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Effects of functional training on strength, function level, and quality of life of persons in intensive care units

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Objective: The purpose of this study was to investigate the effect of exercise therapy and bedside ergometer exercise on muscle strength, function level, and quality of life of persons in intensive care.
Design: Randomized Controlled Trial
Methods: Sixteen patients in the ICU were randomly assigned to either the exercise group (n=8) or the bedside cycle ergometer group (n=8). Activities in the ICU exercise group (rolling, sitting at the edge of the bed, transfer from sitting to standing, standing balance training, ambulation) and bedside cycle ergometer group were performed 5 times a week for 30 minutes during the ICU admission period. Medical Research Council (MRC) and Functional Status Scale-Intensive Care Unit (FSS-ICU) parameters were assessed at the time of admission to the ICU, and reevaluation was assessed on the day of ICU discharge. The Short Form-36 (SF-36) was assessed at the time of discharge from the ICU.
Results: MRC and FSS-ICU were significantly increased before and after intervention in both the experimental and control groups (p<0.05). There was a significant difference between MRC and FSS-ICU in the comparison of the changes before and after the intervention (p<0.05). SF-36 was compared between groups after intervention and there was a significant difference between the experimental and the control group (p<0.05).
Conclusions: Muscle strength and functional levels improved after intervention in both the experimental and control groups. The ICU exercise group was more effective than the bedside cycle ergometer group to improve muscle strength, functional level, and quality of life performance of persons in the ICU.

Key Words: Exercise, Intensive care units, Muscle strength, Quality of life, Rehabilitation

Introduction

In the 2012 issue of Society of Critical Care Medicine, the concept of 'Post Intensive Care Syndrome' was proposed to affect the cognitive, physical, and mental health of persons in the Intensive Care Unit (ICU) and their families after discharge [1,2]. Long-term hospital stay in the ICU may lead to complications, such as deterioration, muscle atrophy, dyspnea, depression, and generation of fear, which degrades the quality of life related to health [3,4]. There has been a 5% to 10% increase in the ratio of long-term bed rest for severe chronic diseases in the ICU [5,6]. Persons in the ICU exhibit muscular dysfunction due to corticosteroids, muscle relaxants, and neuromuscular blockers used for inactivity and inflammation [7,8]. In addition, muscle weakness was most prominent during the second to third week of ICU stay. Patients who were expected to have bed rest for as long as possible should avoid premature muscle weakness and muscle loss [9]. The European Respiratory Society and the European Intensive Care Medicine Association recommend that active and passive exercises be initiated early in the ICU [9].

In order to prevent or reduce neuromuscular complications with physical therapy, it is necessary to perform passive upper and lower extremity range of motion exercises,

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postural exercises, muscle strengthening exercises, standing, and walking [10,11]. Domestic and international research has shown the effects of respiratory physiotherapy for patients admitted to the ICU and the evaluation of clinical physical therapy for patients in the ICU and found that step-by-step exercises and movements in the ICU were among many relevant respiratory-based physical therapy interventions [12,13].

However, studies on Intensive Care Unit Acquired Weakness (ICUAW) are increasing domestically, but there is not much intervention for prevention and treatment of ICUAW. The diagnosis of ICUAW considers of preventive treatment [14], and the limb circumference and limb muscle area of the ICU patients [15]. However, there is a lack of research on preventive, functional, and exercise treatment for the occurrence of ICUAW and related factors in persons in the ICU.

The purpose of this study was to investigate the effects of muscle strength and functional training before and after applying exercise therapy and bedside ergometer exercise in persons in ICU, and to identify its effects on the quality of life after ICU discharge.

Methods

Participants

The subjects of this study were 16 persons admitted to the ICU in Chungnam National University Hospital in Daejeon who fully understood and agreed to exercise therapy and bedside ergometer exercises. The criteria for selecting the subjects were as follows: those who were communicative, had no contractures or limitations of the upper limb joints, were in the ICU for at least 5 days, and those who were able to walk independently before admission to the ICU. The exclusion criteria included those with chronic respiratory failure before admission to the ICU, damage to the leg, pelvis, and back, trauma surgery, severe pressure ulceration, neurological diseases affecting muscle strength, and finally, those who had signed a do not resuscitate consent form.

All procedures and methods of this study have been approved by the Institutional Review Board of Chung Nam National University Hospital (IRB No. CNUH 2017-05-028) and follow the principles outlined in the Declaration of Helsinki.

Procedure

The subjects were randomly divided into two groups, with 8 subjects in the exercise therapy group and 8 subjects in the bedside ergometer exercise group (Figure 1).

