Original Article

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Journal of Rehabilitation and Assistive Technologies Engineering
Volume 7: 1–8
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DOI: 10.1177/2055668319866053
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Does self-initiated sit-to-stand training with an assistive device regain the independence of sit-to-stand in stroke patient? A single-blinded randomized controlled trial

Ng Chee Man Joey[1] and Woo Ka Ho Marc[2]

Abstract

Background: It is unknown whether self-initiated sit-to-stand training with an assistive device is effective to regain the independence of sit-to-stand in stroke survivors.

Objective: To compare the effectiveness of self-initiated sit-to-stand training with an assistive device with manual sit-to-stand training.

Design: Parallel randomized controlled, assessor-blinded trial between January 2015 and May 2018. Randomization was performed by drawing lots to allocate treatment groups.

Setting: A rehabilitation hospital in Hong Kong.

Participants: 69 participants in medical wards with unilateral hemiparetic stroke. A total of 52 participants fulfilled the study requirements.

Intervention: Ten sessions of intervention with conventional physiotherapy program followed, by self-initiated sit-to-stand training with an assistive device, or by manual sit-to-stand training.

Main outcome measure: Number of participants regained the independence of sit-to-stand, sit-to-stand test from the Balance master® and Five-repetition sit-to-stand test.

Results: 69 participants (intervention, $n = 36$; control, $n = 33$) were randomized (mean age, 69.8 years (SD: 10.6), mean post-stroke days 18.6 (SD: 16.0)). Seventeen participants had not completed 10 sessions of training, leaving 52 ($n = 26$; $n = 26$) participants for per protocol analysis. Eighteen participants in the intervention group and 10 participants in the control group had regained the independence of sit-to-stand (Phi and Cramer's V: –0.31 and 0.31). The participants in the intervention group were faster to complete the Five-repetition sit-to-stand test than the control group (32.7 sec (SD: 1.93) versus 48.4 sec (SD, 6.8); 95% confidence interval, –30.8 to –0.7; $p < 0.05$). No adverse side effects occurred during and after the training across groups.

Conclusions: Self-initiated sit-to-stand training with an assistive device may have positive effects on speeding up regaining the independence of sit-to-stand on sub-acute stroke survivors.

Keywords

Sit-to-stand, stroke, assistive device

Date received: 20 June 2018; accepted: 25 June 2019

Introduction

Sit-to-stand (STS) movement is one of the necessary activities in daily lives.[1,2] It is a prerequisite for functional mobility, including transfers, ambulation, and walking up and down stairs.[1,3] It requires excellent lower limb strength and range of motion.[2] The ability to stand up is essential for independent walking[4] and fall

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prevention.[5] Unfortunately, this task is particularly difficult for stroke survivors, which is a significant cause of long-term neurological disability in adults.[6] About half of them have severe functional problems since their acute phase.[7] Low level of STS activity is also observed during the rehabilitation phase.[8] Such a low level of performance in STS may be due to the incapability of standing up because many stroke survivors still require assistance in STS. Hence, it is essential to investigate new methods of STS training that aim at facilitating the STS independence after stroke.

Regaining the STS independence of stroke survivors is one of the essential roles of physiotherapists, including positioning the paretic limb, facilitating forward trunk movement; lifting participant's body assists weight transfer and finally maintains the body alignment.[9] All of the above have to be performed simultaneously so that a good quality STS can be achieved. The repetitive and challenging STS exercise is required to strengthen the extensor muscles and promote neural reorganization for stroke survivors[10,11] but involves remarkable energy outputs from the physiotherapist who may get a musculoskeletal injury.[12] It is not easy to maintain effectiveness when encountering the huge service demand in this population. Also, manual assistance has the potential to damage the participant's soft tissues around the shoulder by pulling them up to standing.[13] In Hong Kong, there is a trend of increased prevalence rates of stroke.[14] It becomes the primary challenge for the physiotherapists to optimize the participant's functional mobility during their hospitalization.

