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Application of PNF (proprioceptive neuromuscular facilitation) concept in hospitalized elderly patients in the context of independence improvement

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Abstract: Introduction: Population aging is associated with increased problems of physical and functional fitness in geriatric patients. Fitness constitutes a key element of independence and quality of life in elderly individuals. The proprioceptive neuromuscular facilitation (PNF) method is widely used in orthopedic and neurological rehabilitation; however, there is a lack of research on its comprehensive application in elderly patients in hospital settings.
Objective: To assess the impact of the PNF concept on independence in elderly individuals and to compare the effectiveness of the PNF method with general rehabilitation (GR) during a maximum 10-day hospital treatment.
Material and Methods: The study included 80 randomly selected patients over 64 years of age hospitalized in the Department of Internal Medicine and Geriatrics. Patients were randomly divided into two 40-person groups: GR and PNF. Functional fitness assessment was conducted at the beginning of rehabilitation and after a maximum of 10 days of therapy or on the day of discharge. The following were used: ADL assessment, IADL, Up & Go test, SPPB test, balance assessment, gait speed measurement, 5-times sit-to-stand test, and NRS scale.
Results: Patients rehabilitated according to the PNF concept achieved statistically significantly greater improvement in functional and physical fitness compared to the GR group.
Conclusions: The PNF method in elderly individuals allows for more effective achievement of the main goal of rehabilitation, which is reaching maximum patient independence.

Keywords: advanced age, functional fitness, physical fitness.

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Introduction

Population aging currently represents one of the most important demographic challenges. It is predicted that by 2050, the number of people over 65 years of age worldwide will increase to 1.5 billion [1]. The aging process is associated with natural deterioration of physical and functional fitness, which directly affects the quality of life and independence of elderly individuals. Physical activity constitutes a key element in preventing, delaying, and mitigating the course of neurodegenerative diseases, disability, and mental disorders [2–4]. Unfortunately, according to current statistics, less than half of the elderly population achieves an adequate level of physical activity. Risk factors such as lack of physical activity, unhealthy diet, or alcohol abuse significantly limit the chances of successful aging [5, 6]. In geriatric rehabilitation, the proprioceptive neuromuscular facilitation (PNF) method gains particular importance, finding wide application in patients with neuromuscular conduction disorders. Unlike classical therapy focusing on range of motion and muscle strength, the PNF concept treats these elements as therapeutic tools for recovering lost function. Treatment is aimed at restoring motor function lost as a result of the disease process, whereby examination, therapy, and work with the patient complement each other [7].

The contemporary therapeutic approach, in accordance with ICF and WHO assumptions, involves treating the patient not only at the structural level but also at the level of participation in daily life. In practice, this means applying the principles of motor learning and motor control to achieve maximum functional fitness [8]. Previous studies on the application of the PNF method in elderly individuals have mainly focused on selected aspects of rehabilitation. However, there is a lack of comprehensive research evaluating the impact of this method on overall functional fitness and independence of geriatric patients in hospital settings. This justifies the need to conduct research comparing the effectiveness of the PNF method with conventional general rehabilitation in hospitalized elderly individuals.

Objective

The aim of this study is to evaluate the effectiveness of applying the PNF method in improving the independence of elderly individuals hospitalized in a geriatric ward.

Material and Methods

Material

The study group consisted of 80 patients aged 65 years and older, hospitalized in the Department of Internal Medicine and Gerontology and referred for rehabilitation treatment in the ward by the attending physician. The inclusion criteria for the study were: a) absence of cognitive function disorders corresponding to dementia, b) absence of coexisting depression.

Exclusion criteria included: terminal patient condition confirmed in medical documentation, active inflammatory processes, cancer disease.

The studies were conducted from June 2017 to June 2019. Approval was obtained from the Bioethics Committee with number 1072.6120.73.2017 dated June 29, 2017.

Patients were randomly divided into two groups of 40 people each. Randomization was performed by computer where the program selected patients from the group of 80 people, of which

40 had the identifier GR (general rehabilitation) and 40 had the identifier PNF (proprioceptive neuromuscular facilitation).

Research methodology

Rehabilitation took place daily from Monday to Friday. The duration of a single therapy session for each patient was 45 minutes. The proposed physiotherapy program was individually selected depending on the patient's needs and problems.

1. Group rehabilitated using the PNF method

In this type of functional therapy, facilitation patterns for upper limbs, lower limbs, scapula, pelvis, trunk, and cervical spine were applied. Rehabilitation according to this method took place in appropriate starting positions for the patient. Attention was also paid to the therapist's body mechanics, appropriate resistance, manual contact, patterns used for facilitation, proper movement sequence, verbal and visual stimuli, to influence function improvement by providing appropriate stimuli. The method was based on the phenomenon of irradiation, thanks to which during exercises, the mechanism of redirecting force from stronger muscle groups to weaker ones was utilized. The choice of techniques or their combinations was related to the patient's condition or therapy goal. The therapy also included restoration of movement patterns, i.e., proper sitting, standing, walking, moving upper limbs using stabilizing, analgesic, relaxing techniques, as well as those teaching movement and coordination, and a program of functional exercises on a mat and walking training. The effect of this therapy is achieving new motor skills, e.g., independent use of the toilet.

