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SAFE AND EFFECTIVE USE OF ARM CYCLE ERGOMETRY IN CRITICALLY ILL PATIENTS

ORIGINAL ARTICLE

ABSTRACT

Purpose: Patients in intensive care units (ICU) are often exposed to prolonged immobilization, which, in turn, plays a vital role in impaired functional status. Exercise with an arm cycle ergometer (ACE) could be a treatment option to minimize the harmful effects of immobility. This study was aimed to investigate whether using ACE is a safe and effective intervention for preventing or attenuating the decrease in functional status in critically ill patients.

Methods: A total of 35 adult critically ill patients were recruited for this study from among those admitted to the ICU. The subjects received conventional physiotherapy or conventional physiotherapy with an additional ACE intervention during their stay in the ICU. The intervention was administered passively or actively based on clinical status for 20 minutes, once a day, five days a week. During the ACE training, cardiopulmonary responses and the highest/lowest values were recorded before, during, and immediately and 5 minutes after the exercise. Cardiopulmonary responses recorded at the first, the second, and discharge days of the training (last training session) were analyzed. Ambulation Score and Barthel Index were used to evaluate the functional level.

Results: Although cardiopulmonary responses were varied with ACE exercise ($p<0.05$), these changes stayed within the safety limits. At ICU discharge, there were no significant differences between the groups regarding functional level scores ($p>0.05$).

Conclusion: In the ICU, the daily exercise of ACE training is possible and safe. Further study is needed to determine the effects of exercise training using ACE on the functional outcomes.

Key Words: Ergometer Training; Intensive Care; Physical Function; Physiotherapy; Exercises.

YOĞUN BAKIMDA KOL BİSİKLET ERGOMETRESİNİN GÜVENLİ VE ETKİN KULLANIMI

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Yoğun bakım ünitelerindeki (YBÜ) hastalar genellikle uzun süreli immobilizasyona maruz kalırlar ve bu da fonksiyonel durumun kötüleşmesinde önemli bir rol oynar. Kol bisiklet ergometresi (KBE) ile egzersiz, immobilizasyonun zararlı etkilerini en aza indirmek için kullanılabilecek bir tedavi seçeneği olabilir. Bu çalışmanın amacı, kritik hastalarda KBE kullanımının fonksiyonel durumdaki azalmayı önlemeye veya azaltmaya yönelik güvenli ve etkili bir müdahale olup olmadığını araştırmaktı.

Yöntem: YBÜ'ye kabul edilenler arasından stabil, kritik hastalığı olan 35 erişkin hasta bu çalışmaya alındı. Bu hastalara, YBÜ'de kaldıkları süre boyunca konvansiyonel fizyoterapi veya konvansiyonel fizyoterapiye ek olarak KBE eğitimi uygulandı. Eğitim, klinik durumlarına göre haftada 5 gün, günde bir kez 20 dakika boyunca pasif veya aktif olarak uygulandı. KBE eğitiminde, egzersiz öncesi, egzersiz sırasında, hemen sonrasında ve 5 dakika sonrasında kardiyopulmoner yanıtlar ve en yüksek/düşük değerler kaydedildi. Eğitimin birinci ve ikinci günü ile taburculukta (son eğitim seansı) kaydedilen kardiyopulmoner yanıtlar istatistiksel olarak analiz edildi. Fonksiyonel düzeyi değerlendirmek için Ambulasyon Skoru ve Barthel İndeksi kullanıldı.

Sonuçlar: Kardiyopulmoner yanıtlar KBE ile değişmekle birlikte ($p<0,05$), bu değişiklik güvenli sınırlar içinde kaldı. YBÜ'den taburculukta fonksiyonel düzey skorları açısından gruplar arasında anlamlı fark yoktu ($p>0,05$).