An assistive device may be able to facilitate the recovery process in STS. It uses an adjustable counter-weight mechanism to take up the weight of the participant during the move so that manual assistance can be significantly reduced. The participant can initiate the training independently, and higher repetitions of STS practice can be performed to have a better training effect.[9] However, only one case study with uncontrolled design and the non-randomized trial have published for this type of training.[15] The purpose of this study was to compare the effectiveness of self-initiated STS exercise with an assistive device or with manual STS exercise to regain STS independence after 10 sessions of training. It hypothesized that participants who performed self-initiated STS exercise with an assistive device to restore the STS independence had a similar effect as manual STS exercise.

Methods

Participants

Participants were recruited from the medical ward in Tai Po Hospital. When the stroke survivors admitted to the medical ward, the corresponding physiotherapist in-charge (PT i/c) referred them to the researcher for screening. Participants were required to meet the following criteria for inclusion in the study: he/she should be (1) first episode of unilateral stroke with hemiparesis, (2) able to understand and follow simple verbal instructions, (3) able to sit unsupported, and (4) able to stand up from an 18 inches high plinth with lifting assistance. Participants were excluded if they had (1) severe pain in the lower extremities during weight bearing or performing the movement, (2) any other acute comorbid diseases such as unstable angina, recent myocardial infarction, and (3) unstable medical/psychological condition.

The participants were informed of the objectives and procedures of the study and signed a consent form. The protocol was approved by the Joint Chinese University of Hong Kong-New Territories East Cluster Clinical Research Ethics Committee, and the study was conducted according to the principles of the Declaration of Helsinki for human experiments.

Design

This study was conducted by using an assessor-blinded, parallel randomized controlled design. Data were collected from a convenience sample of stroke survivors in medical wards. The data were obtained from January 2015 to May 2018. During this period, 80 participants were identified as potential participants for this study. Eleven were excluded because they failed to meet the inclusion criteria or were ruled out by the exclusion criteria (Figure 1). Of the 69 participants, 36 were randomized into the intervention group (conventional physiotherapy program plus STS Trainer® exercise), and the 33 participants were randomized into the control group (conventional physiotherapy program plus manual STS exercise). The randomization was performed by drawing a card from an opaque paper bag. A person who was independent of the study performed the drawing in front of the participant. The assessors responsible for the outcome measures were blinded to the allocations of the participant for the full duration of training. After the randomization, the corresponding PT i/c was responsible for providing the intervention to the participants. Their clinical experience ranged from 2–20 years. Each PT i/c should familiarize with the stroke clinical practice guideline of the physiotherapy department in Tai Po Hospital.

Intervention

Conventional physiotherapy program. All participants received conventional physiotherapy based on the stroke clinical practice guidelines of the physiotherapy

