Master of Philosophy in Medicine

The Effect of Morning Walk® -Assisted Gait Training for Patients with Hemiparesis due to Stroke : a Randomized Controlled Multicenter Trial

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A Dissertation

Submitted to

the Graduate School of the University of Ulsan

In partial Fulfillment of the Requirements

for the Degree of

Master of Science

by

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February 2018

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February 2018

ABSTRACT

Objective To investigate the effects of Morning Walk® -assisted gait training for patients with stroke.

Method This was a randomized controlled trial from December 2016 to April 2017. Three hospital rehabilitation departments (two tertiary and one secondary) participated in this study. I enrolled 58 patients with hemiparesis, following first-time stroke within the preceding year, whose functional ambulation category (FAC) scores were ≥ 2. Ten patients were excluded, leaving a cohort of 48 for final analyses. Patients were randomly assigned to one of two groups: 28 patients were treated with 30 min of Morning Walk® training plus 1 h of conventional rehabilitation program (MW group), and 30 patients received only 1.5 h of conventional rehabilitation program (control group). Both groups received treatment five times per week for 3 weeks. The primary outcome was the walking ability, assessed using the FAC scale, and lower limb function, assessed using the Motricity Index (MI)-Lower. Secondary outcomes included the 10m walk test, the Modified Barthel Index, the Rivermead Mobility Index, and the Berg Balance Scale.

Results After training, all outcome measures significantly improved in both groups. The MW group showed greater improvement in MI-affected limb (p= .034) and BBS (p= .047) than the control group. Patients with baseline FAC scores of < 3 showed significantly greater improvement than those with FAC scores of ≥ 3 on the MBI (p= .011).

Conclusion Compared with conventional rehabilitation program alone, Morning Walk® -assisted gait training combined with conventional rehabilitation program could have additional therapeutic effect in motricity of the affected limb and balance in patients with subacute stroke and hemiparesis.

Keywords Stroke, Neurological Rehabilitation, Gait, Robotics

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INTRODUCTION

Stroke is a cerebrovascular disease that leads to altered mentality and body paralysis. It is caused by cerebrovascular circulatory problems resulting from blocked or ruptured blood vessels in the brain. Stroke can cause permanent disability, motor and sensory impairments, incoordination, abnormal muscle tone, etc. Many patients experience gait disturbance following stroke. Especially for hemiplegic patients in whom gait is significantly impaired, restoration of walking ability is a major rehabilitative goal.

In Korea, the incidence and prevalence of stroke has gradually increased over the last few decades, but stroke mortality rate has decreased.[1] These trends have increased the societal need for effective rehabilitation programs. Numerous clinical trials have been conducted to determine effective rehabilitation methods and establish evidence-based rehabilitation guidelines. For lower extremity rehabilitation, task-oriented physical training for walking, high-intensity therapy for gait recovery, and repetitive task training for gait speed and transfers are recommended.[2-5]

Physical therapists typically conduct hospital rehabilitation through one-on-one treatment sessions with the patient. Consequently, the burden on therapists is heavy, and treatment time is limited. Because the numbers of physical therapists and treatment facilities are limited, it is difficult to meet patients' needs, potentially impeding effective rehabilitation. Rehabilitation robots may help address these challenges. Robotic devices can perform repetitive, interactive, high-intensity, task-specific limb treatment.[5] Furthermore, recent study suggest that robot assisted gait training may help improve post-stroke walking ability by accelerating neuroplastic processes.[6]

Robotic devices used for motor training include end-effector-type and exoskeleton-type

devices.[7] Gait Trainer® (Reha-stim, Germany) is an example of an end-effector device, and Lokomat® (Hocoma, Switzerland) is an example of an exoskeleton device. End-effector devices work by applying mechanical forces to distal limb segments.[8] Several studies have shown that patients with subacute stroke who are treated with an end-effector-type robotic device (Gait Trainer®) in combination with conventional rehabilitation program exhibit greater functional gait improvement than those treated with conventional gait training alone.[9-12] However, other studies have shown no difference in outcomes between robotic and conventional therapy, and the issue remains controversial.[13]

Morning Walk® is an end-effector lower limb rehabilitation robot developed in 2015 in Korea for patients with gait disturbance. It has a saddle that provides a seating type body weight support, which is different from other end-effector type robot. And it provides variety of training mode including not only ground walking, but also ascending stair and descending stair. However, the device is not verified through clinical trial methodologies. This study sought to investigate the effects of Morning Walk®-assisted gait training on patients with subacute stroke.

