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Influence of Range of Motion Exercises on Hemodynamic Parameters for Patients on Mechanical Ventilation

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Abstract

Background: Mechanically ventilated patient is commonly bedridden which limits their mobility and may have harmful effects on different body systems. Passive range of motion exercises are assumed to prevent or reduce these effects and improve outcomes among mechanically ventilated patients. **Aim:** This study aimed to investigate the influence of range of motion exercises on hemodynamic parameters for patients on mechanical ventilation. **Methods:** A quasi-experimental research design was conducted on a convenient sample of 84 adult patients from both genders and were divided into two equal groups (No.=42) for each study and control group at medical intensive care unit of Beni-Suef University Hospital. Two tools were used to collect data: Patient characteristics tool, and Hemodynamic Parameters Assessment tool. **Results:** A statistically significant differences between the study group and control group across the four measurement time points including baseline measurements, five, 20, and 60 minutes after range of motion exercises in respiratory rate, percutaneous oxygen saturation, heart rate, mean arterial blood pressure and central venous pressure with $p \leq 0.05$. On the contrary, no statistically significant differences were detected in systolic blood pressure and diastolic blood pressure, ($p=0.381$ and $p=0.143$) respectively. **Conclusion:** Hemodynamic parameters improved among study group patients after range of motion exercises rather than control group patients. **Recommendations:** A critical care nurses should use passive range of motion exercises in the daily routine care of mechanically ventilated patients as it is an effective, inexpensive, noninvasive, and safe method in improving their physiologic or hemodynamic parameters.

Keywords: Hemodynamic parameters; Mechanical ventilation; Range of motion exercises

Introduction

Intensive care units (ICUs) are structured settings designed for the provision of care to critically ill patients. They provide specialized medical and nursing treatments, continuous monitoring, and multiple modalities of physiologic organ support to preserve life during a period of acute organ insufficiency. Patients' conditions in the ICU can change rapidly from improvement to deterioration. Also, they may experience transitional stages and face life-threatening circumstances (Kvande et al., 2022).

Approximately 13-20 million people worldwide receive treatment in ICUs annually (Latronico et al., 2023). Most critically ill patients suffer from multiple complications related to their critical illness and prolonged ICU stay (Daum et al., 2024). Critically ill patients are enforced to be immobilized due to the nature of the interventions necessary for their care, including sedation, mechanical ventilation (MV), and the insertion of numerous devices for nutrition, fluids, vasopressors, medications and monitoring. These devices like central lines, endotracheal tubes, nasogastric tubes, foley catheters and others (Jannoun, 2021).

During the last 50 years, MV has been a major life-support device for sustaining a patient's breathing, increasing patient survival, and helping in the patient's recovery from life-threatening conditions (Wang, 2020). As a result of using MV and other monitoring equipment, the risk of several patients' medical and psychological problems increased (Amin et al., 2023).

Due to circumstances in the ICU, especially in the first few days, like cardiac, hemodynamic, or pulmonary instability and the necessity for MV and sedation, the patients were unable to actively collaborate in mobilization (Vollenweider et al., 2022).

Bed rest is often necessary to recover from injury or disease but prolonged immobility can lead to significant negative complications in all major organs and human body systems (Šlosar et al., 2023).

These complications such as pressure ulcers, lung atelectasis, aspiration pneumonia, bone mineral loss, muscle atrophy, hypotension, tachycardia, cardiac output decreases and muscular weakness revealed that around 50% of mechanically ventilated patients with a ventilation duration > 48 hours develop ICU-acquired weakness (ICU-AW) (Eimer et al., 2021). Furthermore, increased the length of stay (LOS) in the ICU and hospital and lowered the chance of MV weaning. This can result in decreasing quality of life and rising the mortality rates (Wang, 2020).

Common complications related to bed rest can be resolved by early mobilization. It has multiple benefits, including improvements in ventilation, perfusion, muscle strength, level of consciousness, and functional capacity (Adam et al., 2021).

One of the fundamental methods for assessing and starting movement in a therapeutic intervention is range of motion (ROM) exercises. It includes active range of motion (AROM), passive range of motion (PROM), and active-assistive range of motion (AAROM). AROM is the type of ROM that can be performed when muscles can contract and relax, inducing joint movement. For example, the active range of motion to permit the elbow to bend requires the biceps to contract while relaxing of the triceps muscle (Rahiminezhad et al., 2022).

Passive range of motion is the ROM that is achieved by external force and leads to the movement of a joint. It is usually performed when the patient doesn't have the ability to move the body part. Active-assistive range of motion is produced by partial assistance to the joint from an outside force. Usually performed by force because of weakness, the presence of pain, or changes in muscle tone (Rahiminezhad et al., 2022).

