status.

Feasibility outcome measures

The feasibility outcomes included the application usage, safety, adherence, perceived enjoyment, mHealth quality and patient experiences to use the application.
Information on the number of activities (number of walking activities) total time, total distance, total steps and mean level of fatigue (which is measured by visual analog scale on a 10-level scale at the start and at end of each activity) after the activities per week were extracted to evaluate the use of the WWM app. Also, participants were asked to keep a logbook during the intervention period. The logbook documented any adverse events, physical complaints, experienced difficulties, and contextual factors influencing the walking activities.

Safety is defined as the percentage of participants who experienced one or more adverse events (by logbook).[29] Adverse events included falls and cardiac, respiratory, or new neurological abnormalities; recurrent events and musculoskeletal pain that did not settle after stopping exercise.

Exercise adherence was evaluated by dividing the number of performed sessions by the number of planned sessions of the intervention. An exercise adherence percentage was obtained by multiplying this number by 100 based on daily training record (mean cut-off of 70% was defined as acceptable).[30] The adherence percentage was calculated based on the number of weeks that the app was used (see technical or contextual factors impeding a 10-weeks use) as well as compared to the 10 weeks scheduled.

Walking enjoyment was assessed by the shortened version of the physical activity enjoyment scale (PACES-8).[31] PACES-8 uses a 7-point bipolar rating scale; participants were asked to provide a rating to reflect their level of agreement between two bi-polar statements related to an aspect of enjoyment of the physical activity (one at each end of the continuous scale). The raw score was over 63, with higher score indicating better enjoyment perceived when exercising. The Mobile App Rating Scale (MARS)[32] is the most widely used scale for evaluating the quality and content of mHealth applications. The multidimensional instrument assesses app quality on four dimensions, subjective quality of the app and the perceived impact of the app on the user's knowledge, attitudes, and intentions to change as well as the likelihood of actual change in the target health behavior. All items were rated on a 5-point scale from "1=Inadequate" to "5=Excellent". The reporting score is mean±SD for the MARS. An individual semi-structured face to face interview was administered at the end of 10 weeks intervention to get the participants' experiences, at the [information retracted to maintain the integrity of the review process]. The participants responded individually and freely. A set of six (6) questions were included: (1) Did you like the application? (2) What difficulties did you encounter while using the application? (3) What difficulties did you encounter that prevented you from going for a walk? (4) Did you go for more walks than usual, when using the app in the intervention? (5) Did you find your walking goals achievable? (6) Are you going to walk alone or in company of another person?

Efficacy outcomes measures

- ***Primary efficacy outcome measures***

The primary efficacy outcome measures were the six-minute walk test (6MWT)[33] and ability of locomotion, Benin version (ABILOCO-Benin)[34] to evaluate the walking performance after stroke.[35] The 6MWT was performed to determine the walking distance for evaluating the functional walking performance.[36] Participants walked for six minutes with elapsed time indicated by the WWM app. Distance was measured by the investigator. The

6MWT has high test-retest reliability, a minimal detectable change, was strongly to moderately correlate with gait speed, locomotion (walk) and motor. The 6MWT is a clinically useful measure of walking ability poststroke.[37] ABILOCO-Benin is a patient-reported outcome measure that was used to assess the locomotion ability of participant. This test was validated in people with stroke in Benin, and presents good psychometric properties[34] Outcomes were performed at baseline and post intervention.