Tartışma: YBÜ'de, günlük KBE egzersizinin yapılması mümkün ve güvenlidir. KBE eğitiminin fonksiyonel sonuçlar üzerindeki etkilerini belirlemek için daha fazla çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: Ergometre Eğitimi; Yoğun Bakım; Fiziksel Fonksiyon; Fizyoterapi; Egzersiz.

INTRODUCTION

Critically ill patients are usually sedated and ventilator-dependent, suffering from multi-organ failure. The primary objective of medical treatment is to improve life-threatening acute diseases (1,2). Medical interventions, such as anesthesia, neuromuscular blockade and corticosteroids, systemic inflammation, catabolic process, and increased immobilization, cause functional capacity loss and neurocognitive and neuromuscular disorders in these patients (3-8).

Complications due to prolonged immobilization point out the necessity of early rehabilitation (8-10). The sooner the rehabilitation treatment starts, the more likely it lowers the impact of immobility and bed rest (11,12). Studies have demonstrated that physiotherapy and rehabilitation programs applied in the ICU reduce the effects of ICU-based complications, length of stay in hospital and ICU, number of ventilator days, and need for intubation. These programs also prevent and heal the atelectasis, improve quality of life, contribute to the prevention of brain dysfunction, and reduce mortality and recurrent hospitalization (9,13,14).

Cycle ergometer is a common method applied to prevent muscle dysfunction and strength loss in the ICU. The ergometer could be used passively, actively assisted, and activities based on the patients' needs, and the extremity is the strength. For the lower extremity, the lower extremities of the patient lying in the supine position are placed on the device. For the upper extremity, the patient should grab the handles, or the patient's hands should be fixed by attaching them to the handles. The device could be adjusted to give resistance to the patient. It also provides patients with an active-assisted working opportunity, to whom they do not have sufficient muscle strength. The cycling speed and whether the patient uses the extremities evenly could be easily monitored (15-17). Studies on lower extremity training using bicycle ergometry are common in intensive care. These studies have shown that lower extremity training using bicycle ergometry increases muscle strength and exercise capacity and heals morphology of knee extensors (15,18-20). However, limited studies are demonstrating the effectiveness of arm ergometry training (ACE) in critically ill patients (21,22). This study aimed to investigate whether using arm ergometry is a safe and effective intervention to prevent or attenuate the decrease in functional status in critically ill patients.

METHODS

Patients

This study was performed with critically ill inpatients between April 2017 and February 2018 in the Medical ICU of Hacettepe University Faculty of Medicine, Ankara, Turkey. The inclusion criteria were being critically ill, aged between 18 and 80, and being clinically stable. The exclusion criteria were having trauma or surgery of the cervical, upper extremity, clavicula, or scapula, neuromuscular muscle weakness, acute stroke, status epilepticus intracranial pressure >20 mmHg, coagulation disorders, international normalized ratio >1.5, blood platelets <50,000/mm^3, psychiatric disorders or severe agitation, cardiorespiratory instability, inspiratory oxygen fraction (FiO_2) >55%, arterial oxygen partial pressure (PaO_2) <65 mmHg respiratory rate >30 bpm, systolic blood pressure >200 mmHg or <80 mmHg, diastolic blood pressure >100 mmHg or <50 mmHg, hemodynamic instability, dopamine >5 mcg/kg/min, diagnosis of shock (15). The occurrence of cardiorespiratory instability or other medical conditions impairing the interventions after the inclusion of the study led to the exclusion of the patients. Participants and/or their close family were informed about the study, and written consent was obtained. Hacettepe University Non-Interventional Ethics Committee approved the study, (Approval Date: 14.03.2017 and Approval Number: GO 17/247).

Study Design

The patients were divided into two groups according to the prognosis. The patients were considered eligible for less intensive treatment, and poor prognosis patients were considered candidates for more aggressive treatment. The poor prognosis patients whom the ICU physician considered appropriate in light of the patient's prognosis (using SOFA and APACHE II scores) (23,24) were included in the ACE group (n=15), and the other patients were included in the control group (n=20).

