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A Study on the Effect of Proprioceptive Neuromuscular Facilitation Training by Meta-analysis -Focused on Balance and Gait Ability in Patients with Storke

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[Abstract]

Stroke results in balance disorders, these directly affect autonomy and gait ability. The aim of this meta-analysis was to determine the efficacy of proprioceptive neuromuscular facilitation on balance and gait. We included all randomized controlled trials assessing the efficacy of proprioceptive neuromuscular facilitation on balance and gait control in patients after stroke. This study was conducted according to the PRISMA guideline. Cochrane library, CINAHL, and PubMed were searched for studies published up to November 2021, and all randomized controlled trails(RCT) assessing PNF therapy were included. This analysis included only RCT. A total of 18 studies were selected from 1091 records obtained from the databases. The meta-analysis was performed using the R project for statistical computing version 4.0.2. The overall intervention effect was middle (standardized mean difference (SMD): 0.56) Additionally, berg balance scale (SMD: 0.48), functional reach test (SMD: 0.51), timed up and go test (SMD: 0.78), 10m walking test (SMD: 0.52), and dynamic gait index (SMD: 0.33) had medium effect sizes. The average Pedro scale was 6.63 out of 18, with a low risk of bias. These findings indicate that PNF is an effective therapy for improving balance gait in stroke patients.

▸ **Key words**: Balance, Gait ability, Meta-analysis, PNF(Proprioceptive neuromuscular facilitation), Stroke

[요 약]

뇌졸중은 균형 장애와 보행능력에도 직접적인 영향을 미친다. 본 연구는 고유수용성신경근촉진법이 뇌졸중 환자의 균형 및 보행에 미치는 영향 연구를 목적으로 한다. 따라서 뇌졸중 환자에게 고유수용성신경근촉진법을 적용하여 균형과 보행 능력을 평가하는 모든 무작위 배정 연구를 포함하였다. 본 연구는 메타분석에서 있어서 꼭 필요한 프리즈마 가이드 라인을 준수하였다. Cochrane library, CINAHL, Pubmed에서 2021년 11월까지 발행된 연구를 포함하였고, 그 연구들은 고유수용성신경근촉진법을 적용한 무작위 배정 연구들이다. 데이터베이스에서 검색된 1091개의 논문 중 18개의 연구를 메타분석을 시행하였고, 메타분석은 R 프로젝트 4.0.2를 사용하여 시행하였다. 본 연구의 전체 효과 크기는 0.56으로 중간 정도로, 균형과 보행에 관한 척도에 대한 효과 크기도 중간정도 산출되었다. 무작위 배정 정도를 나타내는 페드로 점수는 18점 만점에서 6.63으로 비뚤림 위험이 낮은 것으로 나타났다. 이러한 결과는 PNF가 뇌졸중 환자의 균형 및 보행을 향상시키는 효과적인 중재 방법임을 알 수 있다.

▸ **주제어**: 고유수용성신경근촉진법, 균형, 뇌졸중, 메타분석

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I. Introduction

Stroke is a public health problem and one of the leading causes of death and disability in both developing and developed countries [1]. Stroke patients often have disturbances balance and gait, resulting in loss of stability and an increased risk of falls, and damage to the nervous system causes neurological disorders and a variety of situational instabilities [2]. Balance and gait ability are important factors for predicting functional independence in stroke patients [3]. Therefore, improving balance and gait ability in stroke patients is necessary for improved quality of life [4]. Proprioceptive neuromuscular facilitation (PNF) is widely used in clinical practice to improve balance in stroke patients [5]. A review of the current evidence and guidelines for the use of PNF therapy has been published [6]. There is insufficient evidence of the efficacy of a single treatment option for stroke patients, and hence, therapists should prescribe treatment based on patients' needs [7]. PNF therapy for retraining exercise has not been found to be more effective than other interventions in patients with acute stroke [8]. The effect of PNF on function recovery in stroke patients has been reported through different studies. According to the different reports, PNF has been used safely in several patient populations with positive results [9]. A study reported that an experimental group that included stroke patients who underwent PNF showed improved walking ability compared to the control group [10]. In another study, PNF had a positive effect on lower extremity function in chronic stroke patients [11]. These findings emphasize the need for high-quality research on PNF [9]. Therefore, it is necessary to comprehensively analyze previous studies on PNF to statistically verify its effectiveness for stroke patients [12]. Systematic review and meta-analysis provide the highest level of evidence of the effectiveness of therapeutic interventions [13]. Meta-analysis is a statistical method that comprehensively evaluates and analyzes the results of different studies on a particular research topic [14]. When researchers conduct individual studies, various problems, such as limited number of subjects, limited number of samples, and flawed research process, can arise. Meta-analysis can systematically derive research results by using comprehensive statistical methods with high verification power [15]. To the best of our knowledge, there has been no review of the literature on the effect of PNF therapy on balance ability in stroke patients. Therefore, this study purposed to verify the effectiveness of PNF therapy on the balance and gait of stroke patients.