2. Group subjected to general rehabilitation

Standard stretching exercises were performed, active exercises for upper limbs, lower limbs and trunk, self-assisted exercises, balance and coordination exercises. This was followed by training on a bicycle ergometer, aerobic exercises, exercises with Thera-Band, general conditioning, resistance, strength training, relaxation and breathing exercises. Position change exercises were also used, and gait re-education was conducted.

The research (rehabilitation) was always conducted by the same physiotherapist. Rehabilitation treatment took place daily for a maximum of 10 working days. For the analysis of exercise systematicity assessment, each day was recorded for each patient depending on the number of rehabilitation days, divided into groups of up to 5 days and over 5 days.

Each patient underwent an interview containing basic patient information, i.e., age, gender, information about past and current diseases, type of professional work performed, day of hospitalization in the hospital.

Before starting the intervention (before the first rehabilitation) and after its completion (maximum after 10 days of rehabilitation), functional fitness assessment was conducted based on elements of comprehensive geriatric assessment used.

Each patient underwent the following examinations:

- Height and weight measurement for body mass index (BMI) calculation
- Activities of daily living (ADL) using the Katz scale
- Instrumental activities of daily living (IADL) — using the Lawton scale
- Timed Up and Go test to assess fall risk

- Short Physical Performance Battery (SPPB) test for physical fitness assessment
- Subjective perception of fitness assessed using the NRS (Numeric Rating Scale)

The tools used are characterized below:

1. BMI (body mass index) — body mass index was assessed, which can be calculated using the formula: BMI = body weight (kg)/[height (m)]^2
2. For functional assessment, the Katz scale (ADL — Activities of Daily Living) was used, which evaluates fitness in 6 basic life activities of the patient such as: bathing, dressing, using the toilet, getting up and lying down in bed, and controlling urination and defecation. If the patient is independent in a given area, they receive 1 point, and if not — 0 points. This scale allows for distinguishing three fitness groups: 0–2 points severe disability, 3–4 points — moderate disability, 5–6 points as fitness.
3. Complex activities of daily living were assessed using the Lawton scale (IADL — Instrumental Activities of Daily Living). These activities include: performing household chores including cleaning, laundry, cooking, current repairs as well as the ability to shop, money management skills and using the telephone. With full independence, the patient receives 27 points, receiving points in the range of 10–26 points indicates moderate dependence (the patient needs partial help from other people when performing complex daily activities), while 9 and less means severe dependence (help is required for all daily activities) [9, 10].
4. "Timed Up and Go" test (TUG test) — a tool assessing two basic daily functions such as: transition from sitting to standing position as well as walking a short distance (3 meters). The test serves to assess gait and functional fitness and gives us information about fall risk. Time determines the patient's fitness; if it exceeds 14 seconds, then the fall risk is increased. Subsequent time ranges cause a gradual increase in fall risk. Time above 30 seconds suggests the need to use walking aids [11].
5. Physical fitness using the Short Physical Performance Battery (SPPB) test. This test consists of three parts that include the following assessment:
    a. Standing up from a chair and sitting down without using hands (SST — Sit-to-Stand Test). Used to assess endurance and strength of lower limbs, the subject has the task of standing up from a chair without the help of their upper limbs, which the subject has arranged and crossed on their chest. With a correctly completed single trial such as sitting and standing up from a chair, the test person performs five repetitions of this activity as quickly as possible and the total time of task completion is recorded.
    b. To assess static balance, the test person has the task of maintaining balance for 10 seconds in three different positions. The next position is adopted only if the previous one does not cause problems. The first position is standing with feet next to each other (Side-by-side), the second position in which one leg is in a forward lunge so that the side of the heel of one foot touches the big toe of the other foot (Semi Tandem Stand) and the third position with one foot positioned behind the other foot so that the heel of one foot stands in front of and touches the toes of the other foot.
    c. To assess gait speed, the test person has the task of covering a distance of four meters. Time begins to be measured from the moment the stopwatch is turned on at the "start" command, until the moment of crossing the marked four-meter line. The test is performed twice and the better time is recorded.

In each range of the SPPB test, the examiner receives from 0 to 4 points. Overall, 12 points are obtained, which gives us the best test result. The SPPB test is a reliable tool used to check physical fitness, which translates to basic daily activities [12–14].

6. Subjective perception of fitness assessed using the NRS (Numeric Rating Scale). The scale is a 10-point scale on which the patient marks their perception of fitness (point 0 worst fitness, point 10 very good fitness) [15].

Statistical analysis

Statistical calculations were performed using SPSS version 23.

Qualitative variables were presented in tables showing % (number). Quantitative variables were initially tested for normality using the Shapiro-Wilk test. If distributions were symmetric, tables presented mean and standard deviation, as well as minimum and maximum values. For distributions deviating from symmetric distribution, median was reported instead of mean, and lower (Q1) and upper quartile (Q3) along with min-max were reported instead of standard deviation.