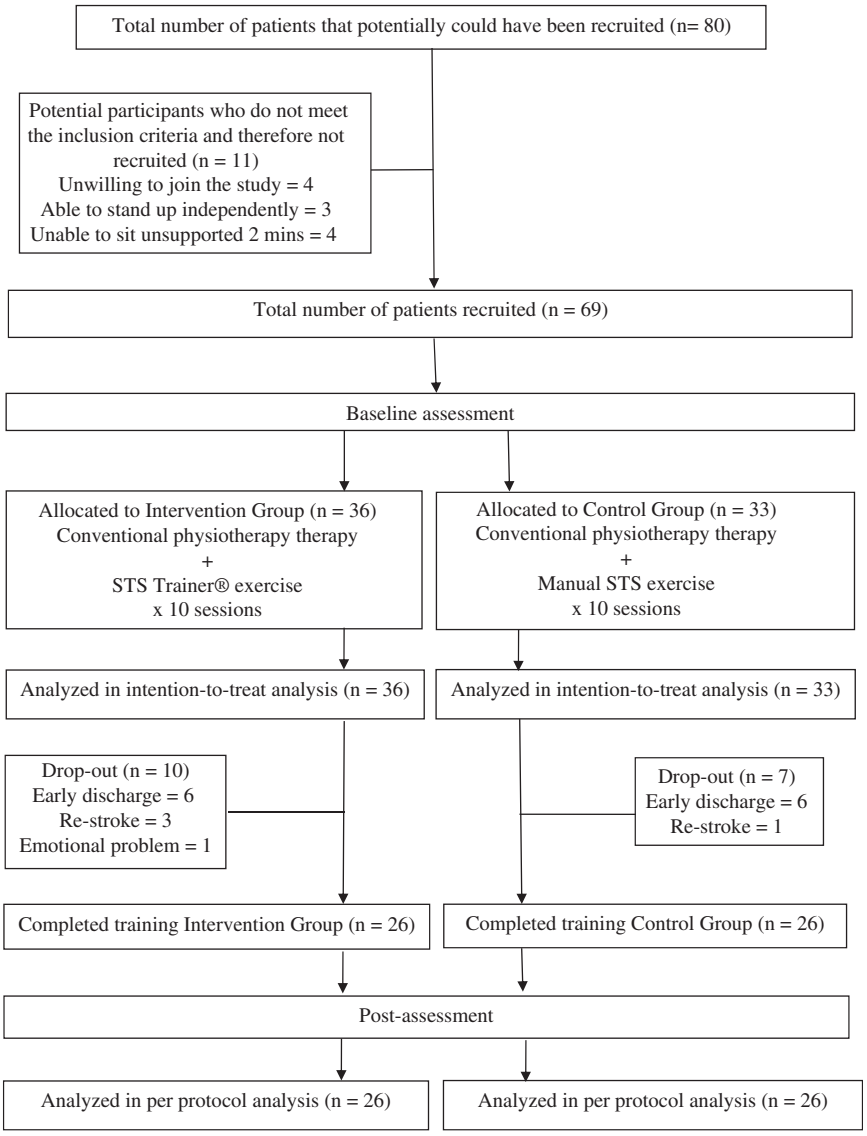

Figure 1. Consort diagram of the study.

department in Tai Po Hospital. The guideline provided the standardization of training goal and interventions to improve strength, flexibility, transfers, balance, coordination, and walking. The choice of the treatments for the conventional physiotherapy was selected by the PT i/c, and these treatments were individualized to the participant. The sequence of the intervention was also not standardized. The participant received either STS Trainer® exercise or manual STS exercise with conventional physiotherapy in each session. The content of the conventional physiotherapy was also recorded in physiotherapy treatment form.

STS Trainer® exercise

Apparatus. An STS Trainer® (Neurogym Technologies, Inc., Ottawa, Ontario Canada; Figure 2) provided the weight support in the intervention group. The device consists of a weight stack, connecting to a rope. There is a pulley to a harness that supports the pelvis to help the participant stand up. The amount of support adjusted from 10 to 120 lbs.

Setup. The participant seated in an armless 18 inches high plinth, which was underneath an overhead suspension frame. Safety harness was fitted on patient and attached to the overhead suspension frame to prevent fall injury.

Each of the PT i/c was trained to operate the equipment. The STS Trainer® (Figure 2) was put in front of the participant whose knees were in contact with the kneepad. Then the four wheels were locked. A sling was positioned under his/her buttock, and inguinal straps were fastened to Velcro attachments once the

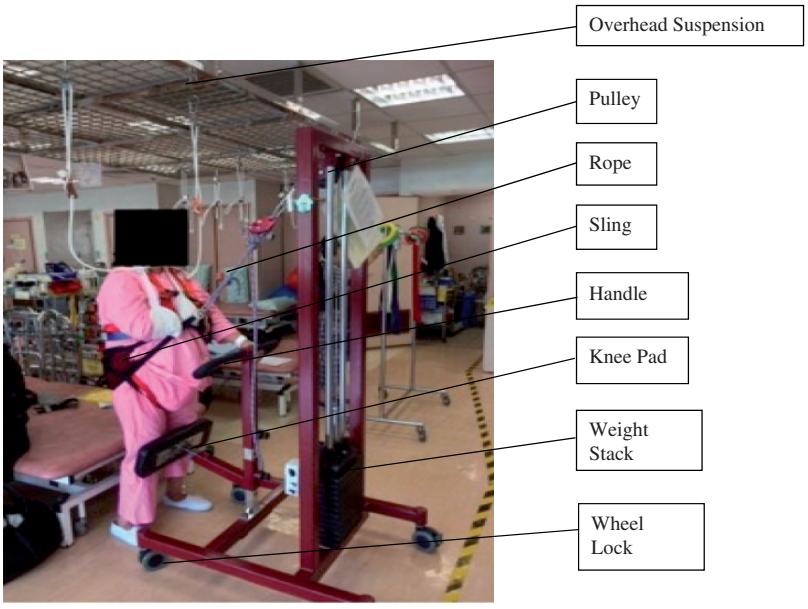

Figure 2. The STS trainer.

participant stood up. The handlebar and kneepad were set so that the participant was supported comfortably. The optimal weight was adjusted so that the participant was able to stand up without physiotherapist manual assistance. It was evaluated throughout the training period. The physiotherapist facilitated the participant's trunk forward weight shift and corrected his/her alignment so that the normal mechanism of the motion was achieved. During the period of training, all participants held the handlebar by both hands. A wrist strap was used to secure his/her hemiparetic side to the handlebar.

