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RESEARCH ARTICLE

ACUTE EFFECTS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION COMPARED TO ACTIVE RANGE OF MOTION EXERCISES ON RESPIRATORY AND HEMODYNAMIC RESPONSES IN CRITICALLY ILL PATIENTS: A PILOT STUDY

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ABSTRACT

Background and Purpose: Proprioceptive Neuromuscular Facilitation (PNF) is a widely used rehabilitation approach. However, limited studies examine the effect of PNF in a critical care setting. We aimed to investigate the acute effects of PNF-based exercises compared to active range of motion (ROM) exercises on respiratory and hemodynamic responses in critically ill patients.
Methods: Twenty-one spontaneously breathing non-intubated critically ill patients were randomly assigned to either PNF-based (n=10) or active ROM exercise group (n=11). Respiratory rate (RR; breath/min), peripheral oxygen saturation (SpO_2; %), heart rate (HR; beat/min), systolic blood pressure (SBP; mmHg), diastolic blood pressure (DBP; mmHg) and mean blood pressure (MBP; mmHg) were measured using bedside monitoring system. The dyspnea severity and perceived exertion of patients were evaluated using the 0-10 numeric rating scale. Data was recorded before, immediately after, and 5 minutes after each exercise session.
Results: There were no clinically significant differences between groups in RR (breath/min), SpO_2 (%), HR (beat/min), SBP (mmHg), DBP (mmHg), and MBP (mmHg), the severity of dyspnea and perceived exertion (P>0.05).
Conclusion: In the treatment of spontaneously breathing non-intubated patients, PNF technique can be applied safely in terms of respiratory and hemodynamic responses, similar to active ROM exercises.

Keywords: Critically ill patients, Proprioceptive Neuromuscular Facilitation, Physiotherapy

INTRODUCTION

Critical illness survivors and disability-adjusted life-years are increasing, though the mortality rates for critical illness have reduced in the last 20 years (1, 2). Critically ill patients are frequently exposed to physical, mental and cognitive intensive care unit-related consequences, especially because of prolonged immobilization (3). Current studies have indicated that skeletal muscle weakness is one of the most common clinical manifestation (4). Its development is significantly associated with delayed functional recovery and reduced health-related quality of life in a longer-term perspective (5). Consequently, there are common impaired functional status and reduction quality of life (6).

Physical therapy is an integral part of a multidisciplinary approach in intensive care units. To prevent functional impairment and enhance recovery, initiating early mobilization and rehabilitation is highly recommended as soon as the vital status of patient has been stabilized (7). Emerging evidence has demonstrated that early mobilization was effective to prevent the intensive care unit-acquired weakness, improve muscle strength, physical function, and decrease the length of stay (8). Standardized early mobilization activities include sitting, transfers, standing and ambulation, as well as bed mobility exercise such as range of motion (ROM) exercises (9). Research has proven that all these activities are well tolerated in critically ill patients (10-12).

Proprioceptive Neuromuscular Facilitation (PNF) has gained considerable interest in the field of patients with neurological and musculoskeletal disorders, with safety and efficacy (13-15). PNF, which was originally developed by Kabat, is a widely used physiotherapy approach in rehabilitation (16). The primary aims of PNF are to improve neuromuscular control and function through optimal resistance, irradiation, tactile stimulation, body position and mechanics, verbal command, visual stimuli, approximation, stretch, timing and movement patterns. It is based on functional and diagonal movements conducted in daily activities. PNF imposes, both physically and mentally, awareness of individual during the performed movement (17).

A common condition in critically ill patients may face a respiratory problem resulting from instability of the respiratory system (18). A recent systematic review conducted by Mankad reported that PNF techniques of respiration play an effective role in improving hemodynamic and respiratory function for mechanically ventilated patients (19). Alternatively, limb muscle proprioceptive play an important role in respiratory activity (20). To date, we have found only several study that applied PNF-based physiotherapy for upper and lower extremities in mechanically ventilated critically ill adults (21-23); however, the impact and safety of the PNF technique in critical illness are still unexplored. In addition, there is a clinical concern that the PNF technique may cause cardiovascular overload, as its close-to-maximal loads and isometric contractions may lead to hemodynamic differences with increasing in blood pressure during exercise (24, 25). This is particularly important for older individuals due to increased vascular resistance with aging (26). Given those individuals being admitted to intensive care unit, we aimed to investigate the acute changes promoted by PNF-based exercises compared to active ROM exercises on respiratory and hemodynamic responses in spontaneously breathing non-intubated critically ill patients.