Patients in the control group received routine physiotherapy (respiratory physiotherapy, range of motion of upper-limb joints, mobilization in and out of bed) five days a week, during their stay in the ICU. Patients in the ACE group received routine physiotherapy, and ACE exercise session five days a week, using a bedside ergometer (MOTOmed Letto 2, RECK-Technique GmbH & Co. KG, and Betzenweiler, Germany). The flow diagram of the study is shown in Figure 1. All interventions were performed until discharge from the ICU. Functional status was assessed at baseline and ICU discharge.

Interventions

All patients received daily sessions of routine physiotherapy. These sessions entailed respiratory physiotherapy, the range of upper-limb joints motions, mobilization in and out of bed. Mainly manual techniques and active cycle of breathing techniques were used as respiratory physiotherapy (26). As the patients were unable to tolerate all the positions required for postural drainage, sitting and side-lying positions were applied. Thoracic or chest and diaphragmatic breathing exercises were performed to patients who could not perform active of breathing techniques (11). Neurophysiological facilitation of respiration was performed in unconscious patients. Stimulation was performed between the nose and lips, second and third costal, and thoracic stretching exercises were performed using shoulder flexion and abduction (11). Resistive, active, active-assisted, or passive range of motion for upper-limb joints were applied to the patients considering their participation. A mobilization protocol was established based on the study of Needham et al. (25). This protocol consisted of five stages: in-bed seating, bedside seating, sitting-out, standing, and walking. Hemodynamics (heart rate and blood pressure) and respiratory parameters (respiratory rate and oxygen saturation) were checked before the patients' mobilization. The patients whose responses were considered appropriate were moved to the next stage, and the patients, whose cardiorespiratory responses were impaired, were returned to the previous stage and stayed at that stage.

Table 1: Demographic and Clinical Characteristics of the Patients.

Characteristics	Arm Ergometry Group (n=15)	Control Group (n=20)	p
Age (years), Mean±SD	63.40±20.50	56.90±24.81	0.416[1]
Gender, n (%)			0.625[2]
Female	7 (47)	11 (55)	
Male	8 (53)	9 (45)	
SOFA, Median (Min-Max)	3.50 (1-10)	3.00 (1-12)	0.825[4]
APACHE II, Mean±SD	21.92±7.80	18.80±9.45	0.316[1]
GCS, n (%)			0.226[3]
3-7	4 (27)	4 (20)	
8-11	3 (20)	2 (10)	
12-14	4 (27)	2 (10)	
15	4 (27)	12 (60)	
Ventilatory Support, n (%)			0.853[3]
Invasive Mechanical Ventilation	6 (40)	6 (30)	
High Flow Oxygen Therapy	1 (7)	2 (10)	
Nasal Cannula	1 (7)	3 (15)	
Oxymask	2 (13)	4 (20)	
Venturi Mask	5 (33)	5 (25)	
Functional Level Score	3.60±0.63	3.00±1.26	0.075[1]
Length of Stay in ICU (Days), Median (Min-Max)	18 (3-70)	8.50 (3-44)	0.169[4]
OAI (Days), Median (Min-Max)	3 (1-20)	2 (1-13)	0,114[4]
Length of Rehabilitation (Days), Median (Min-Max)	8 (3-50)	5 (3-30)	0.298[4]

[1]Student t-Test, [2]Pearson Chi-Square Test, [3]Chi-Square Test, [4]Mann Whitney-u Test. SOFA: Sequential [Sepsis-Related] Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II, GCS: Glasgow Coma Scale, OAI: Onset-to-Admission Interval (Time Interval between Onset of Rehabilitation and Admission to ICU), ICU: Intensive Care Unit.

Table 2: Arm Cycle Ergometer Exercise Training Outcomes.