Exercise therapy consisted of postural and passive or active exercises. Exercise interventions such as strength, postural, balance, and gait training were performed on the subjects [16]. The interventions were conducted by a physiotherapist from the ICU physical therapy department, and the intervention period was during the ICU admission period; the number of interventions was recorded for each subject. Types of functional training included: (1) rolling, (2) sit to stand training, (3) sitting on the end of the bed, (4) standing starting from a sitting position, and (5) dynamic sitting posture balance training/dynamic postural balance training, and (7) gait (Figure 2). The subject began with active range of motion exercises and functional training in supine position and proceeded gradually according to the subject's condition. The exercises consisted of progressive strengthening exercises, movement in bed after stretching, rolling in bed, standing up from the sitting position, and postural alignment while sitting on the end of the bed.

The bedside ergometer exercises (Figure 3) included endurance and strength training, and the subject was instructed to perform passive, active assisted exercise, or active exercises. The intervention period was conducted during the ICU admission period and the number of interventions per was recorded. The control group received a bedside ergometer exercise program for five days a week and used a MOTOmedLetto 2 (Reck-Technik GmbH & Co. KG, Betzenweiler, Germany). This equipment can be operated passively or actively and can adjust the resistance level during active exercise. The goal of each exercise time was a personally adjusted intensity for 30 minutes. Those who received sedation were to perform passive exercise for 30 minutes. When the patient was able to exercise, they would proceed in two 15-minute sessions with a resting period in between. The exercise intensity was assessed at every exercise session and resistance was increased by one increment depending on the condition of the subject [17]. The intervention period was five times a week during the hospital stay in the ICU.

Outcome measures

Muscle strength

The Medical Research Council (MRC) is commonly used as a measurement tool to assess muscle strength within the ICU. MRC evaluates the deltoid, biceps, and wrist extensor muscles of the upper limb, and the hip flexor, quadriceps, and anterior tibial muscles of the lower limbs. Both the upper and lower limb muscles were assessed and reevaluated

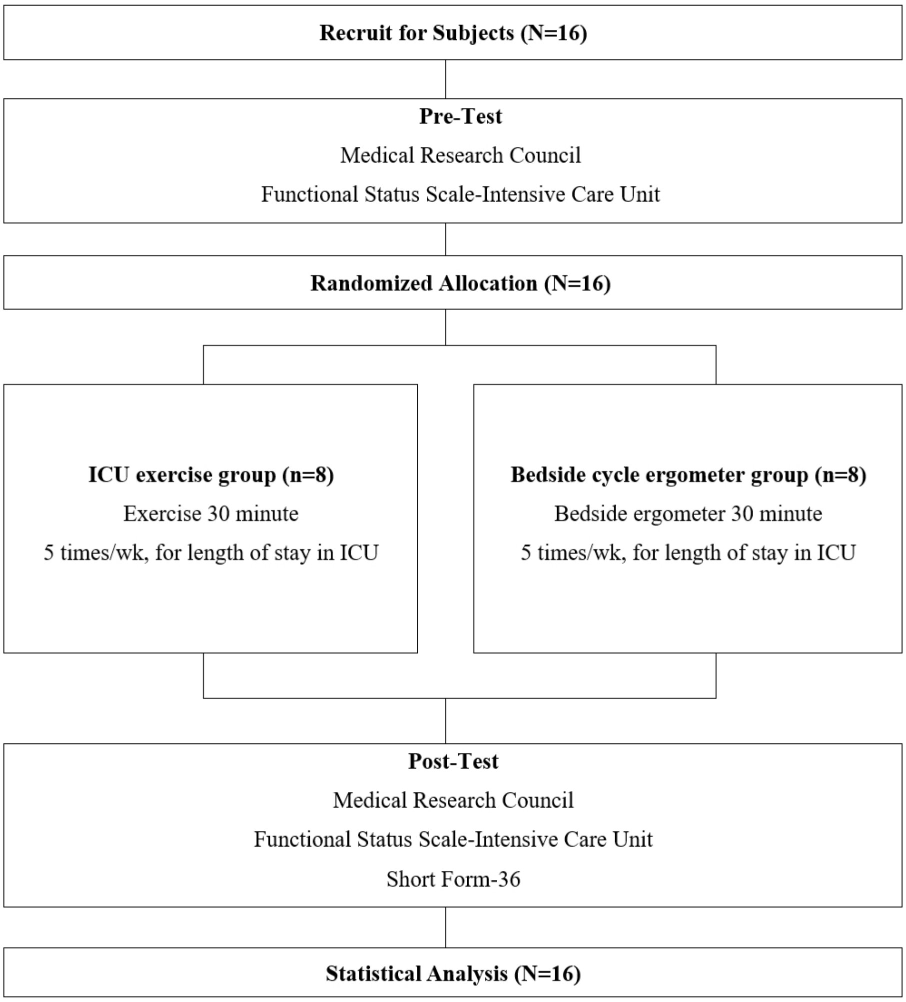

Figure 1. Flowchart of participants through the trial. ICU: Intensive Care Unit.