MATERIALS AND METHODS

The present prospective randomized controlled trial was performed in a 14-bed Anesthesia Intensive Care Unit of Dokuz Eylul University Medical Faculty Hospital, Izmir, Turkey between April 2018 and January 2020.

The study was approved by Dokuz Eylul University Non-Interventional Research Ethics Committee (Date: 15.06.2017, Decision No: 2017/16-16) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from participants.

Subjects

A convenience sample of 21 critically ill patients were enrolled in this study. Inclusion criteria were extubated for at least 24 hours, the ability to perform at least 3 of the following Standardized Five Questions for awakening and comprehension of patients: (1) Open (close) your eyes, (2) Look at me, (3) Open your mouth and put out your tongue, (4) Nod your head, and (5) Raise your eyebrows when I have counted up to 5 (27), and the patients receiving 0 (zero) score from Richmond Agitation and Sedation Scale (28). Exclusion criteria were having subarachnoid hemorrhage, neuromuscular disease, fractures of the upper or lower extremities, cardiorespiratory disease influencing rehabilitation management, hemodynamic instability (heart rate < 40 beats/min and > 130 beats/min, mean blood pressure < 60 mmHg and > 110 mmHg, oxygen saturation ≤ 90%, respiratory rate > 40 breath/min, temperature ≤ 36ºC and ≥ 38.5ºC) (12).

Study protocol

Patients were randomly assigned to each of two treatment groups using sealed opaque envelopes just

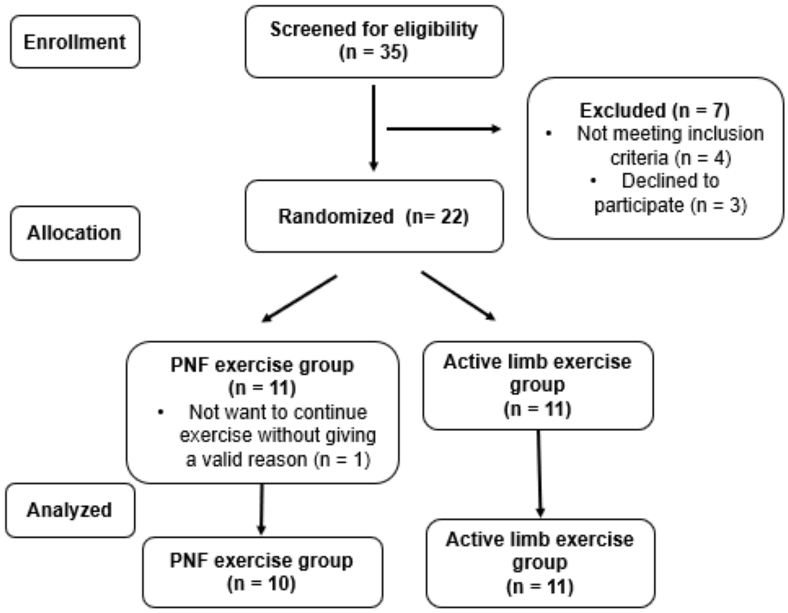

Figure 1. Flow diagram of patients

before the treatment. Two sequentially numbered envelopes were prepared for allocating the participants either to the PNF-based exercise group, or the active ROM exercise group. An envelope was opened by an intensive care nurse who was blinded to our study. According to the group assignment, treatment proceeded.

All treatments and assessments were made by the same physiotherapist, who had 2 years of experience in intensive care unit. Participants received 30-min physiotherapy session.

PNF-based exercise

The PNF-based exercises included dynamic reversal techniques of PNF. It combined the active resisted and concentric contractions of muscle groups. This technique aims to improve the active control of motion, coordination, muscle strength and endurance of upper and lower extremities in diagonal and spiral directions, and to prevent or reduce fatigue (17).