METHODS

Study design and participants

This study was a randomized controlled trial to compare the effects of Morning Walk®-assisted gait training with those of conventional rehabilitation program. Three hospitals participated in this research: the Asan Medical Center and Ulsan University Hospital, which are tertiary hospitals, and the National Health Insurance Service Ilsan Hospital, which is a secondary hospital.

Inclusion criteria were the diagnosis of first-time stroke (either ischemic or hemorrhagic) within the preceding year, age > 18 years, previously independent walker, hemiparesis with gait disturbance after stroke, Functional Ambulatory Category (FAC) score $\geq$ 2, and ability to participate in Morning Walk® -assisted gait training. Patients were excluded if they demonstrated severe cognitive disorders, aphasia that impeded communication, severe lower extremity musculoskeletal disease, psychological instability, body weight > 135 kg, height > 195 cm, severe limb contracture or deformity, open wounds, fracture, pressure ulcer, risk of compression fracture due to severe osteoporosis, or contact infection. Total 58 patients with hemiparesis due to stroke who were hospitalized at rehabilitation departments in three hospitals, from December 2016 to April 2017, were enrolled.

The study was approved by the Institutional Review Board (project number 2016-1337), and all participants were informed of the study purpose and procedures before signing an informed consent form. The participants were randomly assigned to either the experimental group or the control group by the use of random number table.

Intervention

The experimental group received robot-assisted gait training with Morning Walk®, an end-effector-type lower limb rehabilitation robot, for 30 min per session plus 1 h of conventional rehabilitation program. The control group received 1.5 h of conventional rehabilitation program, based on traditional neurodevelopmental treatment techniques, per session. Patients with sensorimotor impairments practiced sitting and standing balance, active transfer, sit-to-stand, and strengthening exercises. As their physical function improved, they progressed to dynamic standing balance training and, eventually, functional gait training while continuing to perform strengthening exercises.[14]

Both groups received their assigned treatment five times per week for 3weeks (15 sessions in total). Dependent variables of interest were measured before and after each of the 15 sessions. A licensed physiotherapist completed all evaluations.

Morning Walk® -assisted gait training

Morning Walk® (Figure 1) is a rehabilitation robot developed by Hyundai Heavy Industries and Taeha Mechatronics in Korea. The Food and Drug Administration approved the device in December 2014. It is an end-effector-type robot for lower limb rehabilitation that enables ankle, knee, and pelvic movements in the patient, according to the footplate trajectory. Patients start with ground-level gait, with a cadence of 30–35steps/min and step length of 30–35cm adjusted according to individual performance. Subsequently, patients progressed to uphill and downhill stair gaits.

Figure 1. Morning Walk® training

Morning Walk® boarding and disembarkation usually takes approximately 5–10 min. The device comprises a saddle to support the patient's weight, so that patients who need assistance can be safely boarded. The therapist can also control the degree of weight support and walking support, according to the patient's physical status. For patient safety, Morning Walk® is equipped with an upper body safety belt, parallel bars on both sides, a ramp, and an emergency stop button.

Measurements

The primary outcome measures are walking ability, assessed using the FAC scale, and lower limb function, assessed using the Motricity Index (MI) -Lower. FAC is a reliable scale for measuring functional gait.[15,16] The test categorizes the patient according to six levels of physical assistance required to maintain gait. An FAC score of 1 indicates that the patient is unable to ambulate. An FAC score of 2 indicates that the patient requires continuous physical assistance from more than one person, and an FAC score of 3 indicates that the patient requires intermittent assistance. An FAC score of 4 indicates that the patient requires only supervision, and patients with a FAC score of 5 walk independently on leveled surfaces. An FAC score of 6 indicates a patient who is able to independently ambulate over all types of surface. The Motricity Index (MI) is a valid tool for evaluating muscular coordination and strength.[17] MI-Lower comprises items from MI that evaluate lower extremity muscles, including those of the ankle, knee, and hip. Because all patients had hemiparesis, we completed individual MI-Lower measurements of the right and left sides. Scores ranged from 0 to 100, with higher scores indicating better function of the tested lower limb.