Comparisons between two independent groups (GR vs. PNF): For qualitative variables, the chi-square test of independence or Fisher's exact test was used if the assumptions of the chi-square test were not met. For quantitative variables, the Student's t-test or its non-parametric equivalent, the Mann-Whitney U test, was used.

Comparisons between two time points (before and after rehabilitation): For qualitative variables (depending on the number of responses), the McNemar test, McNemar-Bowker test, or sign test was used. For quantitative variables, the paired Student's t-test or its non-parametric equivalent, the Wilcoxon test, was used.

For comparing distributions (improvement/no improvement/deterioration), the chi-square test was used to compare proportions.

The significance level for all tests was set at 5% ($\alpha = 0.05$), and hypothesis verification was based on two-tailed statistical tests.

Results

The study included 80 patients (30 women, 50 men). The median [Q1–Q3] age of the subjects was 79.0 [73.3–85.8] years (range: 68–94 years). The median BMI was 25.2 [22.1–29.7] kg/m^2 (range: 17.5–43.1 kg/m^2). The number of days spent in hospital ranged from 1 to 25; the median stay was 4 [2.0–5.5] days, while the number of rehabilitation days ranged between 2 and 10, with a median of 5 [4–8] days. The majority of subjects were patients who performed mental work during their professional activity period: 82% (n = 66) vs. 18% (n = 14) — physical work. One person lived in a rural area, while the rest lived in the city.

The Charlson Comorbidity Index was used to assess morbidity. Patients were asked about the occurrence of 19 different diseases: myocardial infarction (12 people), chronic heart failure, CHF (41 people), peripheral vascular disease (16 people), cerebral ischemic disease (3 people), dementia (0 people/none), chronic lung disease (9 people), connective tissue disease (4 people), peptic ulcer disease (3 people), stroke or TIA (8 people), diabetes (27 people), hemiplegia (0 people/none), moderate/severe kidney disease (19 people), diabetes with organ damage (3 people) — data presented in Fig. 1. In 10 patients, none of the above-mentioned diseases were found. In the remaining 70 patients, 1 to 8 diseases were present.

Twenty-four people had one disease, two diseases occurred in 23 people, three diseases in 13 people, four diseases in 8 people. One person had 5 diseases and one person had 8 diseases — data presented in Fig. 2 according to frequency of occurrence.

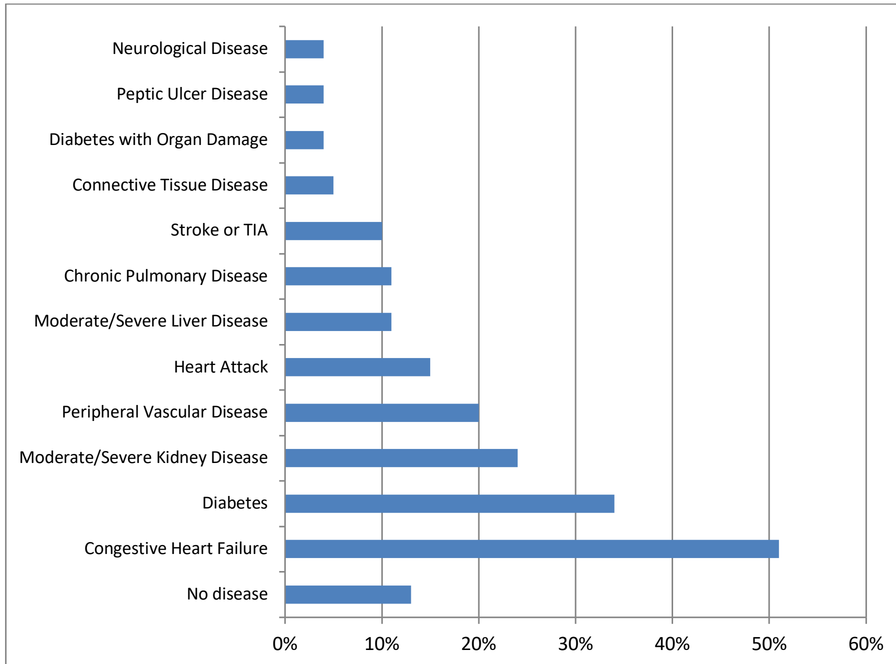

Fig. 1. Prevalence of chronic diseases in the study population.

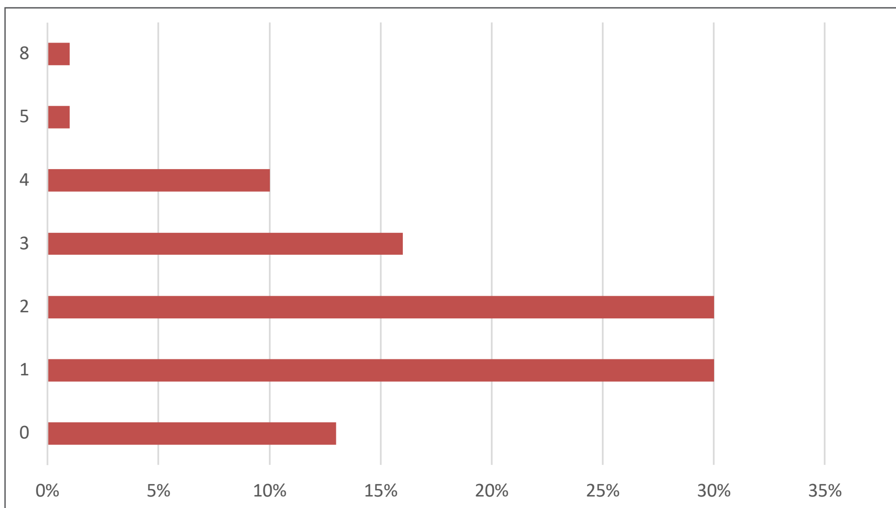

Fig. 2. Number of diseases in the study population.