Manual STS exercise. The starting position was the same as for the STS Trainer® exercise. The physiotherapist assisted the participant to stand up by lifting the participant's body weight, facilitating the trunk forward, and stabilizing the paretic foot. The physiotherapist's clinical judgment decided the extent of the assistance given. During the period of training, all participants should hold the handles of the walking frame with both hands. A wrist strap was used to help the participant hold the handle at the hemiparetic side. Either STS Trainer® or manual STS exercise was performed for 10 min or at least 100 repetitions until 10 sessions of training were completed.

Outcome measures

Demographic data were collected before the commencement of the study. The baseline measurements undertook before randomization to either the STS Trainer® group or manual STS group and after the completion of the 10 sessions. The primary outcome measures were STS Test from the Balance Master® (SST)[16] and Five-Repetition STS Test (5XSST),[17] and the secondary outcome measure was the number of participants who regained the STS independence (RSU). In this study, RSU was defined that the participant was able to complete both the tests of SST and 5XSST in a onetime just after 10 sessions of training. All outcome measures were analyzed between groups.

The Balance Master® provides an objective assessment of the sensory and voluntary motor control of balance.[15] It has high test–retest reliability (internal consistency coefficient: 0.84–0.88) in measuring more complex tests of balance.[14] The SST utilizes a fixed $18'' \times 60''$ dual force plate to measure the vertical forces exerted by the participant's feet. The participant was regarded as failed in this test if he/she was incapable of standing up independently without arm support. The measured parameters were mean weight transfer time (the average amount of time between the onset of the cue to move and the arrival of the Center of the Gravity [COG] over the feet, expressed in seconds), mean rising index (the average amount of force exerted by the legs during the rising phase, expressed in as a percent of body weight), and mean COG (medial-lateral) sway velocity (the average amount of COG sway during the rise to stand and for the first five seconds following the rise, expressed in degrees per second).

5XSST was used to measure the functional lower extremity strength. It has high intra-rater reliability (intra-class correlation coefficient: 0.97–0.976), inter-rater reliability (intra-class correlation coefficient: 0.999) and test-retest reliability (intra-class correlation

coefficient: 0.989–0.999).[17] The procedure of 5XSST was based on Bohannon[17] with modifications. The height of plinth was adjusted to 18 inches from the level ground. The participant was instructed to stand up all the way and sit down once without using the upper limbs as fast as possible for five times. The timing started on the command ''go'' and ceased counting on landing after the fifth stand up.

Statistical analysis

Data analysis was performed by statistical package SPSS version 23. The non-parametric test, Mann–Whitney *U* test (two-sided), was used to compare the participant characteristics of post-stroke duration, weight transfer, and rising index since Shapiro–Wilk tests did not indicate it was normally distributed. A Chi-Square test was used to analyze gender, the type of stroke and hemiparetic side, and RSU between the two groups.

Independent sample t-test was used to compare COG (medial-lateral) sway velocity and 5XSST for normal distribution of data was shown. Statistical significance was set at 0.05 for all analyses. Standard deviation and 95% confidence interval were also shown as indicated. Intention-to-treat analysis was used to compare the two groups that included all participants as initially allocated after randomization. Per protocol analysis was used to compare the two groups that included only those participants who completed the training initially allocated.