Outcomes	First Day	Second Day	Discharge (Last Day)	p
	Mean±SD	Mean±SD	Mean±SD	
Session Duration (min)				
Total	16.32±5.11	18.19±1.38	18.04±3.12	0.227
Pasive	10.43±8.45	11.49±8.14	9.26±8.54	0.343
Active	5.89±7.54	7.10±8.52	8.91±9.01	0.175
Distance (km)				
Total	2.10±0.99	2.47±1.09	2.51±1.19	0.286
Passive	1.07±0.89	1.19±0.84	0.86±0.84	0.145
Active	1.03±1.46	1.15±1.68	1.55±1.81	0.436
Active Performance (watt)				
Mean	1.20±1.62	1.18±1.33	0.90±0.99	0.438
Peak	3.20±5.27	2.82±4.45	1.90±3.35	0.283
Mean Active Speed (cycle/min)	24.60±16.41	28.00±19.56	27.80±17.97	0.449
Maximum Level of Resistance	1.00±1.76	1.18±2.09	0.60±1.26	0.236

Repeated measures of ANOVA.

Additionally, patients in the ACE group received ACE training sessions five days a week, using a bedside ergometer (MOTOmed Letto 2, RECK-Technique GmbH & Co. KG, and Betzenweiler, Germany). The patients were positioned in the long sitting with their elbows supported. The hands of patients who were unconscious or unable to grip the ACE due to insufficient grip strength were fixed to the ergometers' holders by using a non-elastic bandage. If the vascular accesses were in the fixing area, a sponge put on the vascular access before the fixing. The device allows both passive and increasing resistance levels of active cycling. The resistance level was between 1 and 10 points. In each session, the aim was to maintain the cycling exercise for 20 minutes, that the intensity level was patient-specific. Upper extremity exercise was applied to sedated patients for 20 minutes at a fixed rate of 20 rpm. When patients could actively cycle, the training session was paused when necessary, to reach a total of 20 minutes. The patients who could tolerate, each session was increased by one level, and the training was continued. When patients wanted to stop treatment due to fatigue or pain, the treatment was paused or ended. The training session was completed if the patients' heart rate increased over 70% of their age predicted maximal heart rate, or fell below 50 bpm, or increased over 130 bpm or decreased by more than 20%, and systolic blood pressure increased over 180 mmHg, the mean arterial blood pressure fell <60 mmHg or increased >130 mmHg, systolic, or diastolic blood pressure decreased by more than 20%. If cardiorespiratory distress was detected, oxygen saturation decreased below 90%, respiratory rate >35 bpm and <5 bpm (15).

Assessments

Demographic and clinical characteristics

Demographic data and patient characteristics, including gender, age, diagnosis, the Acute Physiology and Chronic Health Evaluation II (APACHE II) (27), Sequential [Sepsis-related] Organ Failure Assessment (SOFA) score (28), and ventilatory support were recorded. Level of consciousness of patients were evaluated by the Glasgow Coma Scale (GCS) (29). The time interval between onset to rehabilitation and admission to ICU, OAI) onset-to-admission interval, length of stay the ICU, and length of rehabilitation period were recorded. Patients' functional status was recorded with a Functional Level Score. Functional Level Score is a score that has 5 points in the range of 0-4. When the score is higher, the functional statue is the worst (30).

Arm Cycle Ergometer Exercise Training Data

During the ACE training, the device recorded the session duration (minute), distance (km), active performance (watt), mean active speed, and maximum level of resistance. At the first, second, and discharge days of the training (last training session), recorded data were statistically analyzed.

Cardiopulmonary Responses

Cardiopulmonary responses were evaluated during ACE exercise training. Respiratory frequency (bpm), heart rate (bpm), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), SpO_2 (%) were recorded at baseline, every five minutes, and five minutes after the end of the exercise. Cardiopulmonary responses recorded at the first, second, and last training session (Discharge day of the training) to determine whether the exercise training with ACE was safe. Recordings were performed before and immediately after and five minutes after the exercise. The highest value (the lowest for SpO_2) reached during the exercise, was also noted.