Patients were randomly divided into two groups of 40 people each. One group underwent individual general conditioning physiotherapy (RO) and the other received individual therapy using the PNF method (PNF).

The studied groups do not differ statistically significantly in terms of sex, type of work, age, BMI, number of days and days of hospitalization, or number of diseases (Table 1).

Table 1. Characteristics of patients from both groups.

	RO	PNF	p
Sex Women Men	 35% (14) 65% (26)	 40% (16) 60% (24)	 0.644
Type of work Mental Physical	 82% (33) 18% (7)	 82% (33) 18% (7)	 1.000
Age, years	78.5 [72.3–85.0] 58–94	80.0 [74.0–87.0] 65–94	0.675
BMI	27.2 (22.4–31.0) 17.5–43.1	24.4 (22.1–28.1) 18.1–36.8	0.252
Days of hospitalization	4.0 (3.0–6.0) 1–25	3.0 (2.0–5.0) 1–22	0.217
Number of rehabilitation days	5.0 (3.3–9.0) 2–10	5.5 (5.0–7.8) 2–10	0.217
Number of diseases 0 1 2 3 4 5 8	 12% (5) 30% (12) 33% (13) 15% (6) 8% (3) — 2% (1)	 12% (5) 30% (12) 25% (10) 18% (7) 13% (5) 2% (1) —	 0.405

Legend: RO — general conditioning physiotherapy; PNF — proprioceptive neuromuscular facilitation; P — statistical significance level. Data presented as percentage distribution (frequency); median [Q1–Q3] and range (min-max).

Analysis of Independence in Activities of Daily Living (ADL): For point values, no differences were observed between the RO vs. PNF groups either before (medians: 5.5 (RO) vs. 5.0 (PNF), $p = 0.925$) or after rehabilitation (medians: 6.0 (RO) vs. 6.0 (PNF), $p = 0.260$). For both groups (RO and PNF), statistically significant differences were observed between results before and after rehabilitation ($p <0.001$, for both RO and PNF, Table 2). Improvement was observed in 47% (19) people in the RO group and 53% (21) people in the PNF group. Although in the PNF group 6% more people achieved improvement compared to the RO group, this difference is not statistically significant between groups ($p = 0.655$). Within each group, the percentage of improvement relative to the percentage of no improvement also does not differ statistically significantly ($p = 0.752$, for both RO and PNF, Table 3).

Table 2. Results of tests before and after rehabilitation.

	RO			PNF		
	before	after	p	before	after	p
ADL (degree of disability)						
Score	5.5 (4.0–6.0) 2–6	6.0 (5.0–6.0) 3–6	<0.001	5.0 (3.3–6.0) 0–6	6.0 (5.0–6.0) 3–6	<0.001
severe (0–2) moderate (3–4) functional (5–6)	10% (4) 27% (11) 63% (25)	— 12% (5) 88% (35)	<0.001	12% (5) 35% (14) 53% (21)	— 2% (1) 98% (39)	<0.001
IADL						
Score	15.0 (13.0–18.0) 8–23	18.0 (15.3–20.0) 10–23	<0.001	14.5 (13.0–16.0) 10–21	19.0 (17.3–21.0) 11–24	<0.001
SPPB Sit-to-stand						
Not performed Performed	42% (17) 58% (23)	18% (7) 82% (33)	0.004	58% (23) 42% (17)	5% (2) 95% (38)	<0.001
>60 s ≥16.7 s <60 s 16.69–13.7 s 11.2–13.69 s ≤11.19 s	43% (17) 45% (18) 2% (1) 10% (4) —	18% (7) 63% (25) 10% (4) 10% (4) —	0.005	58% (23) 25% (10) 12% (5) — 5% (2)	5% (2) 30% (12) 40% (16) 20% (8) 5% (2)	<0.001
Static balance assessment						
Standing with feet side by side						
Did not attempt Below 10 s Maintains 10 s	15% (6) 5% (2) 80% (32)	— 5% (2) 95% (38)	0.010	15% (6) 18% (7) 67% (27)	— — 100%(40)	0.001
Standing in semi-tandem position						
Did not attempt Not for 10 s Maintains 10 s	20% (8) 53% (21) 27% (11)	8% (3) 27% (11) 65% (26)	<0.001	55% (22) 30% (12) 15% (6)	— 20% (8) 80% (32)	<0.001
Standing in tandem position						
Did not attempt Maintains <3 s Maintains 3–9.99 s Maintains for 10 s	52% (21) 20% (8) 20% (8) 8% (3)	18% (7) 28% (11) 35% (14) 20% (8)	<0.001	78% (31) 12% (5) 10% (4) —	8% (3) 10% (4) 47% (19) 35% (14)	<0.001
Total balance test score						
0 1 2 3 4	20% (8) 45% (18) 15% (6) 13% (5) 7% (3)	5% (2) 22% (9) 25% (10) 28% (11) 20% (8)		32% (13) 50% (20) 10% (4) 7% (3) —	— 5% (2) 28% (11) 32% (13) 35% (14)	

Table 2. Cont.

