# 뇌졸중 환자의 균형과 보행기능에 대한 개별-적용 트레드밀 훈련의 효과

# Effects of individually-adjusted treadmill training on balance and walking functions in patients with post-stroke hemiparesis: A group-matched, single-blind pilot trial

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# Introduction

- After stroke, problems in walking are characterized **as slow speed, decreased cadence and stride length, and asymmetrical weight distribution in double-limb support** (Marigold and Eng, 2006; Yang et al, 2007).
- Therefore, **recovery of balance and walking functions is a major goal in stroke rehabilitation** (Franceschini et al, 2009), which is essential to improve the quality of life and facilitate societal return of patients after stroke (Cha and Ji, 2012).
- Repeated limb motions **from treadmill training** encourage symmetrical walking patterns, reduce hypertonus, and improve the cardiovascular-metabolic capacity during walking (Ivey et al, 2008), which is helpful **in improving the speed, distance, and quality of walking** (Ada et al, 2003). For this reason, **the use of treadmill training is reasonable for clinical use in post-stroke patients** (Pohl et al, 2002).

# Introduction

- **Treadmill training is known to be more effective when the speed used is close to that of the age-matched normal population**, which suggests an overload effect of the training (Sullivan et al, 2002).
- On the basis of this concept, **individually-adjusted treadmill training can be used to determine the speed load of treadmill training depending on the individual's performance** (Kim et al, 2020).
- **To achieve this, the walking speed must be measured in comfort and fast modes prior to walking training to obtain sufficient information on the walking ability of patients with post-stroke hemiparesis** (Kollen et al, 2006).

However, **in clinical practice, walking speed during treadmill training has been frequently determined in the convenience of patients with post-stroke hemiparesis**, which is not considered sufficient to improve the effects of treadmill training.

# Introduction

The purpose of this study was to demonstrate whether individually-adjusted treadmill training promotes balance and walking functions in patients with post-stroke hemiparesis.

# Methods

## 2.1 participants

- The criteria for selection were as follows:

(1) >6 months since stroke,

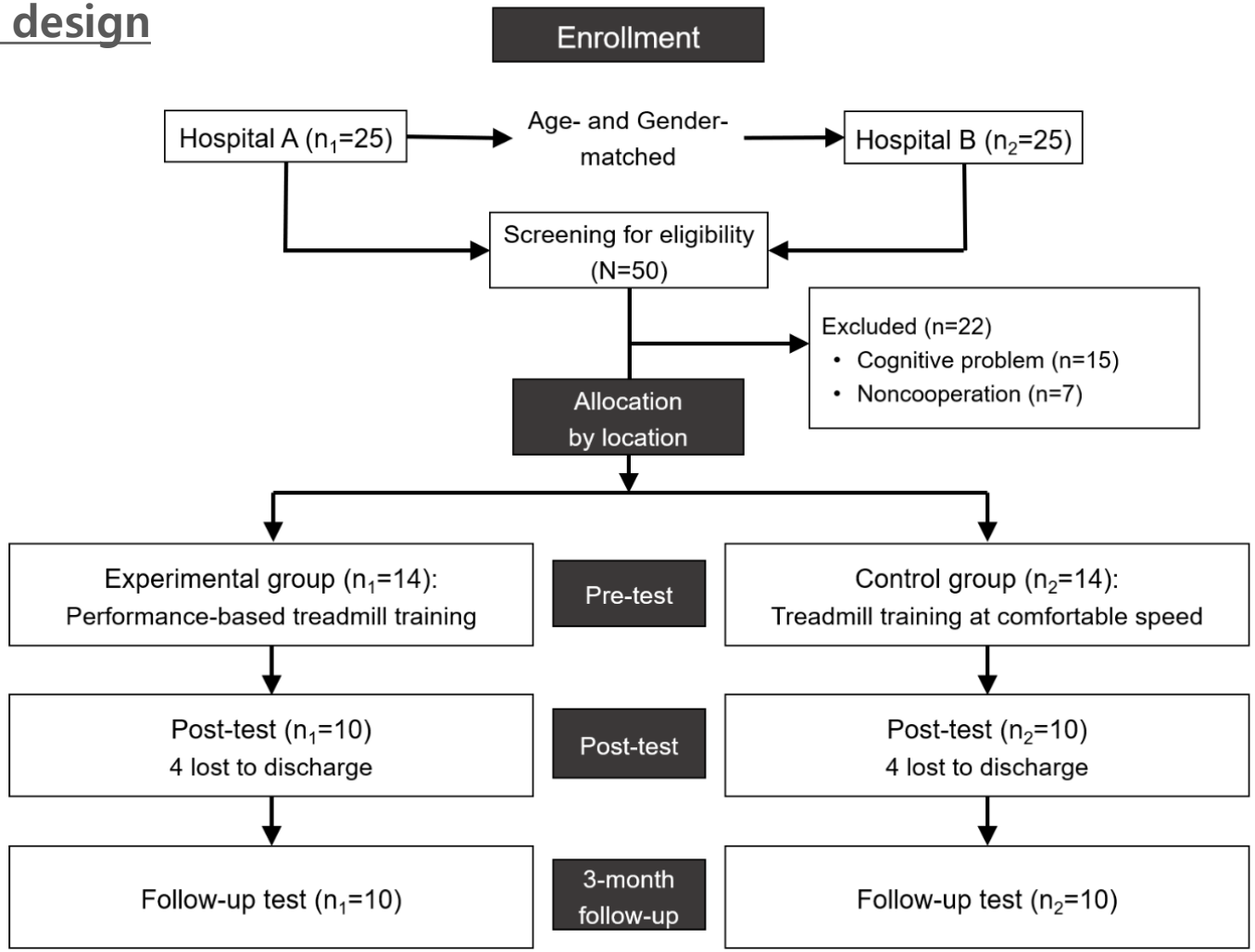
(2) Ability to independently walk on a treadmill by holding a guard rail