Early PROM exercises have been shown to improve circulation, respiration, peripheral and central perfusion, and consciousness. Additionally, they enhance cardiac contractility, thereby strengthening the cardiac muscle, increasing cardiac output, and reducing the resting heart rate (HR) (Sauter et al., 2022); (Adam et al., 2021). They limit the incidence of atrial fibrillation, promote venous return, and decrease the risk of venous thromboembolism. Also, they increase metabolic and hemodynamic demands (Esmealy et al., 2023); (Alaparthi et al., 2021).

Furthermore, it is possible to preserve hemodynamic status in an unwavering state and cardiopulmonary stability with no further comorbidities (Astuti et al., 2020). The importance of hemodynamic stability lies on prevention of progressive organ failure and death subsequently (Falotico et al., 2020). The main vital hemodynamic parameters encompass HR, blood pressure (BP), respiratory rate (RR), percutaneous oxygen saturation (SPO2), mean arterial blood pressure (MABP) and central venous pressure (CVP) monitoring (Comisso et al., 2018).

Even though early mobilization (EM) is becoming progressively well-established in studies; many ICUs still do not currently follow this guideline (Sibilla et al., 2020). So, it is crucial to investigate the effect of ROM exercises on enhancing hemodynamic parameters.

Significance of the study

Fordyce et al. (2020) reported that hemodynamic instability (HI) is common among mechanically ventilated patients. According to a study conducted by Rahman et al. (2021) on more than 32000 patients in the ICU, the results illustrated that patients in the hemodynamically unstable group had longer ICU stay (median length of ICU for stable group: 29 hours; unstable group: 95 hours), more days on invasive MV (stable group: 22 hours; unstable group: 75 hours), increased hospital mortality rate (stable: 1.9%, unstable: 9.0%), and had higher Acute Physiology and Chronic Health Evaluation (APACHE) IV score at ICU admission (stable: 46, unstable: 62).

Hence, when PROM exercises are applied for those patients, they enhance hemodynamic parameters and decrease the incidence of hemodynamic instability complications. It is safe, as reported by Fordyce et al. (2020), because it doesn't require pharmacological approaches, inexpensive, feasible, and applicable to health care members.

Aim of the study

The study aimed to investigate the influence of ROM exercises on hemodynamic parameters for patients on mechanical ventilation.

Research hypothesis

The study group who receives range of motion exercises will have improvement in hemodynamic parameters than the control group.

Subjects and methods

Research design.

A quasi-experimental research design (study group and control group) was utilized to achieve the aim of the study.

Setting:

The study was conducted at medical ICU of Beni-Suef University Hospital. Medical ICU department located at the 2nd floor and consisted of 2 rooms (17 beds), one room includes 8 beds and the other room includes 9 beds.

Sample size:

In this study, we determined the sample size required for an unmatched case-control study using the parameters and formulas provided by Kelsey (1996) and Fleiss (1981). The calculations were based on the following assumptions and inputs:

Two-sided confidence level (1-alpha): 95%

Power: 80%

Ratio of controls to cases: 1:1

Hypothetical proportion of controls with exposure: 40%

Hypothetical proportion of cases with exposure: 70%

Least extreme Odds Ratio to be detected: 3.50

Sample Size Formulas

The formulas used to calculate the sample sizes for cases and controls are derived from Kelsey (1996) and Fleiss (1981). The following formula was applied:

$$N_{Fleiss} = \frac{\left[z_{\alpha/2}\sqrt{(r+1)p(1-p)} + z_{\beta}\sqrt{rp_0(1-p_0) + p_1(1-p_1)}\right]^2}{r(p_0-p_1)^2}$$

Calculated Sample Sizes

Using the inputs and formulas provided the sample sizes for cases and controls were calculated as follows:

Method	Sample Size - Cases	Sample Size - Controls	Total Sample Size
Kelsey	44	44	88
Fleiss	42	42	84
Fleiss with Continuity correction	49	49	98

The sample size calculations have been rounded up to the nearest integer for practical application.

Calculation Tool

The calculations were performed using the OpenEpi, Version 3, open-source calculator 4o. The researcher applied the suggestion of Fleiss (42 for each group).

Subjects:

This study was conducted on a convenient sample consisting of 84 adult patients from both genders who attended to the above-mentioned setting and were divided into two equal groups (No.=42) for each study and control group.

The patients were enrolled in the study according to the following:

Inclusion criteria:

- Patients older than 18 years old.
- Undergoing MV therapy (invasive and noninvasive)
- Have stable hemodynamic status.