	RO			PNF		
	before	after	p	before	after	p
Walking speed test						
Result in seconds	7.50 (5.36–9.54) 2.95–21.43	7.28 (5.31–8.55) 3.41–18.10	0.001	8.55 (7.22–10.09) 3.73–15.34	7.09 (5.80–7.91) 3.29–16.01	<0.001
Did not perform >8.7 s 6.21–8.7 s 4.82–6.20 s <4.82 s	23% (9) 30% (12) 25% (10) 12% (5) 10% (4)	5% (2) 28% (11) 43% (17) 10% (4) 15% (6)	0.003	30% (12) 30% (12) 25% (10) 8% (3) 8% (3)	— 13% (5) 62% (25) 17% (7) 8% (3)	<0.001
Timed Up and Go test						
Result in seconds	15.32 (11.52–18.38) 7.34–30.01	13.35 (10.96–17.01) 6.59–24.99	<0.001	15.95 (11.55–21.44) 7.43–28.20	10.82 (9.47–15.05) 6.51–24.25	<0.001
Did not perform <10 s 10–19 s ≥19 s	25% (10) 8% (3) 52% (21) 15% (6)	5% (2) 12% (5) 75% (30) 8% (3)	0.035	30% (12) 8% (3) 45% (18) 17% (7)	— 23% (9) 72% (29) 5% (2)	0.025
Subjective sense of agency (NRS scale)						
1 2 3 4 5 6 7 8 9	2% (1) 10% (4) 10% (4) 30% (12) 38% (15) 10% (4) — — —	— — — 12% (5) 15% (6) 45% (18) 20% (8) 8% (3) —	<0.001	10% (4) 8% (3) 27% (11) 12% (5) 27% (11) 10% (4) 5% (2) — —	— — — 8% (3) 5% (2) 20% (8) 32% (13) 12% (5) 23% (9)	<0.001
Weak (1–3) Moderate (4–6) Good (7–10)	22% (9) 73% (31) —	— 73% (29) 27% (11)	<0.001	45% (18) 50% (20) 5% (2)	— 32% (13) 68% (27)	<0.001

Table 3. Change between the results before and after rehabilitation for all analysed tests.

		Improvement	No improvement (change)	Deterioration	p
ADL Score	RO	47% (19)	53% (21)	—	0.752
	PNF	53% (21)	47% (19)	—	0.752
ADL Three-level fitness score	RO	33% (13)	67% (27)	—	0.027
	PNF	47% (19)	53% (21)	—	0.752
IADL Score	RO	80% (31)	18% (7)	2% (1)	<0.001
	PNF	98% (39)	2% (1)	—	<0.001

Table 3. Cont.

		Improvement	No improvement (change)	Deterioration	p
SPPB Sit-to-stand Performance	RO	28% (11)	70% (28)	2% (1)	<0.001
	PNF	53% (21)	47% (19)	—	0.752
SPPB Sit-to-stand 5 ranges of execution time	RO	33% (13)	62% (25)	5% (2)	<0.001
	PNF	78% (31)	22% (9)	—	<0.001
Standing with feet together	RO	20% (8)	80% (32)	—	<0.001
	PNF	33% (13)	67% (27)	—	0.027
Standing in a semi-tandem position	RO	47% (19)	53% (21)	—	0.752
	PNF	80% (32)	20% (8)	—	<0.001
Standing in a tandem position	RO	60% (24)	40% (16)	—	0.263
	PNF	92% (37)	8% (3)	—	<0.001
Walking Speed Test None and 4 time ranges	RO	42% (17)	53% (21)	5% (2)	0.409
	PNF	58% (23)	42% (17)	—	0.429
Get up and go test None and 3 time ranges	RO	23% (9)	62% (25)	15% (6)	<0.001
	PNF	30% (12)	42% (17)	28% (11)	0.018
NRS scale Score	RO	95% (38)	6% (2)	—	<0.001
	PNF	98% (39)	2% (1)	—	<0.001
NRS scale The result of 3 levels of efficiency	RO	50% (20)	50% (20)	—	1
	PNF	90% (36)	10% (4)	—	<0.001

For the three degrees of functional capacity, no differences were observed between the RO vs. PNF groups either before (p = 0.721) or after rehabilitation (p = 0.201). For both groups (RO and PNF), statistically significant differences in the degree of disability were observed before and after rehabilitation (p <0.001, for both RO and PNF, Table 2). Improvement was observed in 33% (13) people in the RO group and 47% (19) people in the PNF group. Although in the PNF group 14% more people achieved improvement compared to the RO group, this difference is not statistically significant between groups (p = 0.171). For the RO group, the percentage of people with improvement differed significantly (was smaller) from the percentage of people without improvement (33% vs. 67%, p = 0.027, Table 3), while in the PNF group the percentages of improvement and lack of improvement did not differ significantly (47% vs. 53%, p = 0.725, Table 3).