- ***Secondary efficacy outcome measures***

Impairments were assessed with the Stroke Impairment Assessment Set (SIAS)[38]. The SIAS is a useful measure of stroke impairment with well-established psychometric properties such as unidimensionality interrater reliability, concurrent validity, predictive validity and responsivenes.[39] The International Physical Activity Questionnaire (IPAQ)[40] was used to evaluate the self-reported level of physical activity. It was validated for the stroke population in Benin with excellent evidence of the test–retest reliability in the context of a francophone region of Africa.[41] The Barthel Index (BI)[42] and the activities limitations (ACTIVLIM-Stroke) scale[43] were used to evaluate independence in activities of daily life. The BI is a useful instrument with high inter-rater reliability, internal consistency, convergent and predictive validity, and adequate responsiveness in assessing activities of daily living functions in stroke patients.[44] The ACTIVLIM-Stroke questionnaire provides accurate measures of activity limitations in patients with stroke. It is recommended for evaluating clinical and research interventions in patients with stroke, because it provides a higher discrimination and might be more sensitive to change for stroke in Benin and Belgium.[43] The Participation Measurement-Scale (PM-Scale)[45] was used to assess restrictions in social participation., The PM-Scale presents good responsiveness and accurately detects changes in stroke subjects' involvement in life situations in Africa.[46] Stroke Specific Quality of Life Scale (SSQoL)[47] was performed to evaluate self-reported health-related quality of life, it is a reliable and valid instrument with good psychometric properties such as: reliability, validity and responsiveness of any version of the SS-QOL.[48] It is suited for use in health research as well as in individual assessments of persons with stroke.[49]

Sample size

For pilot and feasibility trials, while a sample size justification is important, a formal sample size calculation may not be appropriate.[50] It has been shown that a minimum sample size of 8 participants is required for trials labeled pilot and feasibility.[50,51] So, for our pilot study, we planned to include at least eight participants.

Quantitative data collection

Quantitative data were collected prior to and after the 10-week use of the WWM app and qualitative data was collected after the 10-week use of WWM app. Data from functional measures, questionnaire, safety, adherence , perceived enjoyment , mHealth quality and semi-structured interviews were used to evaluate the feasibility of WWM app.

Each weekend data (app findings) were collected from the application by the investigator. During the intervention period, the adverse events were documented in the patient's logbook. PACES-8, MARS and the semi-structured interviews were taken after the intervention (Supplementary material 2).

Data-analysis

IBM® SPSS® Statistics for Windows (ver. 25.0; IBM Corp., Armonk, NY, USA) was used for statistical analysis. For descriptive data, variables were expressed as median, percentiles. To compare the clinical characteristics of the participants before and after the intervention, the Wilcoxon signed-rank test was used. The significance threshold was set at 0.05. The qualitative data were analyzed using thematic analysis.

RESULTS

Participants

Fourteen participants were included in the study. However, one participant has been excluded after week 0 (pre intervention) due to medical reasons. Among the thirteen participants who started the intervention, four were unable to complete the intervention due to medical reasons (after three weeks), loss of smartphone (after three weeks), travel (after five weeks) and death (after four weeks), however unrelated to the intervention. The nine participants who achieved the 10 weeks WWM intervention were finally included in the analysis (Figure 1).

The nine stroke survivors were five men and four women with a median (minimum-maximum) age of 60 (50-68) years old. The majority of the participants were married (n=7), had no social insurance (n=6) and experienced an ischemic stroke (n=7). Four participants had an affected side which was previously their dominant side before stroke event. The median (percentiles 25, and 75) time after stroke was 08 (7-13) months and most participants had mild disability, score mRS = 2 (2-~~;~~3)~~)~~. All the participants had a good functional ambulatory classification score, the median (percentiles 25, and 75) FAC = 4 (4-~~;~~5), so could walk independently and only two used an assistive device. Seven participants used the WalkWithMe application independently and did not need help from a caregiver during the intervention. The demographic and clinical characteristics of participants are summarized in Table 2.

Feasibility findings

WalkWithMe application findings and logbook: The number of activities performed by the different participants are presented in Table 3. Overall, activities were performed well during the first 3 weeks with achievement of the respective objectives. We noticed that from the fourth week, the activities dropped in many patients. Different reasons were identified: technical issues with the application and/or the smartphone; illness, pain, fatigue (not due to the use of the application) and no specific reason.

Safety: No participant experienced adverse events during the intervention period due to the use of the WWM app.