Exclusion criteria:

- Patients who had orthopedic or vascular problems.
- Actual or suspected deep venous thrombosis.
- Pelvic or spinal injuries.
- Cardiac dysrhythmias.

Tools of data collection:

The following tools were used:

Tool I: Patient characteristics tool:

It was developed by the researcher based on review of relevant recent literature (Yundari et al., 2023); (Rezvani et al., 2022); (Wang, 2020); (Hickmann et al., 2021); (Santos et al., 2019) and it includes two parts:

Part I: Demographic data:

It includes patient's age, gender, smoking, date of admission and beginning date of mechanical ventilation.

Part II: Health relevant data:

It includes current diagnosis, past medical history, present medical history which includes (type of intubation, ventilator parameters such as mode of ventilation, tidal volume, fraction of inspired oxygen (FIO2) and positive end expiratory pressure (PEEP), and using of sedatives and vasopressors).

Tool II: Hemodynamic Parameters Assessment tool:

This tool was adopted from (Fahmy et al., 2021) and it includes RR, SPO2, HR, systolic blood pressure (SBP), Diastolic blood pressure (DBP), MABP, and CVP. These parameters were monitored four times using an electronic monitor (pre-intervention baseline, and post-intervention after five, 20, and 60 minutes).

Administrative design

The Dean of the Faculty of Nursing, Beni-Suef University granted official authorization to the directors of Beni-Suef University hospital to obtain consent to carry out the research, following an explanation of the study's purpose and objectives. Also, an official permission was obtained from the head nurse of Beni-Suef University hospital and the ICU physicians.

Ethical considerations:

The Scientific Research Ethical Committee of the Faculty of Medicine Beni-Suef University gave their official approval for the study to go ahead (Approval No.: FMBSUREC/06062023/Mohamed). Before completing the informed consent form, the researchers clarified the objectives and aim of the study to the patients or patient's families included in the study before obtaining their consent to participate in the study. The study's ethical considerations included maintaining anonymity and confidentiality of the patient's data, informing participants or their families of their rights to withdraw at any moment, ensuring that patients' data will be used as a part of the research only, and taking measures to protect their privacy so that no one else could access their data without their explicit consent.

Pilot study:

Pilot study was conducted on 10% of patients under study and excluded from the sample size to test the applicability, clarity and efficiency of the tools, then the tool was modified according to pilot study results.

Validity:

The content validity of the suggested tools was revised through a group of experts (5 experts, three in medical surgical nursing and two in critical care nursing).

Reliability:

The Cronbach's alpha (α) coefficient was used to evaluate the internal consistency of the instrument, which obtained a value of (0.89) for tool II which reflects a reliable tool.

Data collection:

The study was carried out through three phases.

A. Preparation phase:

- An official permission obtained from the director of Beni-Suef University Hospital in which the study was conducted.
- The researchers were conducting interviews with available patients or their relatives to explain the aim of the study and get their approval to participate in it prior to any data collection.
- Eligible patients were randomly assigned into two equal groups; the study and control group 42 for each. The study group received ROM exercises program.

- Data collection was carried out from the beginning of June to the end of November 2023.

B. Implementation phase:

1. The baseline data were collected from the patients' records, including demographic characteristics and health-relevant data at admission for all patients using tool I.
2. The control group was given the hospital routine care of ICU like the following (elevation of head of bed, suction, and frequent repositioning) without ROM exercises program.
3. Hemodynamic parameters were measured for all patients using tool II.
4. Study group patients received ROM exercises program while control group patients were under routine hospital care.

ROM exercises protocol includes the following:

This protocol was developed by the researchers based on recent literature (Einstein, 2022); (Coratella, et al., 2021), (Rezaeikia et al., 2020), and (Younis & Ahmed, 2015) and consisted of technique, duration, sites of implementation of the ROM exercises, and times of evaluation after implementation.

- The time frame of the program was as the following (baseline measurement, five, 20, and 60 minutes).
- The program consists of 20 minutes of flexion-extension movements for both limbs (one session/day)
- The patient was placed in a supine position and received 10 repetitive upper and lower extremity ROM exercises.
- ROM exercises for the upper extremities include fingers and wrist flexion and extension, ulnar and redial deviation; elbow flexion, extension, forearm supination and pronation; and shoulder flexion, extension, abduction, adduction, internal and external rotation.
- ROM exercises for lower extremities include toe flexion and extension, ankle dorsiflexion, inversion and eversion, knee flexion, and extension and hip flexion, extension, abduction, adduction, and internal and external rotation.

5. Hemodynamic parameters were measured post intervention five, 20, and 60 minutes.
6. The researchers documented patient's data.