Analysis of Independence in Instrumental Activities of Daily Living (IADL): For point values between the RO vs. PNF groups before rehabilitation, no statistically significant differences were observed (medians: 15.0 (RO) vs. 14.5 (PNF), p = 0.340). After rehabilitation, the median for PNF was statistically significantly greater than the median in the RO group (medians: 18.0 (RO) vs. 19.0 (PNF), p = 0.045). For both groups (RO and PNF), statistically significant differences for IADL were observed before and after testing (p <0.001, for both RO and PNF, Table 2). Differences calculated separately for RO (median: 2; Q1:1; Q3:3; min;max: –2;7) and for PNF (median: 4; Q1:3; Q3:5; min;max: 0;10) were statistically significant between groups (p <0.001).

In the RO group, 80% (31) achieved improvement, 18% (7) showed no improvement, and in one person (2%) deterioration occurred — these percentages differ significantly (p <0.001 Table 3).

In the PNF group, 98% (39) achieved improvement and in 1 person (2%) no change was observed — these percentages differ significantly (p <0.001, Table 3). Percentage distributions of changes differ between groups (p = 0.029) both for improvement (80% RO vs. 98% PNF) and lack of improvement (18% RO vs. 2% PNF). In the PNF group, more patients achieved improvement.

Analysis of Lower Limb Function Using the Sit-to-Stand Test: For comparison of the number of people who performed and did not perform the task, no statistically significant differences were noted between the RO vs. PNF groups either before (percentage of people who performed the task: 58% (RO) vs. 42% (PNF), p = 0.263) or after rehabilitation (percentage of people who performed the task: 82% (RO) vs. 95% (PNF), p = 0.154). For both groups (RO and PNF), statistically significant differences were observed before and after rehabilitation (p = 0.004 (RO) and p <0.001 (PNF), Table 2).

In the RO group, 28% (11) achieved improvement, 70% (28) showed no improvement, and in one person (2%) deterioration occurred — these percentages differ significantly (p <0.001, Table 3). In the PNF group, 53% (21) achieved improvement and in 19 people (47%) no change was observed — these percentages do not differ significantly (p = 0.752, Table 3). Percentage distributions of changes differ between groups (p = 0.038) both for improvement (28% RO vs. 53% PNF) and lack of improvement (70% RO vs. 47% PNF). In the PNF group, more patients achieved improvement.

For the 5 time ranges of the Sit-to-Stand test, statistically significant differences were observed between patients in the RO and PNF groups even before rehabilitation (p = 0.012). Almost half of these patients (45%) achieved a time in the range ≥16.7 seconds <60 s, while in the PNF group this was 25% of patients. It could be stated that patients in the PNF group had initially "better time," but also more people who did not perform the task. After rehabilitation, differences between groups were also observed in favor of PNF (p = 0.001). For both groups (RO and PNF), statistically significant differences were observed before and after rehabilitation (p = 0.005 (RO) and p <0.001 (PNF), Table 2). In the RO group, improvement was observed in 33% (13), no change in 62% (25), and in one person (2%) deterioration occurred — these percentages differ significantly p <0.001. In the PNF group, 78% (31) achieved improvement and in 22% (9) people no change was observed — these percentages differ significantly p <0.001 (Table 3). Percentage distributions of changes differ between groups (p <0.001) both in the percentage of improvement (33% RO vs. 78% PNF) and lack of improvement (62% RO vs. 22% PNF). In the PNF group, more patients achieved improvement.

Static Balance Assessment (Standing with Feet Side by Side): No statistically significant differences between the RO vs. PNF groups either before (p = 0.250) or after rehabilitation (p = 0.494). For both groups (RO and PNF), statistically significant differences were observed before and after rehabilitation (p = 0.010 (RO) and p <0.001 (PNF), Table 2). Improvement was observed in 20% (8) people in the RO group and 33% (13) people in the PNF group. Although in the PNF group 13% more people achieved improvement compared to the RO group, this difference is not statistically significant between groups (p = 0.310). Within each group, the percentage of improvement relative to the percentage of no improvement differs statistically significantly (20% vs. 80%, p <0.001 for RO, and 33% vs. 67% p = 0.027 for PNF, Table 3).

Static Balance Assessment (Standing in Semi-Tandem Position): Already before rehabilitation, there was a clear, statistically significant difference between the RO and PNF groups (p = 0.005). This was related to the fact that in the RO group 20% did not try, and 53% did not maintain the position for 10 s, while in the PNF group the percentages were reversed — 55% did not try, and 30% did not maintain the position for 10 s. After rehabilitation, the percentages of possible results were statistically similar between groups (p = 0.155). Improvement was observed in 47% (19) people in the RO group and 80% (32) people in the PNF group. These differences — between change distributions are statistically

significant (p = 0.005). For PNF, the percentage of improvement relative to the percentage of no improvement differs statistically significantly (80% vs. 20%, p <0.001, Table 3). For RO, the percentage of improvement relative to the percentage of no improvement does not differ statistically significantly (47% vs. 57% p = 0.752, Table 3) — this could be influenced by baseline differences between groups.