(3) No orthopedic, cardiopulmonary, or other neurological disorders that would influence treadmill walking

(4) No cognitive impairment (≥24 points in the Mini-Mental State Examination [MMSE]) (Folstein et al, 1975).

# Methods

## 2.2 Study design



# Methods

## 2.3 Outcome measures

- **10-meter walk test (10MWT)**

The 10MWT was performed to measure walking speed. The walking speed was then calculated. Data from the 3 trials were averaged.

- **6-minute walk test (6MWT)**

The total distance the subjects walked for 6 min was recorded in meters(Mossberg, 2003).

- **Berg Balance Scale (BBS)**

The BBS has been widely used to evaluate the balance ability of patients with stroke(Lisa and Nicol, 2008).

- **Activities-special balance confidence scale (ABC)**

The Korean version of the Activities-special balance confidence (ABC) scale is a self-administered tool to assess the balance confidence of patients with stroke (Jang et al, 2003).

# Methods

## 2.4 procedure

- All the subjects **performed mat exercises, functional training, and therapist-guided activities in a daily rehabilitation schedule.**
- In addition, all the subjects performed treadmill training with different speed options depending on the groups after daily treatment.
- **To prevent falls and ensure the safety of the subjects, the therapist stood behind the patient to supervise the training.**
- The treadmill training was **performed for 30 minutes each session, twice per day, for 5 days over 2 weeks (a total of 20 sessions).**

# Methods

## 2.4 procedure


**Self-selected treadmill training**

✓ Self-selected walking speed

**Individually-adjusted treadmill training**

✓ Maximum speed calculated on the basis of the subject's walking

✓ **10MWT(comfortable walking speedx1.3)** (Kollen et al, 2006).

To compare the effects of treadmill training at different speeds in each group, measurements were performed **at pre- and post-test, and 3-month follow-up.**

# Methods

## 2.4 Data analysis

- The statistical analysis of all the data was performed using **SPSS version 22.0** (Statistical Package for Social Science, Chicago, USA).
- For the **general characteristics of the subjects, homogeneity** was tested using the **chi-square and independent *t*-tests.**
- **Between-group comparisons** were analyzed by using **independent t-test.**
- **Within-group comparisons** were analyzed using **one-way repeated-measures analysis of variance, and a *post hoc* test with Bonferroni adjustment** was used for multiple pairwise comparisons when significant differences were found.
- The statistical **significance level was set at $p<0.05$.**