C. Evaluation phase:

The researcher obtained physiological parameters through four phases using the electronic monitors as follow:

- Phase 1 (time 0): involve baseline measurement of the physiological parameters including the HR, RR, SBP and DBP, MABP, SpO2, and CVP.

- Phase 2 (time 1): the physiological parameters were measured after 5 minutes.
- Phase 3 (time 2): the physiological parameters were measured after 20 minutes.
- Phase 4 (time 3): the physiological parameters were measured after 60 minutes.
- Hemodynamic parameters were measured at the same times for both study and control group patients.
- Comparison between the study and control group results were done to evaluate the effect of ROM exercises on hemodynamic parameters.

Statistical design

Data were fed to the computer and analyzed using IBM SPSS software package version 27.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean and standard deviation. Significance of the obtained results was judged at the 5% level. The used tests were chi-square test, fishers exact or Monte Carlo correction, Friedman test, student t-test, paired t-test, and Anova with repeated measures.

RESULTS

Table (1): Revealed that age of patients enrolled in the study and control group (42 each) with Mean ± SD (46.10 ± 15.57) for study group and (50.21 ± 13.88) for control group. It was noted that (54.8%) in the study group and (52.4%) in control group were male. The table also, showed that there was no statistical difference between the two groups in their selected demographic data and found that only (28.6%) in the study group and (21.4%) in the control group were smokers.

Table (2): Displayed that there was the same percentage (33.3%) of patients had hypertension and free medical history among study group on the other hand hypertension is the most common past medical history among control group patients with percentage (40.5%). Also, showed that there was no statistically significant difference between study and control group in health-relevant data except using vasopressors (χ^2=3.967, p= 0.046).

Table (3): revealed that there was a statistical significant differences in study group across the four measurement time points in RR, SPO_2, HR, MABP and CVP (F= 4.456, p=0.005), (F=7.942, p=0.001), (F=13.115, p=0.001), (F= 5.629, p=0.005) and (Fr=13.057, p=0.005) respectively while there was a statistical significant differences across the four measurement time points in control group in HR, SBP, DBP and MABP (F=2.934, p=0.048),(F= 3.768, p=0.048), (F= 9.649, p=<0.001) and (F=9.790, p=<0.001) respectively.

Table (4): revealed that there was a statistically significant differences in study group and control group across the four measurement time points in SBP, DBP and MABP (t=2.692, p=0.009), (t=2.393, p=0.019) and (t=2.786, p=0.007) respectively.

Table (5): Illustrated that there was a negative relation between age and RR (r = -0.206), SPO2 (r = -0.212) and HR (r = -0.349) respectively and a positive relation in SBP, DBP, MABP and CVP (r = 0.235), (r = 0.276), (r = 0.298) and (r = 0.184) among study group patients. While among control group patients, there was a negative relation between age and SPO2(r = -0.262), SBP (r = -0.016), DBP (r = -0.067) and MABP (r = -0.023*). In addition, there was a statistically significant positive relation between age and CVP among control group patients (r=0.364*).

Table (6) revealed that there was no statistical difference between gender and hemodynamic parameters among both study and control group patients.

Table (1): Percentage distribution of selected demographic data for studied patients in the study group and control groups (No. =84)

Selected demographic characteristic	Study (n = 42) No.	Study (n = 42) %	Control (n = 42) No.	Control (n = 42) %	Test of Sig.	p
Age						
18 to less than 30 years	9	21.4	4	9.5	χ^2= 2.564	0.464
30>40 years	5	11.9	5	11.9		
40>60 years	11	26.2	11	26.2		
≥ 60 years	17	40.5	22	52.4		
Min. – Max.	18.0 – 65.0		18.0 – 65.0		t= 1.280	0.204
Mean ± SD.	46.10 ± 15.57		50.21 ± 13.88			
Gender						
Male	23	54.8	22	52.4	χ^2= 0.048	0.827
Female	19	45.2	20	47.6		
Smoking						
Yes	12	28.6	9	21.4	χ^2= 0.571	0.450
No	30	71.4	33	78.6		

SD: Standard deviation **t**: Student t-test
χ^2: Chi square test **p**: p value for comparing between the studied groups

Table (2): Percentage distribution of health-relevant data of studied patients in the study group and the control group (No. =84).