Secondary outcome variables included the ten-meter walk test (10mWT), the Modified Barthel Index (MBI), the Rivermead Mobility Index (RMI), and the Berg Balance Scale (BBS). 10mWT is a commonly used measure of gait velocity in patients with stroke. I asked

patients to walk 10m, as quickly as possible, using their customary walking aids. I recorded walk time over three trials using a stopwatch and calculated the average velocity (m/s). I considered patients who were unable to walk as having a walking velocity of 0 m/s.[18] MBI (0–100) is a reliable index for measuring activities of daily living, with higher scores indicating more independence. MBI comprises 10 items that assess patient independence from help, whether physical or verbal.[11] RMI (0–15) tests functional abilities and comprises 15 mobility-related items ranging from turning over in bed to running, with higher scores indicating better motor function.[19] BBS (0–56) is a widely used assessment of static and dynamic balance and comprises 14 balance-related tasks, each scored on a 5-point scale from 0 to 4, with higher scores indicating better balance.

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences software (SPSS ver. 18.0; SPSS Inc., Chicago, IL, USA). Kolmogorov–Smirnov verification was used to assess the normality assumption. I examined participant characteristics in each group using independent t-tests for normally distributed variables, whereas Mann–Whitney U tests were used for variables that were not normally distributed. In addition, to analyze the degree of improvement, I used a Wilcoxon signed rank test. Statistical significance was indicated by p-values of < 0.05.

RESULTS

Patient population

I screened 182 stroke patients for eligibility from December 2016 to April 2017, and 124 patients were excluded. I recruited and randomized 58 patients to either the experimental group [MW group (n = 28); Morning Walk® -assisted gait training with conventional

rehabilitation program] or the control group [conventional rehabilitation program (n = 30)] (Figure 2). In the MW group, three patients were excluded because of the following reasons: an unexpected severe medical complication (deconditioning due to sepsis), non-cooperation to treatment due to unstable mood, and initiation of contact isolation precautions (Vancomycin-resistant enterococcus was detected). In the control group, seven patients were excluded during the training because of early discharge due to which they were unable to finish the total sessions: personal reasons such as transfer schedule to other hospitals.

I completed final analyses on 48 patients: 25 in the MW group and 23 in the control group. Measures of height ($p = .032$) and weight ($p = .010$) were significantly greater in the MW group than in the control group. However, age, gender, body mass index, time post-stroke, cause of stroke, and side of hemiparesis did not significantly differ between the two groups (Table 1).