# Results

## 3.1 General characteristics of the subjects

| | EG ($n_1$=10) | CG ($n_2$=10) | $\chi^2$/t | p |
|---|---|---|---|---|
| **Gender** | | | | |
| **Male** | 5 | 6 | 0.20 | 0.65 |
| **Female** | 5 | 4 | | |
| **Age** | 62.60±10.65[a] | 63.90±10.02 | -0.28 | 0.78 |
| **Height (cm)** | 159.10±11.08 | 163.60±9.51 | -0.60 | 0.56 |
| **Weight (kg)** | 58.00±9.68 | 62.10±9.39 | -1.51 | 0.14 |
| **Onset (months)** | 18.70±14.27 | 17.70±12.99 | 0.43 | 0.67 |
| **Types of stroke** | | | | |
| **Hemorrhage** | 5 | 4 | 0.20 | 0.65 |
| **Infarction** | 5 | 6 | | |
| **Paralytic sides** | | | | |
| **Right** | 5 | 6 | 0.20 | 0.65 |
| **Left** | 5 | 4 | | |
| **MMSE-K (scores)** | 25.40±1.78 | 25.20±1.62 | -0.12 | 0.90 |

[a]Mean±standard deviation

EG: Experimental group; CG: Control group; MMSE-K: Korean version of Mini-Mental Status Examination.

| | Experimental group | Difference from pre-test | Control group | Difference from pre-test | ES | t |
|---|---|---|---|---|---|---|
| **10MWT (m/s)** | | | | | | |
| **Pre-test** | 0.62±0.21 (0.47 to 0.76) | | 0.69±0.29 (0.49 to 0.90) | | | |
| **Post-test** | **0.73±0.27 (0.54 to 0.93)§** | 0.12±0.12 (0.07 to 0.23) | 0.67±0.30 (0.46 to 0.89) | -0.02±0.08 (-0.06 to 0.03) | 1.37 | **3.02**** |
| **3-month follow-up** | **0.75±0.28 (0.54 to 0.95)§** | 0.13±0.11 (0.31 to 0.23) | 0.60±0.16 (0.49 to 0.72) | -0.09±0.28 (-0.29 to 0.11) | 1.03 | **2.32*** |
| **6MWT (m)** | | | | | | |
| **Pre-test** | 202.90±85.15 (141.99 to 263.81) | | 247.80±125.80 (157.99 to 337.61) | | | |
| **Post-test** | **244.60±89.38 (185.14 to 308.54)§** | 41.70±32.90 (11.19 to 72.21) | 250.80±125.80 (160.81 to 340.79) | 3.00±10.73 (-6.95 to 12.95) | 1.58 | **3.54**** |
| **3-month follow-up** | **257.20±121.48(170.30 to 344.11)§** | 54.30±57.27 (1.18 to 107.43) | 187.50±99.88 (116.05 to 258.95) | -60.30±132.28 (-183.01 to 62.40) | 1.12 | **2.51*** |
| **BBS (scores)** | | | | | | |
| **Pre-test** | 42.10±8.71 (35.87 to 48.33) | | 46.50±4.90 (43.00 to 50.01) | | | |
| **Post-test** | 45.60±6.04 (41.28 to 49.92) | 3.50±3.98 (-0.19 to 7.20) | 46.70±5.62 (42.68 to 50.72) | 0.20±2.30 (-1.93 to 2.33) | 1.02 | **2.27*** |
| **3-month follow-up** | **47.00±6.15 (42.60 to 51.40)§** | 4.90±4.51 (0.72 to 9.08) | 47.90±6.06 (43.56 to 52.24) | 1.40±3.20 (-1.57 to 4.37) | 0.90 | 2.00 |
| **ABC (scores)** | | | | | | |
| **Pre-test** | 51.38±27.02 (32.05 to 70.70) | | 58.81±20.43 (44.20 to 73.43) | | | |
| **Post-test** | 68.06±21.19 (52.90 to 83.22) | 16.69±18.13 (-0.13 to 33.51) | **62.44±21.71 (46.91 to 72.97)§** | 3.63±4.17 (-0.25 to 7.50) | 0.99 | **2.22*** |
| **3-month follow-up** | **72.38±20.53 (57.69 to 87.06)§** | 21.00±18.74 (3.62 to 38.38) | 68.06±20.88 (53.12 to 83.00) | 9.25±13.52 (-3.29 to 21.79) | 0.72 | 1.61 |

**Data are presented as mean±SD (95% CI of mean). T values were obtained from between-group comparisons of differences from pre-test (*p<0.05 and **p<0.01).**