Figure 2. Intensive Care Unit exercise. (A) Dynamic sitting balance training (B) transfer from sit to stand. (C) Ambulation.

Figure 3. Bedside cycle ergometer.

before and after the intervention. The score is evaluated from 0 to 5 points and consists of a total of 60 points. A 0 point indicates no muscle contraction, 1 point indicates motion but no muscle contraction, 2 points indicate full motion range without gravity, 3 points indicate gravity full motion range, 4 points indicates moderate resistance, range of motion, and 5 points indicate normal muscle strength [18].

Functional level

The Functional Status Scale-Intensive Care Unit was developed to assess the functional levels in the ICU environment. The items are divided into a pre-walking item and a walking item. The pre-gait items can be carried out on the bed, rolling, sitting in the lying position, sitting without support, and the gait items consist of standing and standing from the sitting position as a functional movement out of the bed. The functional level evaluation consists of 5 items. A 0 point indicates it is not possible, 1 point indicates fully assisted, 2 points indicate maximum possible, 3 points indicate moderate, 4 points indicate minimum. If possible, 5 point can be assessed as possible if supervision is possible, 6 points indicate modified independence, 7 points will be assessed as completely independent if possible, score is 8 point points, minimum 0 point to maximum 35 points. The higher scores indicate higher level of performance of the subject [19].

Quality of life

The Short Form-36 consists of 8 domains: physical functioning, social functioning, role limitation due to physical health problem, role limitation due to emotional problems, general mental health, vitality, bodily pain, and general health [20].

Table 1. General characteristics of subjects (N=16)

Characteristic	ICU exercise group (n=8)	Bedside cycle ergometer group (n=8)	χ^2/F
Sex (male/female)	6/2	3/5	0.617
Age (y)	67.37 (10.82)	66.50 (8.66)	0.178
APACHE	21.25 (3.10)	21.87 (5.38)	−0.284
ICU length of stay	22.37 (8.86)	24.00 (4.27)	−0.467
Mechanical ventilator duration	14.50 (7.23)	13.50 (4.10)	1.213

Values are presented as number only or mean (SD).
ICU: Intensive Care Unit, APACHE: Acute Physilolgy and Chronic Health Evaluation.

Data and statistical analysis

Data collected in this study were analyzed using PASW Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, IL, USA). The general characteristics of the subjects were presented as mean and standard deviation by descriptive statistics. Chi-square test and independent sample t-test were performed to evaluate homogeneity in the exercise and bedside ergometer group. The Wilcoxon signed rank test was used to analyze changes in muscle strength and functional assessment indices before and after treatment in each group. The Mann-Whitney U-test was used to assess group-to-group differences in muscle strength, functional motion, and quality of life. The significance level was set at $p<0.05$.

Results

A total of 16 subjects participated in the study. The results were not statistically significant in age, sex, Acute Physiology and Chronic Health Evaluation, ICU length of stay, and mechanical ventilator duration between the two groups ($p>0.05$). The general characteristics of the subjects are shown in Table 1.

There was a significant increase in muscle strength in both the experimental group ($p<0.05$) and the control ($p<0.05$). There was a significant difference between the two groups in terms of the changes before and after intervention ($p<0.05$) (Table 2).

There was a significant increase in functional level in both experimental and control groups ($p<0.05$). There was a significant difference between the two groups ($p<0.05$) (Table 2).

The quality of life was compared between the experimental and the control group after intervention. In the ex-

Table 2. Comparative analysis of MRC and FSS-ICU (N=16)

Variable	ICU exercise group (n=8)	Bedside cycle ergometer group (n=8)	Z (*p*)[a]
MRC			
Pre	34.75 (9.14)	34.75 (6.01)	−0.106 (0.916)
Post	45.62 (4.34)	39.75 (6.29)	−1.835 (0.067)
Change	10.87 (7.14)	5.00 (1.69)	−2.042 (0.041)
Z (*p*)[b]	−2.375 (0.018)	−2.565 (0.010)	
FSS-ICU			
Pre	11.00 (4.84)	10.50 (3.96)	−0.317 (0.751)
Post	17.12 (6.24)	12.12 (4.12)	−1.640 (0.101)
Change	6.12 (2.58)	1.62 (1.06)	−3.196 (0.001)
Z (*p*)[b]	−2.536 (0.011)	−2.392 (0.017)	

Values are presented as mean (SD).
ICU: Intensive Care Unit, MRC: Medical Research Council, FSS-ICU: Functional Status Scale-Intensive Care Unit.
[a]Mann-Whitney U test. [b]Wilcoxon signed rank test.