Health-relevant data	Study (n = 42) No.	Study (n = 42) %	Control (n = 42) No.	Control (n = 42) %	Test of Sig.	p
Past medical history#						
Free medical history	14	33.3	11	26.2	χ^2= 0.513	0.474
Diabetes mellitus	7	16.7	11	26.2	χ^2= 1.131	0.287
Cardiac disease	3	7.1	2	4.8	χ^2= 0.213	^{FE}p=1.000
Surgery	2	4.8	0	0.0	χ^2= 2.049	^{FE}p=0.494
Renal disease	5	11.9	4	9.5	χ^2= 0.124	^{FE}p=1.000
Infection/sepsis	0	0.0	0	0.0	–	–
Lipid disease	0	0.0	0	0.0	–	–
Respiratory disease	2	4.8	6	14.3	χ^2= 2.211	^{FE}p=0.265
Hypertension	14	33.3	17	40.5	χ^2= 0.460	0.498
Neurological disease	0	0.0	0	0.0	–	–
Endocrine disease	1	2.4	0	0.0	χ^2= 1.012	^{FE}p=1.000
Cancer	5	11.9	4	9.5	χ^2= 0.124	^{FE}p=1.000
Hepatic disease	3	7.1	2	4.8	χ^2= 0.213	^{FE}p=1.000
Others						
Systemic lupus erythematosus (SLE)	1	2.4	0	0.0	χ^2= 1.012	^{FE}p=1.000
Fractures	0	0.0	1	2.4	χ^2= 1.012	^{FE}p=1.000
Blood glucose	(n = 7)		(n = 11)			
Min. – Max.	114.0 – 333.0		98.0 – 345.0		U= 36.000	0.860
Mean ± SD.	179.1 ± 77.57		184.3 ± 74.65			
Median	160.0		170.0			
Sedatives						
Yes	21	50.0	16	38.1	χ^2= 1.208	0.272
No	21	50.0	26	61.9		
Vasopressor						
Yes	13	31.0	22	52.4	χ^2= 3.967*	0.046*
No	29	69.0	20	47.6		

SD: Standard deviation
U: Mann Whitney test
χ^2: Chi square test
FE: Fisher Exact
p: p value for comparing between the studied groups
#: More than one answer

Table (3): Comparing hemodynamic parameters between the study group and the control group across the four measurement time points (No. =84).

Hemodynamic parameters	Baseline Mean ± SD.	After 5-min Mean ± SD.	After 20-min Mean ± SD.	After 60-min Mean ± SD.	Test of Sig.	p
Respiratory rate (RR)						
Study group	19.33 ± 5.31	20.17 ± 4.60	19.26 ± 4.17	18.90 ± 3.52	F= 4.456*	0.005*
Control group	20.19 ± 6.11	20.14 ± 5.43	19.81 ± 5.26	19.81 ± 5.25	F= 1.554	0.213
Percutaneous oxygen saturation (SPO_2)						
Study group	96.43 ± 2.91	96.76 ± 2.67	97.05 ± 2.33	97.21 ± 2.35	F= 7.942*	<0.001*
Control group	95.60 ± 3.66	95.64 ± 3.69	95.71 ± 3.60	95.81 ± 3.55	F= 1.233	0.301
Heart rate (HR)						
Study group	90.02 ± 13.24	90.60 ± 12.83	88.21 ± 12.16	87.31 ± 12.41	F=13.115*	<0.001*
Control group	92.10 ± 12.02	91.74 ± 11.50	91.52 ± 11.81	91.24 ± 11.35	F= 2.934*	0.048*
Systolic blood pressure (SBP)						
Study group	124.5 ± 17.82	127.7 ± 25.26	126.8 ± 14.40	124.6 ± 11.77	F= 0.902	0.381
Control group	115.6 ± 17.80	115.8 ± 17.66	117.0 ± 16.58	117.3 ± 16.58	F= 3.768*	0.048*
Diastolic blood pressure (DBP)						
Study group	79.86 ± 15.80	82.24 ± 14.35	79.83 ± 13.17	80.17 ± 11.53	F= 1.930	0.143
Control group	73.07 ± 11.96	73.43 ± 11.63	74.33 ± 10.77	76.40 ± 9.62	F= 9.649*	<0.001*
Mean arterial blood pressure (MABP)						
Study group	94.67 ± 15.99	97.88 ± 14.88	94.74 ± 12.84	93.83 ± 10.79	F= 5.629*	0.005*
Control group	86.29 ± 12.98	87.07 ±12.58	87.81 ± 11.68	89.64 ± 10.89	F= 9.790*	<0.001*
Central venous pressure (CVP)						
Study group	8.88 ± 3.64	8.88 ± 3.64	8.95 ± 3.57	9.12 ± 3.46	Fr=13.057*	0.005*
Control group	10.21 ± 3.98	10.21 ± 3.98	10.21 ± 3.97	10.26 ± 3.92	Fr=2.571	0.463

SD: Standard deviation **F test** (ANOVA) with repeated measures **Fr:** Friedman test
p: p value for comparing between the studied groups
***:** Statistically significant at p ≤ 0.05

Table (4): Comparing hemodynamic parameters between the study group and control group patients (Average) (No. =84).