The exercises were applied bilaterally to the patients positioned supine with a 30-degree head tilt in the four patterns: flexion – abduction – external rotation into extension – adduction – internal rotation and the extension – abduction – internal rotation into flexion – adduction – external rotation for the arm diagonal patterns; flexion – adduction – external rotation with knee extension into extension – abduction – internal rotation with knee extension and extension – adduction – external rotation with knee extension into flexion – abduction – internal rotation with knee extension for the leg diagonal patterns. Each pattern was performed in the three phases: (1) the extremity was placed passively in a starting position following a stretch stimulus in an elongated position, (2) moving actively through the desired motion against optimal resistance, (3) moving back to opposite direction against optimal resistance without relaxation after the end of the desired motion. The optimal resistance, is applied with the intensity of resistance that does not interfere with conducting the pattern and overcoming of the patient, was provided by the physiotherapist (17). Each pattern was repeated 10-12 repetitions, with rest intervals of 30 s between repetitions.

Active range of motion exercises

The exercise protocol consisted of flexion, extension, abduction, adduction, internal and external rotations range of motion for all upper and lower extremity joints. These exercises aimed at promoting skeletal muscle function and control (29). Each movement was applied 10-12 repetitions, with a 30 s rest between repetitions in the supine position with the head of the bed elevated by a 30-degree angle.

Outcome measures

Respiratory and hemodynamic responses were obtained from bedside monitoring systems (Samsung SyncMaster 710v). Respiratory responses included respiratory frequency (RF; breath/min) and peripheral oxygen saturation (SpO_2; %) measurements. For hemodynamic evaluation, heart rate (HR; beat/min),

Table 1. Sociodemographic and health profile of patients

	PNF-based exercise group (n = 10)	Active ROM exercise group (n = 11)	*P**
Age (years)	64.30 ± 15.63	73.73 ± 12.32	0.139
Gender (n, %)†			
Female	5 (50.0)	5 (45.5)	1.000
Male	5 (50.0)	6 (54.6)	
Body mass index (kg/m²)	26.68 ± 5.27	27.46 ± 4.40	0.719
GCS (score)	14.90 ± 0.31	15.00 ± 0.00	0.343
Oxygen support (n, %)†			
High flow oxygen therapy	2 (20.0)	0	0,047
Nasal cannula	6 (60.0)	3 (27.3)	
Oxymask	2 (20.0)	4 (36.4)	
No support (breathing room air)	0	4 (36.4)	
ICU length of stay (days)	7.00 ± 4.39	5.09 ± 1.86	0.227

*Independent t-test
†Chi-square test
GCS: Glasgow Coma Scale; ICU: Intensive Care Unit

systolic blood pressure (SBP; mmHg), diastolic blood pressure (DBP; mmHg) and mean blood pressure (MBP; mmHg) was used.

The patient's severity of dyspnea and perceived exertion were measured through the numeric rating scale (30). The scale consists of 0 (no shortness of breath or exertion) and 10 (worst shortness of breath or extreme exertion) numerical sequence.

Outcomes were recorded at pre-treatment, the end of treatment and at a five-minute follow-up (recovery).

Statistical analysis

The statistical analyses were carried out using the statistical package for social sciences (SPSS) software. The Shapiro-Wilk test was employed to confirm data-distribution normality. Independent t-tests and chi-square tests were used for comparison of sociodemographic and health profile between groups. Repeated-measures ANOVA was performed to evaluate the effects of PNF-based exercises and active ROM exercises on respiratory and hemodynamic responses by time (before, immediately after, and recovery) as the within-subjects effect and group (PNF group or active ROM exercise group) as the between-subjects effect. *P*-value were accepted less than 0.05 for statistical significance.

RESULTS

Of 35 spontaneously breathing non-intubated critically ill patients admitted to the intensive care unit, 21 subjects participated: PNF-based exercise group (n = 10) and active ROM exercise group (n = 11). The flow diagram of patients is shown in Figure 1.

Sociodemographic and health profiles of patients are summarized in Table 1. There were no differences between PNF-based exercise and active ROM exercise groups concerning length of intensive care unit stay and ventilatory support ($P > 0.05$).