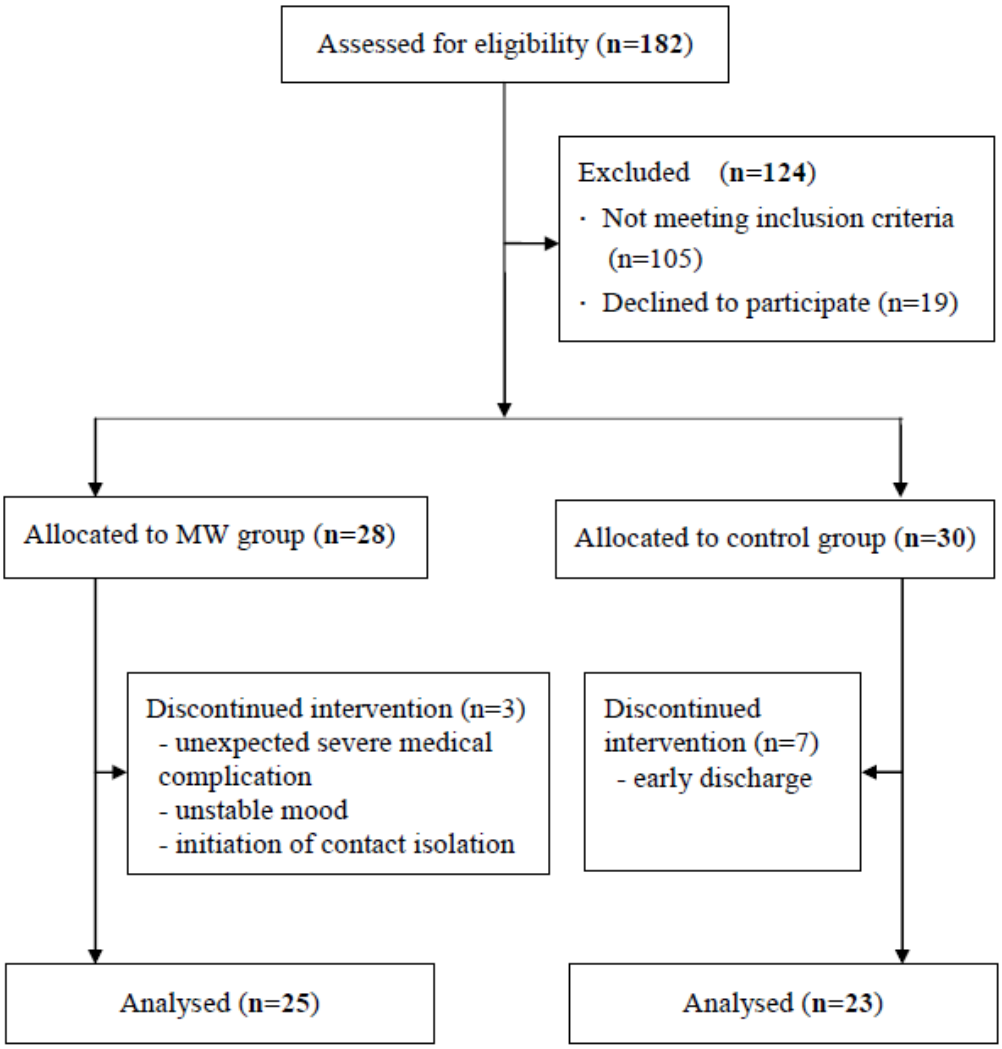

Figure 2. CONSORT Flow Diagram

Table 1. Participants characteristics by group

	Morning Walk® group (n=25)	**Control group** (n=23)	**p-value**
Age, years	57.7±12.9	60.4±13.2	.450†
Gender (%)			
Male	20 (80)	13 (56.5)	.083
Female	5 (20)	10 (43.5)	
Height, cm	168.9±8.2	163.8±8.2	.032†
Weight, kg	68.9±10.4	60.4±11.7	.010†
BMI, kg/m^2	24.4±2.5	22.7±3.6	.066†
Time post-stroke, months	2.0±2.4	2.6±3.1	.327
Cause of stroke (%)			
Infarction	14 (56)	18 (78.3)	.177
Hemorrhage	11 (44)	5 (21.7)	
Side of hemiparesis (%)			
Left	14 (56)	14 (60.9)	.735
Right	11 (44)	9 (39.1)	

Values are presented as mean±SD or number

BMI, body mass index

† independent t-test, otherwise Mann–Whitney U test

Improvement after training

I measured improvement by calculating differences in the scores between before treatment ($T_{0)}$ and after treatment (T_1) for each group. As the data were not normally distributed, Mann–Whitney U tests were used to compare the baseline and post-training measures within and between the two. After 15 training sessions, both groups significantly improved in every outcome measure. No significant between-group difference was observed in any outcome measure before treatment. Improvements in every outcome measures were significant in both group (Table 2). Inter-group analysis revealed the MW group showed significantly more improvement in MI-Lower, affected limb ($p = .034$) and BBS ($p = .047$) than the control group. Gait velocity measured by 10mWT showed more improvement in the MW group (mean±SD; 2.00±5.54 m/s) than in the control group (0.35±0.48m/s), but these results were not statistically significant. Other variables, such as FAC, MBI, RMI also showed a little more improvement in the MW group than in the control group but were not significant.

Table 2. Outcome measures before (T_0) and after (T_1) treatment

	MW (n=25)		**Control** (n=23)		
	T_0	**T_1**	**T_0**	**T_1**	**Δ (95% CI)**
FAC	2.9±1.2	3.9±1.4*	2.9±1.2	3.7±1.4*	0.3 (-0.2~0.8)
MI-Lower, affected limb	55.0±16.2	74.7±19.2*	59.4±14.4	71.0±13.3*	8.0 (1~15)**
10mWT (m/s)	0.5±0.5	2.5±5.4*	0.5±0.5	0.9±0.7*	1.7 (-0.5~3.8)
MBI	56.6±21.5	74.9±19.7*	54.0±4.05	69.6±21.2*	2.8 (-5.8~11.3)
RMI	6.0±2.6	8.6±2.8*	6.7±2.3	8.5±2.6*	0.7 (-0.1~1.5)
BBS	25.5±16.3	39.8±15.6*	26.9±14.8	36.5±14.8*	4.7 (-0.1~9.6)**

Values are presented as mean±SD.