Functional Status

Ambulation Score and Barthel Index were used to evaluate the functional level at baseline and ICU discharge. The ambulation score was graded between 1 and 6 points. "1" referred to the worst and "6" to the best ambulation level (31). The Barthel Index consisted of 10 segments that primarily assess mobility and self-care activities. The total score ranged from 0-100 points, and "0" point meant full dependency; "100" points meant full independency (32).

Statistical Analysis

In the power analysis conducted by PASS 11.0 (PASS Sample Size Software, NCSS, Utah, USA) program, based on the Ambulation Score with 80% power, 0.5 errors, the sample size was determined as 40 control groups and 40 treatment group patients. Descriptive statistics were expressed as means and standard deviations (SD), median and minimum-maximum (min-max), frequencies, and percentages. Shapiro-Wilk test evaluated the suitability of the data to the normal distribution. The Student t-test was used to compare normally distributed age, GKS, APACHE II. Mann Whitney-U test was used to compare SOFA, OAI, length of stay in ICU, and length of the rehabilitation period, as they were not normally distributed. Gender was analyzed with the Pearson Chi-square test. The functional level of patients before the hospital stay analyzed using Student t-test. The mean baseline and discharge scores for Ambulation Score and Barthel Index analyzed using one way ANOVA. The repeated measures of ANOVA were used for

Table 3: Cardiopulmonary Responses During the Arm Cycle Ergometer Training.

Variables	Baseline	Highest Value in the Session	End of the Session	Recovery	p
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Respiratory Rate (bpm)					
1st Day	24.60±4.15	26.27±5.26	24.80±6.96	23.27±4.11	**0.025***
2nd Day	23.60±4.17	25.40±4.64	24.93±5.02	22.87±4.75	**0.007***
Last Day	24.07±3.86	26.00±3.30	25.20±2.60	24.47±3.52	0.055
Heart Rate (bpm)					
1st Day	100.53±17.04	111.80±32.54	101.53±1.09	97.67±20.23	0.119
2nd Day	97.33±19.08	103.27±16.10	98.00±19.37	95.80±20.03	**0.001***
Last Day	94.67±22.23	100.47±18.45	96.33±20.35	92.73±21.69	**0.006***
SBP (mmHg)					
1st Day	121.87±27.55	135.14±24.87	126.33±24.63	122.36±28.05	0.120
2nd Day	113.40±30.07	119.93±30.67	113.60±27.75	111.00±27.70	**0.038***
Last Day	116.07±32.36	126.73±34.53	120.20±31.81	113.67±23.48	**0.044***
DBP (mmHg)					
1st Day	70.87±14.77	75.60±15.47	70.80±15.59	67.73±11.73	0.175
2nd Day	65.53±11.86	72.87±15.07	66.60±13.44	66.00±15.53	0.066
Last Day	67.20±9.79	71.60±10.89	68.80±10.85	65.27±9.04	**0.001***
SpO_2 (%)					
1st Day	93.00±3.85	90.93±3.77[a]	92.47±3.31	93.87±4.09	0.235
2nd Day	93.40±4.47	91.80±4.28[a]	93.73±4.01	94.67±3.52	**0.003***
Last Day	91.93±3.01	91.33±3.13[a]	92.60±2.90	92.87±2.10	**0.004***

Repeated Measures ANOVA, DBP: Diastolic Blood Pressure, SBP: Systolic Blood Pressure, SpO_2: Oxygen saturation
The lowest value for SpO_2.