II. Materials and Methods

1. Eligibility criteria and information sources

Eligibility criteria were designed according to the participants, intervention, comparison, and study design PICOS framework. The study participants were patients with stroke, the intervention was PNF, and the comparison was any other intervention for stroke. The outcomes were balance and gait BBS), FRT, TUG, 10MWT, DGS. The included studies were randomized controlled trials that were published in English or Korean, and the literature search was limited to human studies. This analysis was conducted in accordance with the PRIMA guidelines. Electronic databases, namely Cochrane library, CINAHL, and Pubmed, were searched for studies publish up to November 2021.

2. Search and study selection

Members of the research team and two information experts performed selected searches. Search terms included were descriptive terms, types of interventional studies (RCTs), comprehensive keywords, rehabilitation interventions (PNF, proprioceptive neuromuscular facilitation, and muscle stretching exercise), and stroke-related terms (stroke, cerebrovascular

disease, infarction). Qualification evaluation was conducted independently in a non-blinded manner. The papers were exported to endnote to identify related articles, titles, and abstracts. A reviewer identified and eliminated duplicate documents. Where necessary, the full texts of the articles were retrieved and evaluated, and the references were manually screened to identify relevant studies. In the event of a conflict between the two reviewers in the final decision, a third reviewer was consulted.

3. Date collection process and data items

Data extraction sheets were manually created and pilot tests were conducted for the included studies, and further refinement was carried out accordingly. Two reviewers independently carried out data extraction and calculations. The two sets of data were compared, and inconsistencies were resolved through discussion. Next, the following data were systematically extracted: characteristics of patients, patient age, group number, study design, inclusion criteria, duration of the stroke, and outcome measures (balance and gait). To compare the effectiveness of interventions for each prognosis, the mean and standard deviation of outcome measures were extracted and analyzed at baseline, immediately after intervention, and during follow-up. All the included studies collected data using the same scale; hence, standardized mean difference was determined in this analysis.

4. Risk of bias in individual studies

The risk of bias in the individual studies was assessed by three independent reviewers. The included studies were critically evaluated by using an 11-item scale extracted from The Physiotherapy Evidence Database (Pedro). The Pedro scale assesses the methodological quality of a study based on important criteria, such as concealment allocation, treatment objective analysis, and suitability of follow-up measures. These properties make Pedro a useful tool for assessing the methodological quality of physical therapy. The Pedro scale consists of 11 items and is based on the Delphi list. Items 2 to 9 refer to the internal validity of the studies, and items 10 and 11 refer to statistical analysis to ensure sufficient data for adequate interpretation of results (Morton, 2009). The Pedro total scale was interpreted as follows: 910, super;6-8, good;4-6, fair; and 1-3, poor.

III. Results

1. Study selection

A total of 1091 studies were identified after the removal of duplicate studies. Based on the inclusion criteria, the screening of the titles and abstracts of 183 full-text studies identified 18 relevant studies. The flow chart of the screening process is shown <Fig. 1>.

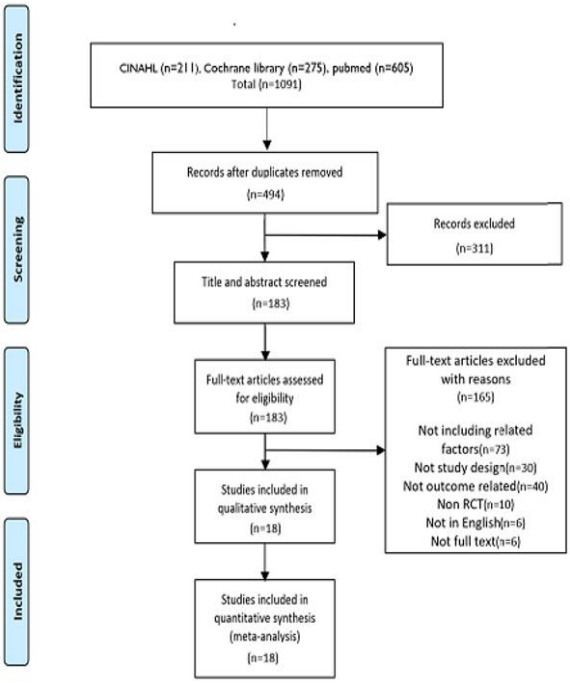

Fig. 1. PRISMA flow diagram

2. Study characteristics

Nineteen studies were analyzed, which included a total of 456 participants, with 238 patients in the experimental group and 218 patients in the control group. The average age of the patients in this study was 55.9 years. This analysis included a study conducted in patients 6 months after the