Results

Characteristics of the participants

Between January 2015 and May 2018, 80 participants were admitted to the medical ward with the first episode of unilateral hemiparetic stroke. Eleven participants had failed to meet the inclusion criteria. Four participants were unwilling to join the study. Three participants were barely able to stand up without arm support. Four participants were unable to sit unsupported for two minutes (Figure 1). In total, 69 participants were randomized, 36 participants were assigned to the intervention group to receive conventional physiotherapy program with self-initiated STS training with an assistive device, and 33 participants were randomized to the traditional program of physiotherapy with manual STS training. Seventeen participants did not complete the study (10 in the intervention group and 7 in the control group). Six participants had to be withdrawn from the study due to early discharge from the hospital. Three participants in the experiment group and one participant in the control group had suffered a recurrent stroke during the study. One participant in the intervention group showed an emotional problem and refused to continue after the first few sessions of training. Baseline characteristics such as age, gender, post-stroke duration, the type of stroke, hemiparetic side, and length of training were similar in both groups (Table 1). A thorough screening such as the mental status of the participant, blood pressure, heart rate, and SpO_2 was performed before attending the physiotherapy training session. All participants were able to tolerate 30–45 min of conventional physiotherapy training, besides with 10 min or not less than at least 100 repetitions of either the STS Trainer® or manual STS exercise without adverse effects during and after the training.

Clinical outcomes. In an intention-to-treat analysis, all participants who had not completed the 10 sessions of training were regarded as failing to perform the SST and 5XSST tests by last observation carried forward method. In the intervention group, there were 18 participants unable to complete the SST and 5XSST. In the control group, 21 participants and 17 participants were unable to perform the SST and 5XSST, respectively. The Chi-Square test reflected that no significant difference was found in the SST, 5XSST, and RSU between the two groups (Table 1).

The participants in the intervention group had completed the 5XSST significantly faster than the participants in the control group after 10 sessions of training ((32.7 sec (8.2) versus 48.4 (24.3); mean 95% confidence interval –30.8 to –0.7; $p < 0.05$)) (Table 2). Significantly more participants in intervention group were able to regain STS independence ($p<0.05$) (Table 3). The tests of the Phi and Cramer's V (–0.31 and 0.31) indicated that the strength of association between the two groups was moderate (Table 3).[18] All the parameters in the SST were statistically insignificant between the two groups.

Discussion

A previous review[19] had found that interventions to improve STS might have a beneficial effect on the time taken to STS. However, it was in the population of stroke survivors who were already able to perform STS independently. In the present study, the selected participants were unable to stand up without support before the training. It demonstrated that self-initiated STS training with an assistive device might significantly help sub-acute stroke survivors to regain STS independence after 10 sessions of training. The assistance provided by the machine helped the participant to perform the movement from horizontal linear momentum to upward momentum without pause to facilitate lower limb extension.[9] It was accountable for the result of 5XSST that the participants in the intervention group

Table 1. Demographic data and outcomes measure results for the SST test, 5XSST, and RSU for both the self-initiated STS training with an assistive device (intervention group) and the manual STS training (control group).

Variables	Intervention group ($n = 36$)	Control group ($n = 33$)	95% CI	p values
Age (years)	67.8 (10.4)	72.0 (10.5)	–9.2 to 0.8	0.10
Post stroke duration (days)	19.8 (18.8)	17.3 (12.5)	–5.2 to 10.2	0.52
Length of training (days)	14.4 (5.9)	5.5 (5.0)	–3.7 to 1.6	0.45
Gender				
Male	20 (55.6%)	19 (57.6%)		0.87
Female	16 (44.4%)	14 (42.4%)		
Type of stroke				
Infarct	28 (77.8%)	28 (84.8)		0.46
Hemorrhage	8 (22.2%)	5 (15.2%)		
Hemiparetic side				
Left	19 (52.8%)	18 (54.5%)		0.90
Right	17 (47.2%)	15 (45.5%)		
SST:				0.25
Able to stand up:	18	12		
Unable to stand up:	18	21		
5XSST:				0.90
Able to stand up:	18	16		
Unable to stand up:	18	17		
RSU:				0.25
Able to stand up:	18	12		
Unable to stand up:	18	21		

p Value significance set as < 0.05.
Intention-to-treat analysis. Values are mean (SD) or n (%).
95% CI: 95% confidence interval; SST: sit-to-stand test from Balance Master®; 5XSST: Five-Repetition STS Test; RSU: regaining the independence in sit-to-stand; STS: sit-to-stand.

Table 2. Comparison of sit-to-stand test from Balance Master® (SST) and Five-repetitions sit-to-stand test (5XSST) after 10 sessions of training in randomized trial in self-initiated STS training with an assistive device (intervention group) or manual STS training (control group).