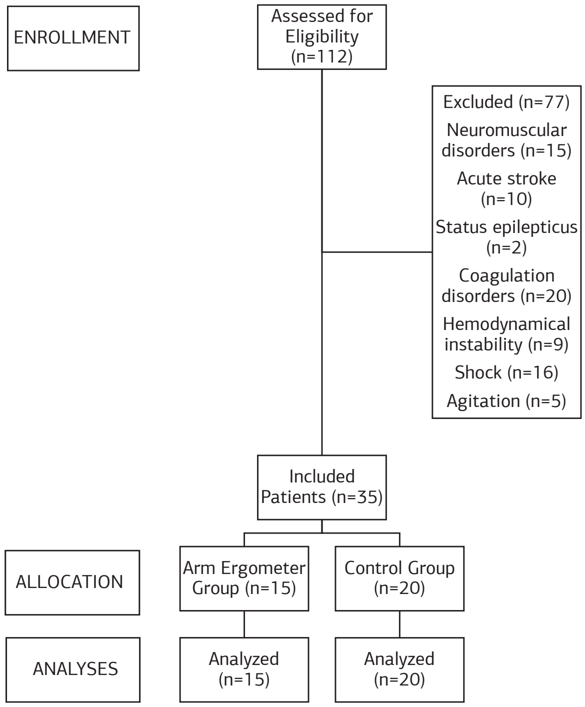

Figure 1: Flow Diagram of the Study.

cardiopulmonary responses recorded during ACE exercise. IBM SPSS 22.0 (Statistical Package for Social Sciences, IBM, New York, USA) program was used to analyze the data. The descriptive level of significance was $p<0.05$. Post hoc power calculations of this study yielded a statistical power of 56%.

RESULTS

The study was carried out with 35 patients who met the inclusion criteria among the patients hospitalized in the medical ICU. We included 15 patients in the study group and 20 patients in the control group.

There were no significant difference between-group differences regarding demographic and clinical characteristics ($p>0.05$, Table 1). All patients had respiratory failure. Nine patients (60%) in the ACE group and 15 patients (75%) in the control group had heart disease. One patient (7%) in the ACE and one patient (5%) in the control group had hematological problems. Five patients (33%) in the ACE and seven patients (35%) in the control group had endocrine issues. One patient (7%) in the ACE had an infection, one patient (5%) in the control group had septic shock. Two patients (13%) in the ACE group and two patients (10%) in the control group had kidney disease and one patient (7%) in the ACE group and three patients (15%) in the control group had dementia. The OAI, length of stay in ICU, and length of rehabilitation were similar between the ACE and control group patients ($p>0.05$, Table 1).

The recorded data by the device is given in Table 2. Five patients performed passive cycling during all their sessions. There were no significant differences between the ACE training outcomes on the first and second days, and the final treatment session ($p>0.05$).

Cardiopulmonary responses of the patients during ACE are shown in Figure 2 and Table 3. On the first day of the ACE exercise, respiratory frequency showed a significant change during treatment ($p<0.05$). Heart rate, systolic, and diastolic blood pressure and SpO_2 did not change significantly during exercise ($p>0.05$) (Figure 2). On the second day of the ACE exercise, respiratory frequency, heart rate, systolic blood pressure, and SpO_2 showed a significant change during exercise ($p<0.05$) (Figure 2). Diastolic blood pressure was the same during

Table 4: The Mean Baseline and Discharge Scores for Ambulation Score and Barthel Index

Variables	Arm Ergometer Group (n=15)	Control Group (n=20)	Time p	Group Time p
	Mean±SD	Mean±SD		
Ambulation Score				
Baseline	1.46±2.07	2.95±1.93	**<0.001***	0.096
Discharge	3.20±2.18	3.75±2.22		
Barthel Index				
Baseline	21.00±33.07	28.50±27.39	**<0.001***	0.957
Discharge	44.66±38.05	51.75±38.19		

One Way ANOVA, *p<0.05

exercise ($p>0.05$) (Figure 2). On the last day of the ACE training, respiratory frequency did not show any significant change during exercise ($p>0.05$) (Figure 2). Heart rate, systolic, and diastolic blood pressure, and SpO_2 showed a significant change during exercise ($p<0.05$) (Figure 2).

Two out of 45 training sessions were terminated due to fatigue, and one session was terminated due to shortness of breath, two sessions were terminated due to heart rate over 130 bpm. One session was terminated due to blush and sweat, two sessions were terminated due to the decrease in blood pressure more than 20%. One session was terminated due to SpO_2 falling below 90%.