onset of stroke. Interventions for stroke patients were performed by physical therapists in hospitals. An important overview of the data of each study is shown in appedix 1.

3. Risk of bias within studies

The Pedro scale, the mean score for the included papers was 6.63, which indicates that the studies had low risk of bias<Appendix 2>.

4. Results of individual studies and synthesis of results

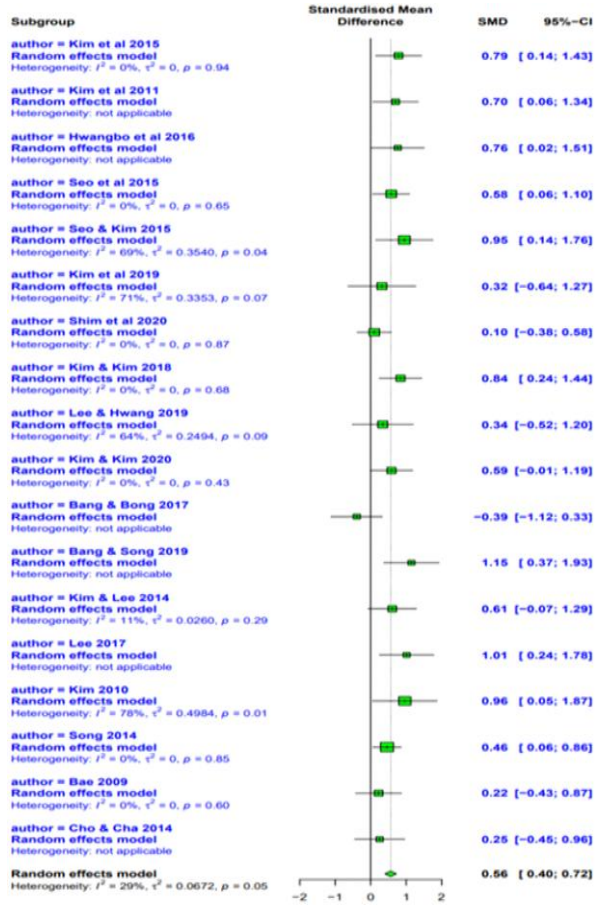

Fig. 2. Overall effect size of PNF

PNF intervention had an overall effect size of 0.56, which was statistically significant because the CI did not include 0. The level of heterogeneity was low (I =28.5) <Figure 2>.All the nineteen studies included outcome variables that measured balance. The overall effect size was 0.59, indicating a medium effect size. BBS (0.48), FRT (0.51), and TUG (0.78), as sub-items for balance evaluation, ha medium effect size <Figure 3>.Five of the studies included outcome variables that measured gait. The overall effect size was 0.46, indicating a medium effect size. DGI (0.33) and 10MWT (0.52), as sub-items for gait evaluation, had medium effect size <Figure 2>.