Adherence: The exercise adherence of the participants is described in Table 4. In a first approach to calculate the adherence, only the weeks that the app was used, were considered to determine adherence. This means that adherence is calculated while the participant is in the walking program, and when not being obstructed by a reason beyond the app (e.g. illness or an event). This is reflected in Table 4 as “Adherence (%) versus supposed active use of the app”. P9 scored the least on exercise adherence with a percentage of 66.7. In the first three weeks for his participation, he performed only four activities resulting in this low score. He did not perform the rest of his activity due to the smartphone being spoiled. P8 scored 70% because over the five weeks that he participated, he performed only seven activities. He explained that he had several sessions not recorded by the application (the application turns off when he puts the smartphone in his pocket to walk, so the bad weather (rain all day) did not allow him to do these sessions). P3, P5, P6 scored 75% and P2 scored 85%. They almost reached 100% of the planned activities because they took part in the activity longer (more than 6 weeks) and did not have leg pain, fatigue or poor temporary health as an impediment. P1, P4 and P7 performed more activities than expected and scored more than 100% of adherence.

For completeness, Table 4 also shows the adherence when comparing with the total planned sessions of the walking program in the intervention. When reporting adherence when comparing with the total planned sessions of the walking program (20 sessions over 10 weeks), the adherence rates are consequentially lower.

Perceived enjoyment of walking activities: the perceived enjoyment of the physical activity (walking) is summarized by Figure 2. The stroke survivors in this study rated the app-guided walking as very fun (total score=57/63), stimulating (total score=50/63) and enjoyable total score=46/63). They also found the walking activity invigorating and gratifying with a total score of 40/63. However, they found the walking activity less refreshing (total score=37/63) and exhilarating (total score=36/63).

WalkWithMe application's quality evaluation: The average MARS quality rating was above the minimally acceptable cut-off value[32] defined by the MARS questionnaire of 3.0 (mean 4.0, SD 0.2; range 2.9-4.8). The average MARS subjective quality rating of the WWM app was also acceptable (mean 3.4, SD 1.1; range 2.0-4.5) and the MARS perceived impact of the WWM app rating was acceptable (mean 3.9, SD 0.1; range 3.0-5.0). Also the individual mean score for MARS rating was more than 3.0 points below the minimal acceptable quality (mean 3.8, SD 0.5; range 2.7-4.5).[32] Considering sections of app quality, the best scores were found in engagement, mean 4.5 (0.1) and the lower score found in functionality, mean 3.5 (0.3), (Supplementary material 3).

Patient experiences

The individual semi-structured interview was administered with all nine participants. All participants indicated they like the app and reported their walking goals were achievable. However, they mentioned some difficulties which could be categorized in 3 themes: technical software issues, health issues that made it difficult to use the app and some practical issues that make the use of the app difficult.

- Technical software issues were mentioned with regard to the functionality of the app during the activity ("app crashes during walking activities"), issues with regard to the accuracy ("the number of steps is badly counted") and issues about the combined function in the within the smartphone ("data disappears after a call received on the smartphone", "the slightest gesture cancels all the activity and no possibility of continuing an activity already started"). Issues probably due the low level in Android use, an incoming phone call interrupts the app or sends it to the background.
- With regard to health issues, hand dexterity, fatigue or less mobility were an obstacle. Two patients reported that "my health condition was the biggest difficulty in using the

app". In this same state of order, four participants mentioned that "I have pains, aches in the body", "I felt tired", "I had the flu, an episode of malar".

- For the latest theme (practical issues), one participant said that "it was difficult to carry the smartphone myself". She was not used to keeping a smartphone on her to go for a walk. Three other patients were prevented by the rain or were either restrained due to other activities (to receive guests, outings or trips). Two stroke survivors reported that "frequent technical issues discouraged me from using the app" and also "found the 10 weeks too much".