Table 3. Comparative analysis of SF-36 after intervention (N=16)

Variable	ICU exercise group (n=8)	Bedside cycle ergometer group (n=8)	Z (*p*)
PF	60.62 (27.18)	36.87 (8.42)	−1.748 (0.080)
SF	71.25 (5.66)	39.06 (10.43)	−3.437 (0.001)
RL PHP	68.75 (22.16)	34.37 (12.93)	−2.902 (0.004)
RL EP	95.83 (11.77)	37.47 (11.80)	−3.623 (<0.001)
GMH	67.50 (7.83)	46.50 (9.54)	−2.976 (0.003)
Vitality	66.25 (6.94)	41.25 (5.82)	−3.403 (0.001)
Bodily pain	76.25 (7.55)	50.93 (5.65)	−3.467 (0.001)
GH	63.12 (9.23)	42.50 (5.97)	−3.184 (0.001)
Total score	71.19 (7.93)	41.11 (5.02)	−3.363 (0.001)

Values are presented as mean (SD).
SF-36: Short Form-36, ICU: Intensive Care Unit, PF: physical functioning, SF: social functioning, RL PHP: role limitation due to a physical health problem, RL EP: role limitation due to emotional problems, GMH: general mental health, GH: general health.

perimental and the control group, social functioning, role limitation due to physical health problems, role limitation due to emotional problems, general mental health, vitality, pain, general health and quality of life were significantly different after intervention ($p<0.05$) (Table 3).

Discussion

Subjects in the ICU suffered from cognitive, physical, and mental health problems for a month or a year after discharge. Physical health-related problems included weakness in mobility, reduction in bed activity, decreased ability to walk, and mental health problems, such as anxiety and depression [5]. This is a case of ICUAW, which can be explained by critical illness myopathy, critical illness polyneuropathy and myopathy, and critical illness polyneuropathy [21]. Severe disease muscle neuropathy is characterized by changes in muscle and sensory nerves, and severe myopathy is characterized by limb paralysis [22]. Muscle weakness and dysfunction were reported in 25% of ICU patients [23], and the development of management of mechanical ventilation improved patient outcomes and survival [24]. Muscle weakness and dysfunction cause further complications and are associated with dysfunction and long-term rehabilitation [2,6]. The muscular atrophy process begins within 72 hours and may be associated with loss of muscle mass and muscle loss within 10 days after bed rest in healthy and nutritious muscles [22]. Interventions aimed at improving functional recovery may not only minimize or improve physical function, but may also affect cognitive processes and emotional health. Therefore, measurements that evaluate these aspects should be investigated at various points in time [23]. It is recommended that interventions for rehabilitation treatment of ICUs should be implemented early in order to reduce the duration of ICU length of stay and to prevent complications in the ICU [9]. The purpose of this study was to investigate the effect of exercise therapy and bedside ergometer exercise on muscle strength, function level, and quality of life of persons in the ICU. Positive effects on strength, functional level, and quality of life were confirmed through interventions during the subject's stay in the ICU.

In the ICU, muscular strength and muscle endurance were influenced by exercise therapy and bedside ergometer exercises. This trial shows that both muscle strength and functional level outcomes of persons with critical illness on mechanical ventilation can be improved by the implementation of exercise therapy and bedside ergometer exercise [22]. The reason why there was a significant difference in muscle strength in the functional training group was that the dynamic and functional training intervention also affected muscle strength. There was a significant difference between the exercise group and the general treatment group in correlation to maximum walking distance with improvement of muscle strength [23]. Bridge exercise performance as a bed mobility exercise can strengthen the hip and trunk muscles, and trunk muscle training affects the core muscles [25]. Improvement of walking speed and balance ability and functional ability occurs by strengthening the hip muscles [26].

There is an increasing interest in assessing the level of physical functioning of severely ill patients and studies are being conducted to evaluate ICU-based interventions that can reduce these disorders [27-29]. In the exercise group, functional training, such as bedside functional training, balance training, and gait training assisted to improve physical performance or functional level [29]. Active functional training and rehabilitation in the ICU is consistent with research that improves functional levels, reduces movement restrictions, and improves muscle strength and gait ability [27]. Exercise improves cardiopulmonary endurance by strengthening postural control muscles and inspiratory muscle strength [30].

Persons with psychological disturbances such as depression, anxiety, and fear may also experience physical disabilities in the ICU [1]. Patients after ICU discharge are more likely to have anxiety and depression, higher dependence, and lower quality of life due to psychological related quality of life and health related quality of life [31]. There was a significant difference in the quality of life between the two groups in the ICU. It is consistent with the study that the quality of life was improved by improving muscle strength, functional training and gait training.

The factors affecting the quality of life after ICU discharge were physical strength, functional level, and physical activity level. Therefore, a gradual exercise program intervention is needed [12].

As a result of this study, the following limitations were noted: First, it consisted of patients who could cooperate with exercise therapy. Thus, these findings have limited application for all persons in the ICU. Second, a prospective screening for the presence of critical illness or neuromuscular abnormalities in all subjects was not performed.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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