At discharge, the level of consciousness of five patients in the ACE group, one patient in the control group, became 15, according to GCS. Table 4 shows intergroup changes within-group comparisons of functional levels. An inter-group comparison revealed significant improvements in Ambulation Score and Barthel Index in both groups ($p<0.05$) (Table 4). There were no significant differences in the functional level between the groups ($p>0.05$).

DISCUSSION

This study is the first to examine the practicality and effectiveness of early exercise training in a selection of acute critically ill patients with an expected prolonged ICU stay. We showed that an individually adjusted exercise protocol could be performed in critically ill patients. The ACE training can be applied in the ICU daily, and is safe and feasible to perform.

In this study, ACE protocol, applied by Burtin et al., for the arm ergometry training, was used (15). When we searched for studies investigating the effects of ACE training, we found that the conscious state, according to the GCS was 15 (normal conscious level) (21,22,29). According to the GCS, the level of consciousness, 46% of patients in the ACE group were a score of <14-15. For this reason, the study of Burtin et al., which explained in detail the educational protocol applied in the unconscious patient group, was taken as reference in this study (15).

An ACE device that can be carried easily and comfortably from patient to patient was used in the study. The intensity of exercise could be adjusted according to the patient's condition and the physiological responses to exercise. In patients with unconsciousness, the hands were fixed to the ACE and performed passive cycling movements at 20 rpm for 20 min. When the patients started to regain consciousness, they cycled the ACE in the rate and resistance they could tolerate following their condition. The patients' training sessions were planned to be divided into 10-minute sessions, but the patients were not interrupted as they did not want to take a break or did not necessitate a break. The presence of vascular catheters did not cause any limitations during arm exercises.

Cardiopulmonary responses of the patients during the training period were closely monitored to ensure the safety of ACE training. There was no change in heart rate, systolic, and diastolic blood pressure except respiratory frequency. In the second session, respiratory frequency, heart rate, systolic pressure changed, while diastolic blood pressure was similar. Change in all hemodynamic responses except the respiratory frequency was observed in the last session. Oxygen saturation was similar in the first session, but it changed during the second and last sessions. Despite the statically significant changes in hemodynamic responses, they were not