Variables	Intervention ($n = 26$)	Control ($n = 26$)	95% CI	p Value
Length of training (days)	16.9 (3.6)	16.6 (3.9)	–1.9 to 2.3	0.88
SST:				
Able to stand up	18 (69.2%)	10 (38.5%)		
Unable to stand up	8 (30.8%)	16 (61.5%)		
Weight transfer (sec)	1.4 (1.1)	1.2 (1.4)	–0.9 to 1.1	0.29
Rising index (%)	13.7 (10.0)	17.8 (17.9)	–15.0 to 6.6	0.44
COG sway (deg/sec)	3.8 (0.9)	4.0 (1.1)	–1.0 to 0.6	0.59
5XSST (sec)				
Able to stand up	18 (69.2%)	13 (50%)		
Unable to stand up	8 (30.8%)	13 (50%)		
Time to finish (sec)	32.7 (8.2)	48.4 (24.3)	–30.8 to –0.7	0.04

p Value significance set as < 0.05.
Per protocol analysis. Values are mean (SD) (n = number of subjects).
95% CI: 95% confidence interval; STS: sit-to-stand.

Table 3. Comparison of the regaining the independence in sit-to-stand (RSU) after 10 sessions of training in randomized trial in self-initiated STS training with an assistive device (intervention group) or manual STS training (control group).

Variables	Intervention group ($n = 26$)	Control group ($n = 26$)	Odds ratio	95% CI	p Values
Able to stand up	18 (69.2%)	10 (38.4%)	3.6	1.14–11.35	0.03[a]
Unable to stand up	8 (30.7%)	16 (61.5%)			

0 cells have expected count less than 5. The minimum expected count is 12.00.
[a]Chi-Square test. Pearson Chi-Square is used to compare two groups (assumption not violated). Phi and Cramer's V are –0.31 and 0.31, respectively. RSU was defined as the number of patient who can complete the SST and 5XSST (frequency). p value significance set as <0.05.
Per protocol analysis. Values are mean (percentage).
95% CI: 95% confidence interval; STS: sit-to-stand.

were faster than the control group to finish the test. Also, it was probable that the assistance relieved the manual support from the physiotherapist who was able to focus on correcting the body alignment and facilitating the normal mechanism of STS. It reduced the physical burden of the physiotherapist, but further study is needed to confirm this assumption.

Both 5XSST and SST were assessed when the participant had just finished the last session of training. Participants required more strength and endurance to finish them. Some participants only passed one of the tests, so they were not fulfilled as STS independence. During the training, the participants were closely monitored by the physiotherapist for any discomfort caused by the exercise. No participant complained of exhaustion after the training.

Further research with a larger sample size would be useful to determine optimal intervention strategies for specific categories of stroke-related impairments. It is also essential to investigate the relationships between STS, gait, and balance training. How the speeding up the regaining of the STS independence influence the improvement of the functional mobility of the stroke survivors was still unknown.

Limitations

The sample size was small, and the participants were recruited by convenient sampling. Also, the study population was limited to participants with sub-acute stroke and hence did not generalize to all stroke survivors. Also, the participants did not receive long-term follow up. The longtime effect of the training was unable to confirm. Future studies using a larger sample size with a longer duration of training were needed.

Summary

Indications from this study were that self-initiated STS training with an assistive device had positive effects on speeding up regaining the STS independence after 10 sessions of training. It is crucial, especially in the situation that the stroke survivors were unable to stay in the rehabilitation hospital for a longer duration. The STS exercise can start once the participant can tolerate sitting unsupported.

Acknowledgements

We would like to thank Mr. Lau Fuk On, Titanic for his support. Miss. Lo Tak Man, Catherina and Miss. Wong Sze Man, Queenie for assessing the participants, Miss. Chow Ka Wai, Chelsea for proofreading of the paper, and Mr. Chung Ping Ho, Bryan for his advice. We also acknowledge the support of all participants who participated in this study.

Contributorship

All authors conceived the principles of the methodology. WKHM analyzed the data. NCMJ wrote the first draft of the paper and all authors reviewed and edited the manuscript and approved the final version of the manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was supported by the Physiotherapy Department and the Department of Medicine and Geriatrics of Tai Po Hospital.

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