MW, Morning Walk® group

Δ = (T_1-T_0) of MW group vs. (T_1-T_0) of control group

FAC, Functional Ambulation Category. 10mWT, 10m Walk Test. MBI, Modified Barthel Index. MI-Lower, Motricity Index-lower. RMI, Rivermead Mobility Index. BBS, Berg Balance Scales

* $p < .05$, by Wilcoxon signed rank test of T_0 vs. T_1

** $p < .05$, by Mann–Whitney U test of difference (T_1-T_0) of MW group vs. Control group

Subgroup analysis

For the MW group, the subgroup analysis was performed according to etiology (either infarction or hemorrhage), age (under or over 60 years), and baseline FAC score (< 3 or ≥ 3). I divided patients in the MW group according to etiology. The etiological groups were similar, with the exception of age. The patients who had sustained hemorrhage (50.6±13.6 years) were younger than those who had sustained infarctions (63.0±9.7 years). I observed no significant difference in the changes in outcome variables, according to etiology, among MW group patients (Table 3).

I also divided MW group patients according to age (i.e.,< 60 years or ≥ 60 years). Though the means of differences of FAC, 10mWT, MBI, MI-Lower affected limb, and BBS were larger in patients aged < 60 years, the differences were not statistically significant (Table 3). Notably, the p-value of BBS (p = .052) was marginally insignificant.

I also divided MW group patients according to FAC scores (i.e.,< 3 or ≥ 3). Characteristics of those subgroup were similar. Patients with FAC score < 3 showed significantly greater improvement in MBI than those with FAC scores ≥ 3 (Table 3). The differences in means of 10mWT, MI-Lower affected limb, RMI, and BBS were larger for patients with FAC scores <3; however, these differences were not statistically significant.

Lastly, I compared the groups according to etiology. Patients with histories of infarction or hemorrhage were similar at baseline. In the MW group, patients who had sustained infarction showed significantly greater improvement in MI-Lower in the affected limb. Among patients who had sustained hemorrhage, those in the MW group exhibited slight improvement over those in the control group, but the differences were insignificant (Table 4).

Table 3. Difference of the outcome measures before and after treatment according to etiology, age, initial FAC scores in the Morning Walk® group

	Difference before and after treatment					
	Cause of stroke		Age		iFAC	
	Infarction (n=14)	**Hemorrhage** (n=11)	**Age<60** (n=14)	**Age≥60** (n=11)	**iFAC<3** (n=15)	**iFAC≥3** (n=10)
ΔFAC	0.9±1.0	1.2±1.2	1.2±1.1	0.8±1.0	1.3±1.2	0.7±0.7
Δ10mWT (m/s)	1.9±6.2	2.1±4.8	3.4±7.2	0.2±0.2	3.1±7.0	0.3±0.5
ΔMBI	17.3±17.4	19.7±16.2	19.5±15.4	16.9±18.7	24.2±16.6*	9.6±12.8
ΔMI-Lower, affected limb	20.6±12.1	18.6±16.8	22.1±15.8	16.5±11.5	22.5±14.1	15.4±13.5
ΔRMI	2.3±1.4	2.9±1.9	2.5±1.7	2.6±1.7	2.9±1.6	2.0±1.6
ΔBBS	14.6±10.1	14.0±7.6	17.5±9.2	10.4±7.3	16.7±8.7	10.8±8.7

Values are presented as mean±SD.

FAC, Functional Ambulation Category. iFAC, initial FAC. 10mWT, 10m Walk Test. MBI, Modified Barthel Index. MI-Lower, Motricity Index-lower. RMI, Rivermead Mobility Index. BBS, Berg Balance Scales

* $p<.05$, by Mann–Whitney U test of iFAC<3 group vs. iFAC≥3 group

Table 4. Difference of the outcome measures before and after treatment in patients who had sustained infarction and hemorrhage

	Difference before and after treatment			
	Infarction		Hemorrhage	
	MW (n=14)	**Control** (n=18)	**MW** (n=11)	**Control** (n=5)
ΔFAC	0.93±1.0	0.7±0.8	1.2±1.2	1.0±1.0
Δ10mWT (m/s)	1.9±6.2	0.3±0.4	2.1±4.8	0.7±0.7
ΔMBI	17.3±17.4	15.9±3.1	19.7±16.2	14.4±14.9
ΔMI-Lower, affected limb	20.6±12.1*	11.8±10.7	18.6±16.8	11.4±11.8
ΔRMI	2.3±1.4	1.9±1.2	2.9±1.9	1.6±1.5
ΔBBS	14.6±10.1	10.5±8.7	14.0±8.0	6.6±5.6

Values are presented as mean±SD.