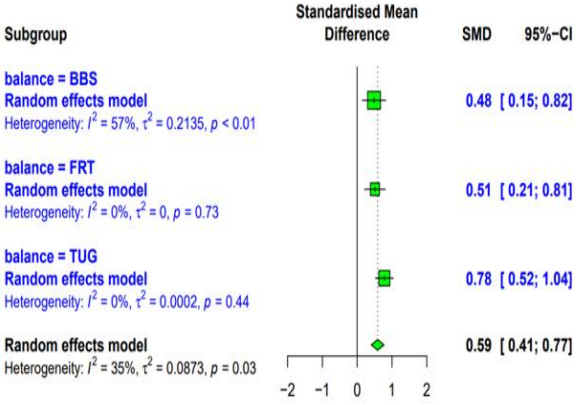

Fig. 3. Balance effect size of PNF

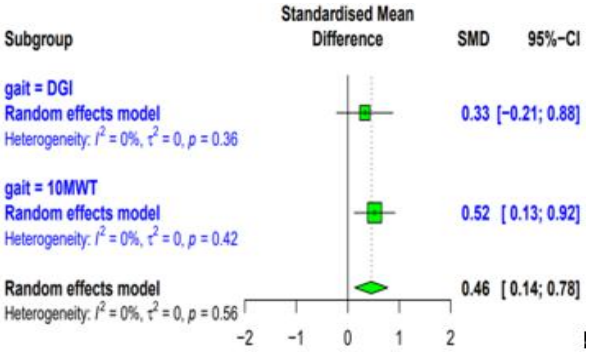

Fig. 4. Gait effect size of PNF

5. Risk of bias across studies

Funnel plot was used to investigate the risk of publication bias. The funnel plot of PNF intervention for improved balance and gait in stroke patients is symmetrical, demonstrating a low probability of publication bias<Figure 5>.

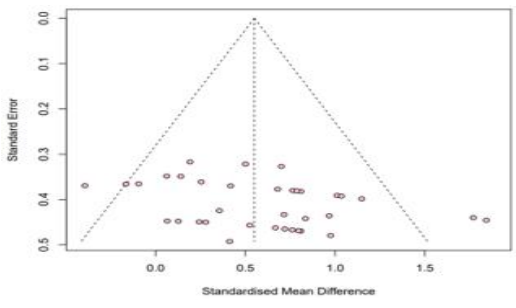

Fig. 5. Publication bias plot

IV. Discussion

This meta-analysis was conducted to demonstrate the effectiveness of PNF intervention for improved balance and gait ability in stroke patients. To the best of our knowledge, this is the first meta-analysis to focus on the evidence of the effectiveness of PNF intervention in stroke patients. In most stroke patients, the balance ability decreases due to the abnormal activation of the muscles, and the whole body is supported by the non-paralytic side rather than the paralyzed side in the straight posture, which ultimately causes difficulties in daily life activities [16]. In addition, stroke patients rely on the non-paralytic side for their daily activities [17]. Such asymmetric weight support causes damage to the musculoskeletal system of the non-paralyzed side, a decrease in balance ability, and a decrease in walking function [18]. Intervention programs designed to improve the functional ability of stroke patients are very important. The PNF approach stimulates proprioceptors, making it easier for the patients to perform functional activities. For this reason, the goal of any intervention for stroke patients is to increase balance and gait ability by activating the muscles of the paralyzed side in order to improve its weight-bearing capacity. In order to verify the overall effect of PNF, a homogeneity test was performed on a total of 18 studies. In this study, random effect model was implemented while assuming that there was heterogeneity in the effect sizes of the individual studies. Our results showed that the heterogeneity was low, as the actual dispersion ratio I = 28.5%. This means that the effect size of the studies was relatively insignificant [19]. The overall effect size of PNF in stroke patients was 0.56, which is considered statistically significant. This result indicates that PNF therapy has a middle effect on balance and gait ability. The analysis of the studies revealed that through PNF therapy, the alternating movement of the arms and legs are transmitted to the trunk, which intensively activates the muscle spindle. In addition, the stimulation of the proprioceptive sensation of related muscles improves the balance ability of stroke patients. The results of this study are similar to those of a previous study conducted by Lee and Hwang [20]. The effect sizes for the sub-items of balance, BBS, FRT, and TUG, were 0.50, 0.51, and 0.78, respectively. In addition, the effect sizes were statistically significant as the 95% CI did not include 0. TUG, a widely used parameter in clinical practice had a large effect size, and BBS and FRT had medium effect sizes. Similarly, DGI (0.33) and 10MWT (0.33) had medium effect sizes. Our analysis showed that irradiation, one of the fundamental principles of PNF, positively contributed to the improvement of gait ability by activating injured muscles. Irradiation promotes physical function at the irradiated site by inducing resistance [21]. PNF uses a diagonal pattern of movement, which is based on irradiation, to activate the injured areas, thereby improving gait [22].

V. Conclusion

The results of this study suggest that PNF therapy had positive effects on balance and gait ability in stroke patients. Furthermore, this study is significant in that it is the first study to attempt a quantitative and comprehensive analysis of the effects of PNF on balance and gait in stroke patients and present clinical evidence for physical therapy intervention. Therefore, the important conclusion that can be drown from these PNF therapy studies are that collectively, we try to prove the consistent evidence of the beneficial effects of PNF based therapeutic interventions in comparison with those of other rehabilitation exercises. Finally, PNF interventions may be beneficial to stroke patients, and we present the basis for the PNF therapy applied in stroke patients by analyzing the intervention and type of outcome measurement. The study results can be used as a basis for the application of PNF interventions in stroke patients in clinical settings. In order to provide concrete evidence of the effectiveness of PNF, further meta-analyses of studies that have

reported its effectiveness in various types of diseases should be conducted.