Static Balance Assessment (Standing in Tandem Position): No statistically significant differences were observed (borderline significance 0.5< p <0.1) between the RO vs. PNF groups either before (p = 0.076) or after rehabilitation (p = 0.065). Differences for pre-results were related to percentages of people who did not try — there were more of them in the PNF group (78% vs. 52%). For post-rehabilitation results, the largest differences were in responses: maintaining position for <3 s (28% RO vs. 10% PNF). For both groups (RO and PNF), statistically significant differences were observed before and after rehabilitation (p <0.001 for both groups, Table 2). Improvement was observed in 60% (24) people in the RO group and 92% (37) people in the PNF group. These differences — between change distributions are statistically significant (p = 0.001). For PNF, the percentage of improvement relative to the percentage of no improvement differs statistically significantly (92% vs. 8%, p <0.001, Table 3). For RO, the percentage of improvement relative to the percentage of no improvement does not differ statistically significantly (60% vs. 40% p = 0.263, Table 3). In the PNF group, more patients achieved improvement.

Static Balance Assessment (Total Balance Test Score): For the point score, no statistically significant differences were noted between the RO vs. PNF groups either before (p = 0.320) or after rehabilitation (p = 0.075, borderline p). For both groups (RO and PNF), statistically significant differences were observed before and after rehabilitation (p <0.001, for both RO and PNF, Table 2). Improvement was observed in 65% (26) people in the RO group and 95% (38) people in the PNF group. These differences — between change distributions are statistically significant (p = 0.001). For PNF, the percentage of improvement relative to the percentage of no improvement differs statistically significantly (95% vs. 5%, p <0.001, Table 3). For RO, the percentage of improvement relative to the percentage of no improvement does not differ statistically significantly, although p is borderline (65% vs. 35% p = 0.082, Table 3). In the PNF group, more patients achieved improvement.

Gait Speed Test Assessment: For the result measured in seconds, no statistically significant differences were noted between the RO vs. PNF groups either before (medians: 7.50 (RO) vs. 8.55 (PNF), p = 0.351) or after rehabilitation (medians: 7.28 (RO) vs. 7.09 (PNF), p = 0.472). For both groups (RO and PNF), statistically significant improvement in time was observed before and after rehabilitation (p = 0.001 (RO) and p <0.001 (PNF), Table 2). Differences calculated separately for RO (median: –0.82; Q1:–1.1; Q3:–0.13; min;max: –4.43;3.34) and for PNF (median: –0.95; Q1:–1.86; Q3:–0.36; min;max: –6.09;0.67) were also not statistically significant between groups (p = 0.104).

For results presented as test non-completion and 4 execution time ranges: In the RO group, 42% (17) achieved improvement, 53% (21) showed no improvement, and in two people (5%) deterioration occurred — these percentages do not differ significantly (p = 0.409, Table 3). In the PNF group, 58% (23) achieved improvement and in 42% (17) no change was observed — these percentages do not differ significantly (p = 0.429, Table 3). Percentage distributions of changes also do not differ between groups (p = 0.237).

Timed Up and Go Test Assessment: For the result measured in seconds, no statistically significant differences were noted between the RO vs. PNF groups either before (medians: 15.32 (RO) vs. 15.95 (PNF), p = 0.635) or after rehabilitation (medians: 13.35 (RO) vs. 10.82 (PNF), p = 0.117). For both groups (RO and PNF), statistically significant improvement in time was observed before and after rehabilitation (both p <0.001, Table 2). Differences calculated separately for RO

(median: –1.42; Q1:–2.99; Q3:–0.49, min;max: –5.02;6.40) and for PNF (median: –3.26; Q1:–5.31; Q3:–1.02; min;max: –15.45;0.42) were statistically significant between groups ($p = 0.024$).

For results presented as test non-completion and 3 execution time ranges: In the RO group, 23% (9) achieved improvement, 62% (25) showed no improvement, and in six people (15%) deterioration occurred — these percentages differ significantly ($p < 0.001$ Table 3). In the PNF group, 30% (12) achieved improvement, 42% (17) showed no improvement, and in eleven people (28%) deterioration occurred — these percentages differ significantly ($p = 0.018$ Table 3). Percentage distributions of changes do not differ between groups ($p = 0.194$).

Subjective Functional Capacity Assessment (NRS Scale): For the NRS numerical scale before rehabilitation, no statistically significant differences were noted between groups, although p was borderline ($p = 0.097$). After rehabilitation, differences between groups were statistically significant ($p = 0.002$). Response range before rehabilitation varied between 1 and 7 (allowable values are 0–10), and after rehabilitation between 4–9 — patient assessment increased slightly. For both groups (RO and PNF), statistically significant differences were observed before and after rehabilitation ($p < 0.001$ for both groups, Table 2). Differences calculated separately for RO (median: 2; Q1:1; Q3:2; min;max: –0;3) and for PNF (median: 3; Q1:3; Q3:4; min;max: 0;5) were statistically significant between groups ($p < 0.001$). Improvement was observed in 95% (38) people in the RO group and 98% (39) people in the PNF group; this difference is not statistically significant ($p = 0.998$). Within each group, the percentage of improvement relative to the percentage of no improvement differs statistically significantly ($p < 0.001$, for both RO and PNF, Table 3).