MW, Morning Walk® group

FAC, Functional Ambulation Category. 10mWT, 10m Walk Test. MBI, Modified Barthel Index. MI-Lower, Motricity Index-lower. RMI, Rivermead Mobility Index. BBS, Berg Balance Scales

* $p < .05$, by Mann–Whitney U test of MW inf. group vs. Control inf. group

DISCUSSION

This study demonstrated that compared with conventional rehabilitation program alone, Morning Walk® -assisted gait training together with conventional rehabilitation program was beneficial for patients with subacute stroke and hemiparesis. Significantly greater improvements were observed in the motricity of affected limb (MI-Lower, affected limb) and balance (BBS) in the MW group than in the control group. The degree of improvement was not correlated with stroke etiology or age. In the MW group, younger patients and patients with baseline FAC scores < 3 tended to show more improvement.

To my knowledge, this is the first study to verify the effect of Morning Walk® -assisted gait training for patients with subacute stroke and hemiparesis. I completed this study in three reputable hospitals to minimize selection bias. I recruited patients based on strict inclusion and exclusion criteria, and all patients were randomized assigned to one of the two treatment groups. Because performing a double-blinded rehabilitation trial poses logistical concerns, patients knew to which group they were assigned. The study outcome measures have been widely used in other studies on robot-assisted gait training (RAGT).[20]

The MW group showed significantly greater improvement in MI-Lower, affected limb and BBS than the control group. These data are in agreement with the results of a recent study indicating that gait training with an end-effector robotic device is effective for improving strength, balance, and endurance.[21] Gait velocity, measured by the 10mWT, showed more improvement in the MW group than in the control group, but difference was not statistically significant. Lower limb muscle strength correlates with gait speed.[22, 23] Suzuki et al. have reported that muscle strength on the affected and unaffected sides is a determinate of maximum walking speed in patients.[23] As the MI-Lower, affected limb showed significantly greater improvement in the MW group than in the control group, gait velocity appears to be a

potential outcome measure. Future studies should examine this using a larger patient cohort.

After 15 training sessions, every outcome measure showed significant improvement in both groups. Stroke recovery is complex, comprising spontaneous and learning-dependent processes.[24] Therefore, along with the effects of intensive rehabilitation treatment, we should consider the contributions of spontaneous recovery. Age did not appear to affect the results of this study as there were no age-dependent differences observed between pre- and post-treatments.

Recently, Yang et al. have described structural and functional improvements attributable to RAGT in patients with stroke using diffusion tensor imaging (DTI).[6] DTI data was acquired from 10 non-ambulatory patients receiving inpatient rehabilitation before and after the received 20 sessions of RAGT using Walkbot® (P&S Mechanics, South Korea). The results suggested that RAGT correlates with post-stroke brain reorganization. RAGT may help improve post-stroke walking ability by accelerating neuroplastic processes required to redistribute motor function away from affected areas and toward unaffected areas.

Via a Cochrane review, Mehrholzet al. have indicated moderately strong evidence in favor of automated electromechanical and RAGT devices for improving gait after stroke. Patients with stroke who receive electromechanical-assisted gait training in combination with rehabilitation program achieve higher levels of independent walking than patients who receive rehabilitation program alone.[25] However, RAGT alone does not include necessary adjunctive training, such as sit-to-stand, transfer, and balance training. Therefore, a combined therapy (with traditional rehabilitation program) is preferable.[16] Patients sustaining subacute stroke within 3 months post stroke and those who are unable to walk likely benefit the most from RAGT.[25]