No significant changes in RR (breath/min), SpO_2 (%), HR (beat/min), SBP (mmHg), DBP (mmHg), MBP (mmHg), the severity of dyspnea (score) and perceived exertion (score) in spontaneously breathing non-intubated patients treated with PNF-based exercises compared to active ROM exercises (Table 2, $P > 0.05$).

DISCUSSION

To the best of our knowledge, this is the first study investigating the acute effects of PNF technique on respiratory and hemodynamic responses in intensive care units. We found that the PNF-based exercises and active ROM exercises observed similar changes in respiratory and hemodynamic variables of spontaneously breathing non-intubated critically ill patients. None of the severity of dyspnea and perceived exertion changes was also statistically significant. Our results indicated that PNF-based exercises could be all well-tolerated in awake and spontaneously breathing non-intubated patients when compared to active ROM exercises.

Physical rehabilitation is one of the cornerstones for critical illness management. It is becoming more widely recognized that physical-based rehabilitation interventions improve the pulmonary and muscular function of critically ill patients, as well as functional independence. Active mobilization including ROM exercises is recommended safely in international guidelines (31).

Table 2. Changes in respiratory and hemodynamic responses at before, immediately after, and recovery of exercise session

		Intervention groups		Repeated-measures ANOVA		
		PNF-based exercise group (n = 10)	**Active ROM exercise group (n = 11)**	**Group effect**	**Time effect**	**Interaction effect**
Respiratory frequency (breath/min)	Before	23.80 ± 3.96	21.36 ± 5.44	F = 0.303	F = 1.119	F = 2.652
	Immediately after	23.30 ± 5.53	24.18 ± 6.43	P = 0.588	P = 0.326	P = 0.099
	Recovery	24.10 ± 3.90	22.18 ± 5.41	$\eta p^2 = 0.016$	$\eta p^2 = 0.056$	$\eta p^2 = 0.122$
Peripheral oxygen saturation (%)	Before	98.30 ± 1.94	97.54 ± 2.97	F = 0.693	F = 0.544	F = 0.127
	Immediately after	98.20 ± 1.39	97.27 ± 3.16	P = 0.415	P = 0.585	P = 0.881
	Recovery	98.40 ± 1.34	97.45 ± 3.01	$\eta p^2 = 0.035$	$\eta p^2 = 0.028$	$\eta p^2 = 0.007$
Heart rate (beat/min)	Before	85.20 ± 17.69	89.00 ± 22.44	F = 0.035	F = 0.698	F = 1.564
	Immediately after	86.60 ± 16.93	88.09 ± 18.69	P = 0.853	P = 0.504	P = 0.222
	Recovery	86.30 ± 17.32	85.54 ± 18.28	$\eta p^2 = 0.002$	$\eta p^2 = 0.035$	$\eta p^2 = 0.076$
Systolic blood pressure (mmHg)	Before	121.60 ± 19.53	124.90 ± 25.33	F = 0.130	F = 0.481	F = 0.006
	Immediately after	121.40 ± 18.93	124.81 ± 22.44	P = 0.722	P = 0.622	P = 0.994
	Recovery	119. 80 ± 16.27	122.72 ± 22.88	$\eta p^2 = 0.007$	$\eta p^2 = 0.025$	$\eta p^2 = 0.000$
Diastolic blood pressure (mmHg)	Before	64.20 ± 7.59	62.54 ± 13.14	F = 0.022	F = 0.736	F = 1.569
	Immediately after	62.50 ± 10.40	64.09 ± 15.46	P = 0.883	P = 0.486	P = 0.221
	Recovery	63.40 ± 10.53	65.81 ± 15.17	$\eta p^2 = 0.001$	$\eta p^2 = 0.037$	$\eta p^2 = 0.076$
Mean blood pressure (mmHg)	Before	87.00 ± 13.44	88.27 ± 20.18	F = 0.208	F = 0.029	F = 0.513
	Immediately after	84.40 ± 16.28	90.45 ± 21.99	P = 0.654	P = 0.971	P = 0.603
	Recovery	85.90 ± 16.12	88.18 ± 13.89	$\eta p^2 = 0.011$	$\eta p^2 = 0.002$	$\eta p^2 = 0.026$
The severity of dyspnea (0 – 10)	Before	1.30 ± 2.75	0.50 ± 1.58	F = 0.390	F = 0.412	F = 0.412
	Immediately after	1.00 ± 1.88	0.60 ± 1.57	P = 0.540	P = 0.547	P = 0.547
	Recovery	0.70 ± 1.63	0.50 ± 1.58	$\eta p^2 = 0.021$	$\eta p^2 = 0.022$	$\eta p^2 = 0.022$
Perceived exertion (0 – 10)	Before	2.20 ± 3.29	1.60 ± 2.59	F = 1.276	F = 1.224	F = 1.290
	Immediately after	3.20 ± 2.89	1.20 ± 2.09	P = 0.273	P = 0.299	P = 0.283
	Recovery	2.00 ± 2.66	1.00 ± 2.10	$\eta p^2 = 0.066$	$\eta p^2 = 0.064$	$\eta p^2 = 0.067$