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Appendix 1. Study characteristics

No	study	Study	Group			PNF intervention			Outcome Balance Gait
		design	Experiment	Control	Type	Duration (week)	Session (count)	Length (min)	
1	Kim et al (2015)	RCT	10	10	PNF	6	30	30	BBS,TUG, FRT
2	Kim et al (2011)	RCT	20	20	PNF	6	30	30	FRT
3	Hwangbo et al (2016)	RCT	15	15	PNF	6	30	30	BBS
4	Seo et al (2015)	RCT	10	10	PNF	4	12	30	BBS,TUG, FRT
5	Seo & Kim (2015)	RCT	15	15	PNF	4	12	30	BBS,TUG, FRT
6	Kim et al (2019)	RCT	15	15	PNF	8	24	60	BBS,TUG, FRT
7	Shim et al (2020)	RCT	16	17	PNF	4	20	30	BBS
8	Kim & Kim (2018)	RCT	12	12	PNF	6	30	30	BBS,DGI
9	Lee & Hwang (2019)	RCT	15	15	PNF	6	30	30	TUG, 10MWT
10	Kim & Kim (2020)	RCT	13	10	PNF	4	20	60	BBS, 10MWT
11	Bang & Bong (2017)	RCT	6	6	PNF	4	20	30	BBS,TUG
12	Bang & Song (2019)	RCT	7	7	PNF	4	20	30	BBS
13	Kim & Lee (2014)	RCT	6	6	PNF	6	30	30	BBS
14	Lee (2017)	RCT	15	15	PNF	6	30	30	BBS,TUG
15	Kim (2010)	RCT	20	20	PNF	6	30	30	BBS,T10MWTUG, FRT
16	Song (2014)	RCT	20	20	PNF	4	12	30	BBS,TUG, 10MWT,DGI
17	Bae (2009)	RCT	8	9	PNF	4	40	30	BBS,TUG
18	Cho & Cha (2014)	RCT	15	16	PNF	6	18	20	10MWT

BBS, berg balance scale; DGI, dynamic gait scale; FRT, functional reach test; PNF, proprioceptive neuromuscular facilitation; RCT, randomized controlled trials; TUG, timed up and go test; 10MWT, 10m walking test

Appendix 2. Quality assessment(PEDro scale)

No	study	ITEM											
		1	2	3	4	5	6	7	8	9	10	11	Total
1	Kim et al (2015)	1	1	1	1	0	0	1	1	0	1	1	8
2	Kim et al (2011)	1	1	1	1	0	0	1	1	0	1	1	8
3	Hwangbo et al (2016)	1	1	1	1	0	0	1	1	1	1	1	9
4	Seo et al (2015)	1	1	0	1	0	0	0	1	0	1	1	6
5	Seo & Kim (2015)	1	1	1	1	0	0	1	1	0	1	1	8
6	Kim et al (2019)	1	1	1	1	0	0	1	0	1	1	1	8
7	Shim et al (2020)	1	1	0	1	0	0	1	1	0	1	1	7
8	Kim & Kim (2018)	1	1	0	1	0	0	1	0	0	1	1	6
9	Lee & Hwang (2019)	1	1	1	1	0	0	0	1	0	1	1	7
10	Kim & Kim (2020)	1	1	1	1	0	0	1	1	0	1	1	8
11	Bang & Bong (2017)	1	1	1	1	0	0	1	0	1	1	1	8
12	Bang & Song (2019)	1	1	0	0	0	0	0	1	0	1	1	5
13	Kim & Lee (2014)	1	1	0	1	0	0	1	1	0	1	1	7
14	Lee (2017)	1	1	0	1	0	0	1	0	0	1	1	6
15	Kim (2010)	1	1	1	0	0	0	0	0	0	1	1	5
16	Song (2014)	1	1	1	1	0	0	1	0	0	1	1	7
17	Bae (2009)	1	1	1	1	0	0	1	1	0	1	1	8
18	Cho & Cha (2014)	1	1	1	0	0	0	0	0	0	1	1	5

1,eligibility criteria; 2,random allocation; 3,concealed allocation; 4,baseline comparabilty; 5,blinded subjects; 6,blinded therapists; 7,blind assessors; 8,adequate follow-up; 9,intention to treat; 10,between group; 11,point estimators