**ES: effect size; 10MWT: 10-m walk test; 6MWT: 6-min walk test; BBS: Berg balance scale; and ABC: Activities to specific balance confidence scale.**

**§Significant difference in comparison with pre-test data as within-group comparison.**

# Results

### 3.2 Comparison of data collected at pre- and post-test and 3-month follow-up between the two groups

- **In the between-group comparison**, although no significant differences in all the parameters were found at all measurement times between the groups ($p>0.05$), change values in the **10MWT and 6MWT values between pre- and post-test and between pre-test and 3-month follow-up**, and change values in the **BBS and ABC scores between pre- and post-test appeared to be significantly different** ($p<0.05$).

# Results

## 3.2 Comparison of data collected at pre- and post-test and 3-month follow-up between the two groups

- Furthermore, **in the within-group comparison**, subjects in **the EG showed** significant differences in **10MWT (F=6.68, p=0.02), 6MWT (F=7.20, p=0.02), BBS (F=5.75, p=0.03), and ABC (F=5.58, p=0.03)** scores across the measurement times.
- The post hoc test results showed that the **10MWT and 6MWT values were significantly different between pre- and post-test and between pre-test and 3-month follow-up.** The **BBS and ABC scores showed significant differences between pre-test and 3-month follow-up.**
- However, in **the CG**, a significant difference in the **ABC score was found (F=7.00, p=0.02), with post hoc test results showing significant differences between pre- and post-test.**

# Discussion

## 4.1 Discussion to study Methodology

- **This study supports that individually-adjusted treadmill training may be favorably used to improve the balance and walking functions of patients with post-stroke hemiparesis.**
- In general, clinical observation has shown that **fast-speed treadmill training has some advantages** in activating the anti-gravity muscles of the lower extremities, thereby helping to facilitate efficient walking patterns of patients with post-stroke hemiparesis (Pohl et al, 2002; Lee, 2015; Dobkin et al, 2010; Danks et al, 2016).
- **However, its application could be difficult in clinical practice because no standard has been established to clearly determine the speed load on treadmill training** (Yamada et al, 2015).

# Discussion

## 4.1 Discussion to study Methodology

| Park, 2017 | Lee, 2015 | Individually-adjusted treadmill training |
|---|---|---|
| **Heart rate** for determining the walking speed | **1.2–1.3 m/s** during the training, exceeding the average walking speed of patients with stroke | The training load should be **individualized depending on the individual walking capability** of patients |

**On the basis of this concept, this study investigated the effects of individually-adjusted treadmill training that individually adjusts the walking speed of the training depending on the walking ability of patients with post-stroke hemiparesis.**

# Discussion

## 4.2 Discussion to study's results

- The main results of this study were that compared with training at comfortable speeds, **individually-adjusted treadmill training has greater benefits to balance and walking functions after stroke, and gains were maintained at the 3-month follow-up**.
- In this study, the improvement in **the 6MWT and BBS scores in the EG** after the intervention were **> 40 meters and >3.50 scores** respectively, which met the criteria for the **minimum detectable change (6MWT: 36.6 meters and BBS: 2.7 points)** (Flansbjer et al., 2005; Alghadir et al., 2018).
- As the ability to maintain **balance has a significant impact on walking function**, improvement in **BBS score** is also thought to be related to the improvement in the **10MWT and 6MWT values** (Mohammadi et al, 2017).

# Discussion

## 4.2 Discussion to study's results

- **Walking training at fast speeds highlights intensive repetitive movements of the lower limbs with greater effort** (Kuys et al, 2011), which helps to increase the fitness level and facilitate the alternating control of the limbs after stroke.
- Therefore, the **improved 6MWT value after the intervention may be one of the greatest benefits** from the training, indicating possible effects on walking endurance.
- In this study, the 6MWT value was improved by an average of **41.0 m in the EG**, which was higher than the **34.4-m criterion for the minimal clinically important difference** (Tang et al, 2012).
- **Walking endurance is closely related to self-efficacy and quality of life after stroke.**
- As seen in this study, **the improved ABC scores** indicate that **individually-adjusted treadmill training may be more useful** than training at self-adopted speeds for addressing psychological issues such as balance confidence and fall efficacy.