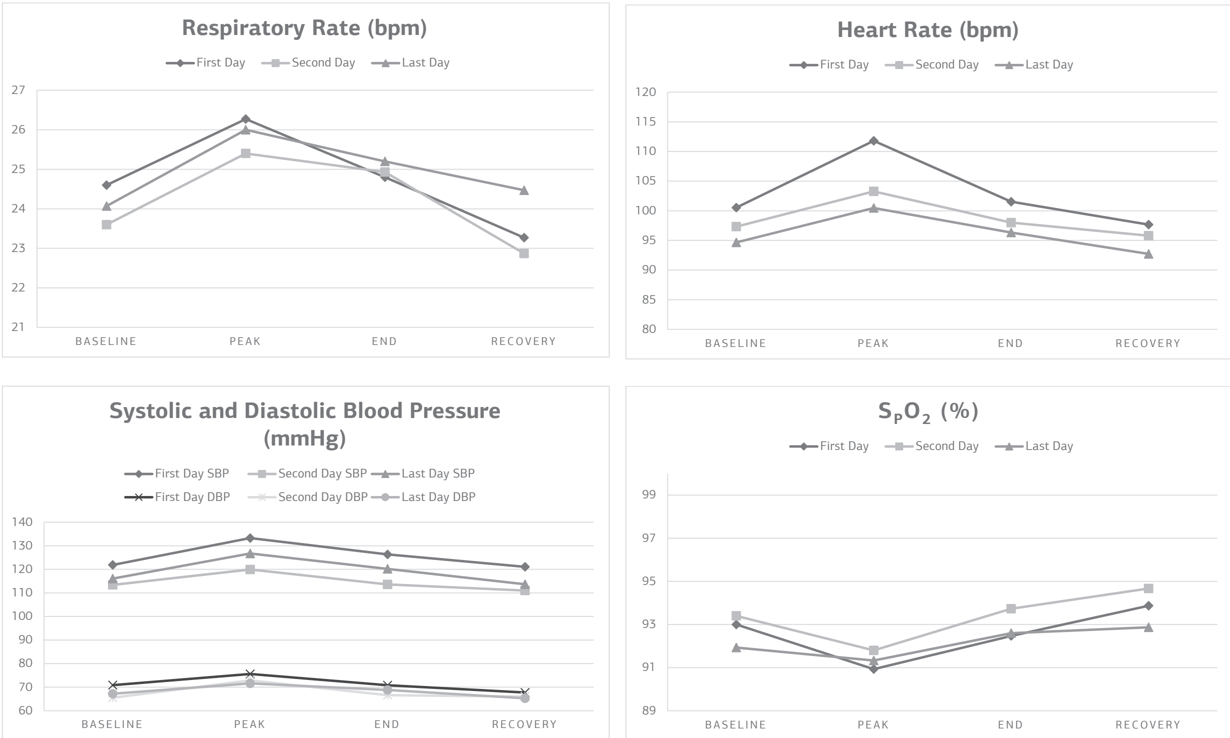

Figure 2: Cardiopulmonary Responses during Arm Cycling Exercise.
Repeated measures ANOVA.

clinically significant as the responses stayed within the limits.

A single training session, including installation, removal, and cleaning, last for 30-40 minutes, depending on the patient's cooperation. Similar to a previous study, it was observed that exercise with ergometer motivated most of the patients, and they found this activity amusing (18). On the other hand, it also caused some patients to think that the session would be exhausting. In this sense, encouraging patients during exercise sessions was quite significant (18). This study pointed out that an individually adjusted exercise protocol could be safely applied to critical patients during the ICU stay. This consequence may bring a new perspective to the clinical practice of physiotherapy and rehabilitation of hospitalized patients in ICU because of the critical illness.

We did not find any study investigating the safety of ACE in unconscious patients in the literature. However, a few studies demonstrate that patients ACE is safe to use in consciousness staying at ICUs (21, 22).

In this study, the functional levels of the patients at discharge were similar between the ACE and the control groups. Most patients in the groups could not stand up or walk independently at discharge. The ACE training could not prevent the effects of the ICU stay on the functional status of patients. It may be the consequence of patients being discharged when their cardiorespiratory status is stabilized, independent of their functional status. Additionally, the sample size calculation of our study showed that requiring 40 people in each group was of considerable significance to make a difference. Therefore, this study was did not enough power to show a statistically significant difference. It was concluded that a randomized investigation of the efficiency of ACE exercise with increased sample size would be more useful.

Some limitations should be noted for this study. Exercise intensity during ACE training was mainly based on the patient's or the physiotherapist's subjective perception of the exercise tolerability. It is planned five days/week for exercises. However, due to the variability of the patients' clinical status, the number of sessions was unequal. However, we thought that it was the real clinical situation in ICU. Therefore, it may not be seen as a significant limitation. Due to the variability of the patients' clinical status, the number of patients could not ensure enough power.

In conclusion, this study is the first to examine the safety and efficacy of ACE training in the early period in acute critically ill patients. Our study demonstrated that an individually adjusted ACE protocol could be followed during the ICU stay in critically ill patients. The ACE training can be performed in the ICU, and is safe and secure. Further study is are needed to determine the effects of ACE exercise training on functional outcomes in critically ill.

Sources of Support: None.

Conflict of Interest: None.

Ethical Approval: Hacettepe University Non-Interventional Ethics Committee approved the study (Approval Date: 14.03.2017 and Approval Number: GO 17/247).

Peer-Review: Externally peer-reviewed.

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