Efficacy findings: walking performance

Table 5 displays the results of primary and secondary efficacy outcomes. Following the 10 week intervention period, there were positive significant differences in ABILOCO ($p = 0.018$), SIAS ($p = 0.024$), Barthel Index ($p = 0.042$), ACTIVLIM-Stroke ($p = 0.017$) and SSQoL ($p = 0.012$). Overall, the use of the WWM app has improved walking ability, reduced impairments, disabilities and improved the quality of life of stroke survivors.

Given that the main outcome was walking, we wanted to see how individual participants evolved during the 10 weeks of using the WWM program. The supplementary material 4 ~~Figure 3~~ ~~showed~~ shows the~~is~~ individual ~~aspect~~ data of walking endurance measured by 6MWT (a), locomotor skill measured by ABILOCO-BENIN (b) and walking energy expenditure provided by the walking subdomain of the IPAQ (c).

DISCUSSION

This study reported on the use of a mHealth application in adults with chronic stroke who agreed to try to increase their walking activity in their community setting. The feasibility and efficacy of the WWM app was evaluated in a mixed methods study in terms of use of application, safety, adherence, perceived enjoyment, mHealth quality and participant experiences to use the application and effect of WWM used on walking performance among nine late sub-acute and chronic strokes survivors. Quantitative and qualitative results were integrated after data analysis to gain a thorough understanding of the feasibility of WWM app.[52]

Participants experienced the WWM app positively, they indicated that the application was enjoyable, easy to use, and stimulating their physical activity. This is consistent with the previous application of WWM in persons with multiple sclerosis.[24,25] These qualitative results go together well with the quantitative ones which show improvement in stroke impairments, overall disabilities, activity limitations and quality of life of stroke survivors. Emphasizing on primary outcomes (6MWT and ABILOCO-Benin), a significant improvement was observed in ABILOCO-Benin and the majority of subjects improved their distance on the 6MWT. A recent meta-analysis, showed that remote physical rehabilitation intervention technologies are useful in improving PA behavior.[53] This meta-analysis also indicated that interventions including internet, telephone, telehealth monitoring and pedometers were not effective in improving walking ability.[53] In fact, even though WWM program offered gait training based on the current PA guideline, the intervention was unable to improve endurance measured with the 6MWT. The outcomes used in our study were chosen to reflect physical function trained while using WWM. Those who did worse on these outcomes at baseline and especially those who had more practice improved more than those who had higher scores and less practice. Training effects of exercise can appear as soon as after two weeks, especially if the person is inactive, but the effects are considerably greater with regular exercise for several months.[6,54] Although most of the cortical reorganization in the brain takes place in the first 6 months after a stroke,[55] there is a growing evidence on stroke survivors improving their function in the chronic phase of stroke, well beyond the first 6 months.[56] All this agrees with the significant results of secondary outcomes such as SIAS, BI and ACTIVLIM-Stroke. This is thought to be because repetitive, task-specific training of the lower extremities can result in functional gain over other forms of usual care or attentional control.[57] Still concerning this improvement in the functionality of post-stroke patients, Nindorera et al.[58] found that exercises targeting walking speed would be very useful for people with chronic strokes living in low-resource countries, in order to promote their functional autonomy. In addition to functional independence, motor skills, depression, social participation and participation in socio-cultural activities were improved in people with chronic stroke after an intervention community walk.[6] Other studies have also found that appropriate community-based rehabilitation technique increases rehabilitation participation rates and improves stroke survivors' motor function, daily activity and social activity.[6,59] Increased duration of exercise can improve function in stroke survivors[29] and therefore it is important to motivate stroke survivors to engage in exercise. Most of the stroke survivors in our study went to walk once or twice a week and most of them remained inactive. The stroke survivors in our study seemed to be very inactive when compared with community-dwelling stroke survivors in international studies[60,61] and are far from meeting the guidelines for physical activity.[29]