For the three degrees of functional capacity, statistically significant differences were observed between groups (RO vs. PNF) both before ($p = 0.024$) and after rehabilitation ($p = 0.001$). Before rehabilitation, the RO group had significantly fewer people with poor assessment (1–3) compared to the PNF group (22% vs. 45%), while in the moderate group (4–6) there were significantly more people in the RO group compared to PNF (73% vs. 50%). In the RO group, 50% (20) achieved improvement, and the same number showed no improvement — these percentages do not differ significantly ($p = 1$, Table 3). In the PNF group, 90% (36) achieved improvement and in 4 people (10%) no change was observed — these percentages differ significantly ($p < 0.001$, Table 3). Percentage distributions of changes differ between groups ($p = 0.024$). In the PNF group, more patients achieved improvement, but the significance of this result may be influenced by differences between initial distributions between RO and PNF.

Conclusions

After conducting the study, it was found that:

- Effectiveness of the PNF method compared to general rehabilitation (RO)
  Patients rehabilitated according to the PNF concept in hospital conditions achieved statistically significantly greater improvement in functional efficiency compared to the group treated with general rehabilitation. In none of the functional tests used did RO physiotherapy bring better results than the PNF method. The PNF method in older people allows for more effective implementation of the main goal of rehabilitation, which is to achieve the greatest possible independence of the patient.
- Impact of the duration of rehabilitation on its effectiveness
  The number of days of rehabilitation significantly affects the improvement of the efficiency of a hospitalized patient. Comparing the groups with rehabilitation lasting up to 5 days and

5 days or more, better results were observed in the group with a longer therapy time, both in the PNF and RO methods. Each additional day of physiotherapy increases the chance of improving the efficiency of the patients.

- Importance of early rehabilitation
  It is important to include the rehabilitation program in the treatment process as early as possible, if there are no significant medical contraindications. This is particularly important in the case of hospitalization lasting from a few to a dozen or so days.
- General benefits of hospital rehabilitation
- Rehabilitation in a hospital setting brings beneficial effects in terms of improving functioning in everyday life. After completing therapy, patients treated with both the PNF method and general rehabilitation showed improved results compared to the state before the start of therapy, with the PNF group achieving better results.

Discussion

Rehabilitation of elderly people encounters numerous limitations, including comorbidities, cognitive impairment, and caregiver dependence, which significantly affect cooperation with the physiotherapist. The age-related deterioration in ability to maintain independence requires various forms of assistance and care. The contemporary standard of care for elderly patients is comprehensive geriatric assessment, which proves essential in creating an individualized rehabilitation program [16, 17].

The proprioceptive neuromuscular facilitation (PNF) method represents a neurodevelopmental concept whose essence is restoring proper movement patterns and teaching correct reactions. For the patient, the ability to undertake life activities such as independent dressing, eating, or personal hygiene is crucial [18]. Studies by Kałużny *et al.* showed that PNF is the most effective rehabilitation method in patients after ischemic brain stroke. Similar results were obtained by Kaniewski *et al.*, who proved greater improvement in muscle strength, muscle tone, and daily life functioning in patients rehabilitated with the PNF method [19, 20]. British studies conducted among 5,100 physiotherapists showed that 61% of respondents consider PNF to be appropriate clinical practice [21].

Proprioceptive exercises significantly increase balance through modulation of body balancing. Exercise programs aimed at improving balance in elderly people must include coordination and proprioceptive activities [22, 23]. The motor learning process in PNF therapy focuses on recovering lost motor function through the use of tactile, visual, and auditory stimuli [24, 25].

Studies comparing PNF with the Pilates method in elderly women showed that both methods improved balance parameters, however PNF showed greater reduction in center of pressure sway [26]. Kofotolis and Kellis proved that four weeks of PNF exercises significantly increases lumbar spine range of motion and reduces lower back pain symptoms [27].

Physical activity constitutes the most important factor in "successful aging," and its low level affects reduced functional capacity [28]. A study of 30 elderly people with fall experience showed that a 4-week PNF program significantly improved gait speed and step length compared to general exercises [29]. Studies in obese elderly women showed that PNF exercises more effectively improve physical functions and blood lipid levels than elastic band exercises [30]. Gait training on an obstacle course using PNF improved dynamic balance ability in stroke patients [31].

In patients after hip joint arthroplasty, two weeks of intensive PNF therapy positively affected joint mobility, muscle strength, gait pattern, and pain reduction [32]. Proprioceptive

neuromuscular facilitation focuses on proprioception and joint mechanics, enabling movement similar to natural movement.

PNF concept therapy, through its diversity, allows for individual work with the patient, taking into account functional status and disease stage. The multi-aspect approach emphasizes the essence of motor control as a determinant of optimal function restoration [33].

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Conflict of interest

None declared.

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