Hemodynamic parameters	Study (n = 42)	Control (n = 42)	Test of Sig.	p
Respiratory rate				
Min. – Max.	11.75 – 26.0	10.0 – 31.25		
Mean ± SD.	19.42 ± 4.22	19.99 ± 5.45	t= 0.538	0.592
Median	19.88	20.75		
Oxygen saturation				
Min. – Max.	86.25 – 100.0	85.75 – 100.0		
Mean ± SD.	96.86 ± 2.48	95.69 ± 3.60	t= 1.740	0.086
Median	97.38	95.75		
Heart rate				
Min. – Max.	59.50 – 103.3	64.75 – 107.8		
Mean ± SD.	89.04 ± 12.44	91.65 ± 11.61	t= 0.995	0.323
Median	91.75	96.38		
Systolic BP				
Min. – Max.	87.50 – 147.5	85.0 – 153.8		
Mean ± SD.	125.9 ± 15.21	116.4 ± 16.98	t= 2.692*	0.009*
Median	130.0	119.9		
Diastolic BP				
Min. – Max.	50.0 – 103.5	52.50 – 95.0		
Mean ± SD.	80.52 ± 12.99	74.31 ± 10.70	t=2.393*	0.019*
Median	80.0	72.50		
MABP				
Min. – Max.	61.25 – 117.5	64.50 – 109.5		
Mean ± SD.	95.28 ± 13.11	87.70 ± 11.78	t= 2.786*	0.007*
Median	94.63	86.75		
CVP				
Min. – Max.	3.75 – 18.0	5.0 – 20.0		
Mean ± SD.	8.96 ± 3.57	10.23 ± 3.96	U= 708.000	0.119
Median	9.0	9.0		

SD: Standard deviation **U:** Mann Whitney test **t:** Student t-test

p: p value for comparing between the studied groups

***:** Statistically significant at $p \leq 0.05$

Table (5): Correlation between age and hemodynamic parameters among studied patients (No. =84)

Hemodynamic parameters	Age			
	Study (n = 42)		Control (n = 42)	
	r	p	r	p
Respiratory rate (RR)	-0.206	0.190	0.203	0.198
Percutaneous oxygen saturation (SPO_2)	-0.212	0.177	-0.262	0.094
Heart rate (HR)	-0.349*	0.024*	0.232	0.139
Systolic blood pressure (SBP)	0.235	0.135	-0.016	0.921
Diastolic blood pressure (DBP)	0.276	0.077	-0.067	0.673
Mean arterial blood pressure (MABP)	0.298	0.056	-0.023*	0.885*
Central venous pressure (CVP)	0.184	0.244	0.364*	0.018*

r: Pearson coefficient ***:** Statistically significant at $p \leq 0.05$
p: p value for comparing between the studied

Table (6): Correlation between Gender and hemodynamic parameters among studied patients (No. =84)

Hemodynamic parameters	Gender			
	Study (n = 42)		Control (n = 42)	
	Male (n = 23)	Female (n = 19)	Male (n = 22)	Female (n = 20)
	Mean ± SD.	Mean ± SD.	Mean ± SD.	Mean ± SD.
Respiratory rate	19.55 ± 3.80	19.25 ± 4.77	18.68 ± 5.33	21.43 ± 5.33
t (p)	0.230 (0.819)		1.665 (0.104)	
Percutaneous oxygen saturation	97.27 ± 1.87	96.37 ± 3.05	95.22 ± 3.18	96.21 ± 4.02
t (p)	1.180 (0.245)		0.895 (0.376)	
Heart rate	89.79 ± 11.63	88.12 ± 13.62	92.48 ± 10.21	90.74 ± 13.19
t (p)	0.430 (0.669)		0.480 (0.634)	
Systolic blood pressure	126.37 ± 15.89	125.32 ± 14.76	117.82 ± 15.32	114.89 ± 18.93
t (p)	0.221 (0.826)		0.554 (0.583)	
Diastolic blood pressure	81.15 ± 13.39	79.76 ± 12.81	76.45 ± 10.35	71.95 ± 10.83
t (p)	0.341 (0.735)		1.378 (0.176)	
Mean arterial pressure	95.85 ± 13.19	94.59 ± 13.34	89.82 ± 11.68	85.38 ± 11.74
t (p)	0.306 (0.762)		1.228 (0.227)	
Central venous pressure	8.60 ± 3.67	9.39 ± 3.49	10.49 ± 4.12	9.94 ± 3.86
U (p)	182.500 (0.362)		202.000 (0.649)	

SD: Standard deviation **U:** Mann Whitney test **t:** Student t-test
p: p value for comparing between the studied

Discussion

Hemodynamic instability is an important and prevalent condition in the ICU. One-third of critically ill patients have been developed hemodynamic instability and received hemodynamic interventions with a mortality rate around 40–59% (Dung-Hung et al., 2022). That enforced the researchers to investigate the influence of ROM exercises on hemodynamic parameters.