# Discussion

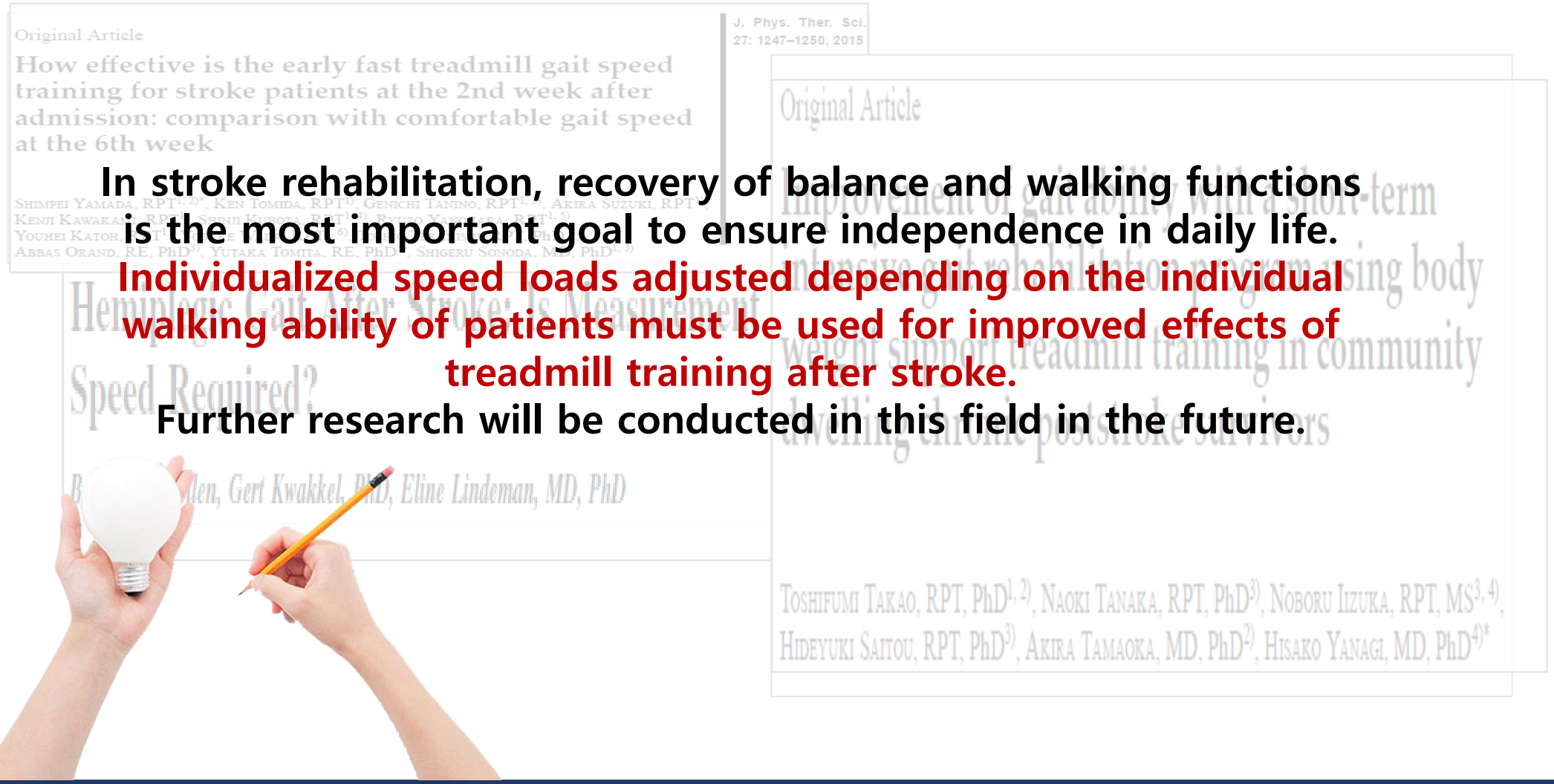
## 4.3 Limitations of study

**Sample size**

**Training effects until 3 months after the intervention**

**The quantitative data**

# Conclusion




**In stroke rehabilitation, recovery of balance and walking functions is the most important goal to ensure independence in daily life.**

**Individualized speed loads adjusted depending on the individual walking ability of patients must be used for improved effects of treadmill training after stroke.**

**Further research will be conducted in this field in the future.**

경청해주셔서 감사합니다.