As with other end-effector-type robots, Morning Walk® allows the therapist to easily board and disembark the patient within 10 min. This stands in contrast to Lokomat®, which requires more than 30 min for the patient to board. In addition, Morning Walk® provides partial body weight support (PBWS) by saddle, chest support, and body weight support link. Therefore, it is applicable to both non-ambulatory and ambulatory patients who require continuous manual contact for body weight support, and it also reduces therapists' efforts. PBWS is effective for gait rehabilitation in patients with stroke.[26]

Study Limitations

This study had several limitations. My study cohort was smaller than that in other multicenter studies. This may have reduced the statistical power for some variables. Second, the patient groups had unequal distributions of height and weight at baseline. These differences persisted despite baseline randomization procedures. Third, patients were not blinded to the treatment they received. It is possible that patients in the MW group felt as if they were receiving double therapy, although the net treatment time was identical for both groups. And the measurements evaluator were also not blinded to the treatment group, that it would have limited the internal validity. Lastly, this study assessed outcomes only at the beginning and at the end of the treatment. Future research should examine the persistence of treatment effects over time.

CONCLUSIONS

In conclusion, compared with conventional rehabilitation program alone, Morning Walk®-assisted gait training combined with conventional rehabilitation program resulted in superior measures of motricity of the affected limb and balance in patients with subacute stroke and hemiparesis. Most hospital-based gait rehabilitation programs rely on the manual assistance

by a physical therapist. Fatigue in the therapist makes it difficult to provide continuous, intensive walking training for patients. RAGT can provide necessary treatment intensity, increase the number of gait cycles, and reduce the burden on therapists. Morning Walk® -assisted gait training potentially benefits both patients and physical therapists. Future clinical trials with more numbers of patients and longer follow up are necessary.

ACKNOWLEDGEMENT

I would like to thank Jeong Joon Lee, Seong Min Koo, Seo Woo Nam and Na Young Joo for their technical assistance with the study interventions included in this investigation. This paper is the result of research project of Future Growth Engine Flagship Project by Minister of Science, ICT and Future Planning, supported by Korea Institute of Science & Technology Evaluation and Planning(KISTEP). I am not in conflict of interest.

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뇌졸중으로 인한 반신불완전마비 환자에서 모닝워크를 이용한 보행 훈련의 효과 : 무작위 다기관 시험

목적 아급성 뇌졸중 환자에서 모닝워크를 이용한 보행 훈련의 효과를 조사하고자 하였다.

방법 본 연구는 비-맹검, 무작위 대조 기법의 전향적 연구로서 2016년 12월부터 2017년 4월까지 세 병원의 재활의학과에서 시행되었다. 1년 이내에 처음 발병한 뇌졸중으로 반신불완전마비를 보이며 functional ambulation category (FAC) 점수가 2점 이상인 환자들을 대상으로 검토하여 58명의 환자를 등록하였다. 환자들은 무작위로 모닝워크군과 대조군에 배정되었고, 이 중 10명이 탈락하여 최종 분석은 48명을 대상으로 하였다. 치료는 주 5회로 3주간 시행되었고, 1회 치료 시 28명의 모닝워크군은 30분의 모닝워크를 이용한 보행 훈련 및 1시간의 고식적 재활치료를, 30명의 대조군은 1시간 30분의 고식적 재활치료를 시행하였다. 일차 결과 지표는 보행 능력을 평가하기 위한 FAC 점수와 하지의 운동 기능을 평가하는 Motricity Index(MI)로 설정하였다. 또한 이차 결과 지표로 10m walk test, Modified Barthel Index, Rivermead Mobility Index, Berg Balance Scale 등을 평가하였다.

결과 양 군 모두 치료 후에 모든 결과 지표들이 유의미한 향상을 보였다. 모닝워크군은 위약이 있는 하지의 MI ($p = .034$) 및 BBS ($p = .047$)에서 대조군보다 더 큰 폭의 향상을 보였다. 모닝워크군 내에서는 초기 FAC 점수가 3 미만이었던 환자들이 초기 FAC 점수가 3 이상이었던 환자들보다 MBI ($p = .011$)의 향상 폭이 더 컸다.

결론 아급성 뇌졸중으로 인한 반신불완전마비 환자에서 모닝워크를 이용한 보행 훈련을 고식적 물리치료와 함께 시행할 때, 고식적 물리치료를 단독으로 시행하였을 때 보다 위약이 있는 하지의 운동 능력 및 균형 기능이 향상되었다.