The findings of the current study showed that there was no statistical difference detected between the two groups in their selected demographic data which reflects the homogeneity of the participants. Regarding the participant's age, the majority of the studied patients were within the age group of ≥ 60 years old as comorbidities increase with age and increase the risk of ICU admission.

This finding agreed with Omar et al., 2024, who study Effect of Passive Range of Motion Exercise on Hemodynamic Parameters on Mechanically Ventilated Patients and revealed that more than one-third of participants within the age group 51-65 years old. While contradicted a study of Yundari et al. (2023), who investigate Effects of Progressive Mobilization on Hemodynamic Status of Bedridden Patients in the Intensive Care Unit and revealed that less than half of participants were between the ages 36 and 45. Concerning gender, the present study findings revealed that more than half of participants in both groups were males. This result aligned with the findings of Zhou et al. (2022) study, which explored the effect of early progressive mobilization on intensive care unit-acquired weakness in mechanically ventilated patients and found that over half of them were male.

Also agreed with younis & Ahmed (2015), who carried out a study in Egypt which entitled Effectiveness of PROM exercise on hemodynamic parameters and behavioral pain intensity among adult mechanically ventilated patients and reported that less than two thirds of participants were males. On the other hand, Aryanti et al. (2022), who carried out a study called Effectiveness of Progressive Mobilization on Functional and Hemodynamic Status in Bed rest Patients in the ICU and reported that less than two–thirds of participants were females.

Regarding smoking the findings of the current study revealed that the number of smoker patients who enrolled in the study was small. This result could be due to the fact that smoker patients were expected to admit to the chest ICU. This finding was similar to Ismail et al. (2023), who carried out a study which entitled Identification of Hemodynamic Challenge Changes in Post-Cardiac Operation Patients with Early Mobilization in National Heart Institute and revealed that less than one-quarter of studied patients were smokers.

In relation to past medical history, the current study showed that more than one-third of participants had hypertension. This result may be due to the highest prevalence of hypertension in Egypt. This finding was in the same line with Zhou et al. (2022), who revealed that more than one-half of participants had hypertension, also agreed with Ismail et al. (2023) who illustrated that the majority of participants had hypertension.

Moreover, the current study revealed that half of participants used sedation in the study group compared to one-third in the control group. This may be because deeply unconscious patients didn't need sedation to decrease fighting against mechanical ventilation therapy. This finding is similar to Younis & Ahmed (2015), who found that less than two thirds of participants didn't used sedation. Also, in contrast with Møller et al. (2022) who illustrated that the majority of studied patients used sedation.

Around one-third of patients in the study group were taking vasopressors compared to half of the patients in the control group, with a statistically significant difference. According to the researcher's view, this may be due to more than one-third of study group had a past medical history of hypertension and using of vasopressor may become more limited. This finding agreed with Borges et al. (2022), who study Hemodynamic impact of early mobilization in critical patients receiving vasoactive drugs and revealed that the minority of study group used vasopressors. On the other hand, Watanabe et al. (2023), who carried out a study which entitled "Association between the early mobilization of mechanically ventilated patients and independence in activities of daily living at hospital discharge" announced that about two-thirds of the study group patients use continuous vasopressors during their ICU stays.

The results of the current study showed that significant difference in the mean scores of the RR, SPO_2, HR, CVP and MABP among the study group after five, and 20 minutes of PROM exercises as compared to the pre-intervention mean scores with a highly statistically significant difference. However, after 60 minutes of the intervention, the mean scores of the RR and HR were near the mean baseline scores. On the contrary, no statistically significant changes were noted in the same parameters in the control group.

From the researcher's point of view, it may be because the physiological response that aggregates the HR after passive movements enhances cardiac output and oxygen consumption. Also, increased RR may be related to an increase in the metabolic rate made by passive exercises. Moreover, the oxygen saturation value will either rise or remain the same, but it will still be within the normal ranges after completing physical activity.