Physical exercise requires an increase in cardiac output and metabolic oxygen consumption to maintain both muscle perfusion and venous return during skeletal muscle contractions (32). Based on our study, respiratory frequency, peripheral oxygen saturation, heart rate, systolic, diastolic and mean blood pressure were not observed to increase statistically in response to PNF-based exercises and active ROM exercises. Our results are in accordance with a previous study, which performed in healthy elderly women. The authors demonstrated that PNF-based exercise did not change diastolic and systolic blood pressure (33). There is also similar evidence that PNF did not alter heart rate, SBP and DBP responses in healthy sedentary women and swimmers (34, 35). However, Gultekin et al. found that hemodynamic responses (HR, SBP and DBP) increased after PNF exercises in university students (36). Cornelius et al. (37) and Rahman et al. (38) observed that PNF did not alter significant changes in DBP while the authors reported a significant increase in SBP. This acute increase in SBP may be explained by Valsalva maneuver. The number of repetitions in exercise protocol might also result in lower metabolic demands.

Fatigue and dyspnea are distressing symptoms for many critically ill patients (39) and identified as barriers for a cessation to early rehabilitation (40). Physiotherapy in the early period should be instigated to combat these issues. In recent reviews, PNF respiratory exercises performed in critically ill patients showed better respiratory function (19, 41). However, the effectiveness of PNF-based exercise performed on the upper and lower extremities on the severity of dyspnea and perceived exertion is not still known. Liu et al. revealed that patients with chronic obstructive pulmonary disease received 5 days per week for 6 weeks pulmonary rehabilitation and 10-minute PNF stretching combined with aerobic training have reduced dyspnea and improved pulmonary function (42). Consistent with this study, we found that PNF-based performed on the upper and lower extremities and active ROM exercises reduced in the severity of dyspnea of patients, there were only minor but not statistically significant differences between groups. Our finding suggests that PNF-based and active ROM exercises can be safely used in non-intubated critically ill patients.

There are a few limitations to our study. Firstly, the time interval between onset of rehabilitation and admission to intensive care unit was very broad: 7.00 ± 4.39 days for PNF group, 5.09 ± 1.86 days for active ROM exercise group. Secondly, the sample size was relatively small due to the difficulty of accessing patients who would be cooperative to active exercises in the level three intensive care unit and the cancellation of the data collection process during the COVID-19 pandemic. Thirdly, our study design did not include critically ill patients who are mechanically ventilated. Thus, further research should address respiratory and hemodynamic responses of PNF-based exercise in mechanically ventilated patients.

CONCLUSION

Our findings suggest that the PNF-based exercise did not significantly affect acute respiratory and hemodynamic effects compared to active ROM exercises in awake, spontaneously breathing non-intubated critically ill patients. No changes were noted in the severity of dyspnea and perceived exertion. We observed that PNF-based exercise is well-tolerated and can be safely used in intensive care unit setting for awake, non-mechanically ventilated, non-intubated critically ill adults. The long-term effectiveness and functional outcomes of PNF technique in critical illness could be worth examining for future research.

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