However, looking at the performed activities, the application was not always used optimally. One participant did walking activities without registering them with his smartphone. Also, there was sometimes a discrepancy between the registered time and distance, and participants did not share their activities in the community feature of the WWM app. Several participants did not fill in the fatigue scale before and after each walking activity, this can possibly be explained by incorrect understanding or use of the application. Usability problems among stroke survivors using a mobile rehabilitation application for a first time were also seen in other literature.[14,19] During the intervention period, there were some drop-out due to no adherence caused by practical reasons. Besides, activities were sometimes not performed due to sickness, fatigue, or pain, this could indicate that the participants had a need for a more flexible program. The WWM app sets an individual based walking program at the beginning, but there was no flexibility to change or delay the weekly walking goals during the intervention in the context of this study.[25]

The individualized walking goal was determined on their initial walking capacity with the physiotherapist and all participants, indicated that they were stimulated to walk longer periods resulting in a positive impact on their walking performance. Furthermore, exercise adherence was not optimal indicating that the participants possibly needed more motivation and support during the intervention. All participants participated well in the WhatsApp group. In addition to sharing some of their activities, they also asked questions about the difficulties they were encountering. They also provided information about their state of health and sent greetings images. Many also communicate in this group through audios. This is consistent with the literature on experience sharing and motivation to use mHealth to support physical activity.[62,63] Overall, the WWM app has been accepted as a whole, recognized as aesthetically but has some functionality issues. Regarding the results of the subjective quality and perceived impact session, it can be said that the majority of participants would recommend this application to people who could benefit from it and found, for example, that the application was likely to raise awareness or increase knowledge about walking in stroke survivors in Benin.

Implications and recommendations for clinical field and future research

This pilot study is the first study in Benin investigating a mobile application for the rehabilitation of stroke survivors. Participants were generally positive about using the WWM application. The application based walking program is feasible but there is a need for some technical adaptations in the WWM app for future use. Besides, the

WWM application stimulated the participants to walk more regularly resulting in an increased physical activity. However, we will recommend that for future research, participants walk more than 3 times according to current recommendations.[64,65] The WWM application can be an additional approach to stimulate walking activities and improve quality of life among chronic stroke survivors in an easy and low cost way.

However, the clinical effect of the WWM application on late sub-acute and chronic stroke survivors is still unclear as there seemed to be participants not experiencing a benefit, potentially related to lower adhering to the full program. Further interventional research on the WWM application, with adapted technical, supportive modalities in a larger sample size, take into account other activities which participants engaged that might influence results and with case-controls is needed.

CONCLUSION

This study investigated a feasibility of walking program using mHealth for stroke survivors that took full advantage of community resources rather than relying on institutional rehabilitation treatment. The WWM app was feasible among late sub-acute and chronic stroke patients in Benin, a lower middle-income country but it appeared that the participants need for technical adaptations. Results have shown that the use of the application can help improving locomotion skills after stroke and help stroke survivors improve motor function, daily activity and social activity. The WWM app is a promising approach to stimulate walking activities among community-dwelling people with late sub-acute and chronic stroke in an easy and low cost way.

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FIGURE LEGENDS

Figure 1: Flow chart of participant selection.

Figure 2: Participants enjoyment (Y-axis) to the use of the WWM app measured by the PACES (maximal score is 63) with confidence interval.

Supplementary material 1: Overview of the WalkWithMe application options and screens (a. MENU interface; b. Home screen; c. Walking activity; d. 6 minute walk test; e. Personal training schedule; f. Weekly overview; g. Activity overview).

Supplementary material 2: WWM program and data collection procedure
MRS: modified Rankin Scale, FAC: functional ambulatory classification, 6MWT: 6 minute walking test, ABILOCO: Benin validate scale for ABILOCO; SIAS: stroke impairment stroke set, IPAQ: Benin validate international physical activity questionnaire scale, BI: Barthel index ACTIVLIM-Stroke: activity limitation scale for stroke, PMS: participation measurement scale, SSQoL: stroke specific quality of life, PACES-8: shortened version of the physical activity enjoyment scale, MARS: Mobile App Rating Scale.

Supplementary Material 4. Individual aspect of main variables between PRE and POST WWM program used: 6MWT (a) ABILOCO-Benin (b) and Walking/IPAQ (c).