This result similar to Sivrikaya (2023); Borges et al. (2022); Rezvani, et al. (2022), who found that there was a statistically significant increase in HR and RR after mobilization when compared to rest and contraindicated Köse and Avşar (2021), who studied the impact of early and regular mobilization on vital signs and oxygen saturation in patients undergoing open-heart surgery and showed a significant decrease in the HR and RR after the first mobilization session.

The findings of the current study presented a significant increase and improvement in oxygen saturation values after performing PROM exercises and agreed with this finding Asyulia et al. (2023), who carried out a study which entitled "Physical Activity on Oxygen Saturation and Pulse Frequency" and showed that there is a significant difference between physical activity on oxygen saturation values. But it is incompatible with da Silva et al. (2019), who carried out a study which entitled "The influence of the order between resistance and stretching exercises on the hemodynamic response" and reported decreased SPO_2 values in the subjects performing physical activities.

As regards to MABP, there were an increase in its values among the study group more than in the control group with a statistically significant difference. This result was in the same line as Rezaeikia et al. (2020). Additionally, a significant increase in SBP and DBP readings during PROM appeared, and returning to the baseline values in the study group. Similarly to Borges et al. (2022), who found the majority of studied groups had an increase in MABP measurements. Contrary to Fahmy et al. (2021); Indriani et al. (2018); Taghizadeh et al. (2013), who noted a significant decrease in patients' SBP and DBP toward stability after the progressive mobilization.

Concerning the CVP values, there is an increase in the mean CVP readings after five, 20, and 60 minutes of PROM exercises as compared to the pre-intervention mean within the study group with statistically significant difference. It may be because the patients involved in the current study received vasopressors and considered another strong factor can raise CVP. Similarly to Li & Du, (2019), who reported that any change of vasopressors dose will cause change in CVP measurements. On the other hand, Ni Putu et al. (2023), which investigated the effect of passive range of motion exercises on hemodynamic parameters of mechanically ventilated patients, found that were no significant changes over time in the CVP readings between the study and control groups.

Furthermore, in the current study, there were obvious statistically significant differences in SBP, DBP and MABP within the control group. This may be because MV causes cyclic changes in vena cava blood flow, pulmonary artery blood flow, and aortic blood flow. In addition, respiratory changes in aortic blood flow are reflected by "swings" in blood pressure values. Also, it was noticed that the percentage of patients taking vasopressors in the control group was higher than in the study group.

When comparing hemodynamic parameters between the study group and control group across the four measurement time points, the results revealed that there was a statistically significant difference in the study group across the four measurement time points in RR, SPO_2, HR, MABP, and CVP. This is parallel to Lima et al. (2015), who investigated the hemodynamic responses during and after multiple sets of stretching exercises and revealed a significant increase in BP and HR. Also agreed with Koohpeyma et al. (2020), who carried out a study which entitled "Effect of Gradual Mobilization with Bed Activity on Hemodynamic Parameters in Patients Undergoing Sleeve Gastrectomy revealed an increase in SPO2 immediately after mobilization and six hours later in both groups.

Besides, the current study illustrated that there was a statistically significant negative relation between age and HR within the study group; this result is in line with Candel et al. (2022), who carried out a study which entitled "The association between vital signs and clinical outcomes in emergency department patients of different age categories" and found that there was an obvious decline in HR values when advancing the participant's age.

Also, there was a positive relationship between age and SBP, DBP, MABP and CVP. It may be due to physiological changes and functional decline in all body systems with advancing age, especially in the part of cardiopulmonary status. That also agreed with Singh et al. (2019), who carried out a study which entitled "physiology, blood pressure age related changes" and discovered that age is the dominant risk factor that can increase BP measurements during lifespan.

The present study announced that there was no statistical difference between gender and hemodynamic parameters among both groups. This finding was agreed upon by Wang et al. (2021); Ahmed (2019), they found there weren't statistical difference between gender and hemodynamic parameters.

Conclusion

In the light of the study findings, it can be concluded that:

- There were improved statistically significant differences in the study group across the four measurement time points ($p \leq 0.05$) in RR, SPO2, HR, MABP, and CVP. On the other hand, a statistically significant differences were noticed in HR, SBP, DBP and MABP among the control group.
- There was a strong negative relation between age and

hemodynamic parameters across measurement time points.

Recommendations

- A critical care nurses should use PROM exercises in the daily routine care of mechanically ventilated patients as it is an effective, inexpensive, noninvasive, and safe method in improving their hemodynamic parameters.
- Early PROM exercises protocol should be started as early as possible for mechanically ventilated patients.
- Further study is recommended on a larger sample and more units at different settings.
- Hospital policies should be directed toward providing adequate resources needed for implementation of PROM exercises.

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