

Ruy Camargo Pires-Neto¹, Aná Luiza Pereira¹,
Camila Parente¹, Guadalupe Nery de Sant'Anna¹,
Daniela Daguer Esposito¹, Aline Kimura¹, Carolina
Fu^{1,2}, Clarice Tanaka^{1,2}

Characterization of the use of a cycle ergometer to assist in the physical therapy treatment of critically ill patients

Caracterização do uso do cicloergômetro para auxiliar no atendimento fisioterapêutico em pacientes críticos

1. Physical Therapy Service, Central Institute, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo - USP - São Paulo (SP), Brazil.

2. Speech-language Pathology, Physical Therapy and Occupational Therapy Department, Faculdade de Medicina, Universidade de São Paulo - USP - São Paulo (SP), Brazil.

ABSTRACT

Objective: The objective of this study was to use a cycle ergometer to assess cardiorespiratory changes during active exercise and to verify patients' satisfaction with this type of activity.

Methods: A single intervention involving active lower limb exercise was performed with a cycle ergometer (without load) for 5 minutes. The following variables were measured before, during and immediately after exercise: heart rate, blood pressure, respiratory rate, peripheral oxygen saturation and the Borg dyspnea scale score. Following the exercise, the patients answered a questionnaire to evaluate their satisfaction with this type of activity.

Results: A total of 38 patients (65% male) with a mean age of 48 ± 16 years old participated in the study. Enrolled patients presented a sequential organ failure assessment (SOFA) score of 2 (0 - 5 scale).

During the exercise, 16% of the patients used ventilation support and 55% of them were breathing at room air. A comparison of the initial and final values of the variables indicated increases in the heart rate (92 ± 17 beats/min vs. 95 ± 18 beats/min; $p < 0.05$), the respiratory rate (19 ± 8 breaths/min vs. 23 ± 8 breaths/min; $p < 0.05$) and the Borg dyspnea scale score (1.3 ± 1.8 vs. 2.8 ± 2.2 ; $p < 0.05$). In addition, 85% of the patients reported enjoying the activity. Only 25% of the patients reported some discomfort, and 100% of the patients wanted to repeat this type of activity in future treatments.

Conclusion: During the cycle ergometer exercises, minor cardiorespiratory changes were observed in the patients. The evaluated patients reported high satisfaction with this type of activity.

Keywords: Physiotherapy; Intensive care units; Early mobilization; Exercise; Dyspnea; Hemodynamics

This study was conducted at the Respiratory Intensive Care and Clinical Emergency Units of the Central Institute of the Hospital das Clínicas da Universidade de São Paulo – São Paulo (SP), Brazil.

Conflicts of interest: None.

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Corresponding author:

Ruy Camargo Pires-Neto
Faculdade de Medicina, Universidade de São Paulo
Avenida Dr. Arnaldo, 455, sala 1.155, 1º andar
E-mail: ruy@usp.br

INTRODUCTION

Intensive care units (ICUs) focus primarily on life support and the treatment of acutely ill patients with clinical instability.⁽¹⁾ Other factors that are associated with the cause of hospitalization can worsen a patient's condition. The time under mechanical ventilation and drugs, such as corticosteroids and neuromuscular blockers, can lead to conditions related to generalized muscle weakness (including the diaphragm) and polyneuropathy.⁽²⁻⁴⁾ Consequently, a patient's physical capacity and quality of life can be compromised, and these changes may persist for years after the patient is discharged from the hospital.^(5,6)

Recent studies have highlighted the role of physical therapy in the ICU.⁽⁷⁻¹⁰⁾ Physical therapy can lead to decreased time of mechanical ventilation,⁽¹⁰⁾ ICU hospitalization and regular hospitalization;⁽⁹⁾ reduced loss of muscle strength; and improved functional capacity.^(8,10,11)

Physical therapy procedures that are performed in the ICU cause minor hemodynamic changes and are considered to be safe and feasible for most patients.^(12,13) The cycle ergometer is a stationary device that allows cyclic rotations and can be used to perform passive, active and resistance exercises.⁽¹⁴⁾ Despite the frequent outpatient use of the cycle ergometer to rehabilitate patients with chronic obstructive pulmonary disease (COPD),⁽¹⁵⁾ few studies have evaluated the cycle ergometer for ICU patients.^(8,11,16,17)

Porta et al. were the first authors to use cycle ergometer devices. However, the exercises only started after the weaning of mechanical ventilation, and the exercises were performed with the upper limbs (ULs).⁽¹⁷⁾ The studies by Burtin et al. and Dantas et al. suggest that the early use of this device (during mechanical ventilation assistance) increases muscle strength and is associated with improvements in functional capacity.^(8,11)

Cycle ergometer use with lower limbs (LLs) is uncommon, though this method has benefits and can assist with a patient's functional recovery process. There are few reports on the cardiorespiratory changes that LL cycle ergometer exercises can promote, and no studies have verified the patients' acceptance of performing this type of activity in the ICU. The present study used a cycle ergometer to evaluate the associated cardiorespiratory changes and to verify the patients' satisfaction with the device.

METHODS

The present study was a case series that was performed between August and November 2011 in the Respiratory Intensive Care or Clinical Emergency Units of the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP). The study was approved by the HCFMUSP Ethics Committee for the Analysis of Research Projects (Comissão de Ética para Análise de Projetos de Pesquisa - CAPPesq; protocol number 0543/10), and all patients signed an informed consent form before participating in the study.

The inclusion criteria were patients older than 18 years old, patients with an adequate level of consciousness that allowed them to perform the proposed activity (Glasgow coma scale - GCS=15; for patients on mechanical ventilation, GCS=11), patients with a minimum mean LL muscle strength of 3,⁽¹⁸⁾ patients who were hemodynamically stable,⁽¹⁰⁾ patients without severe heart disease (grade IV congestive heart failure and myocardial infarction less than 72 hours before the intervention) or

restrictions for LL movements (osteoporosis, external fixation or neurological disease that prevented active movements) and patients who agreed to participate in the study by signing the informed consent form. Each patient was assessed only one time.

The exclusion criteria were active bleeding, dialysis or agitation that required sedation on the day of the intervention. After patients received medical approval for performing the exercises, they were reassessed every day until their last day of ICU hospitalization. If a patient was hemodynamically stable, the presence of invasive or non-invasive mechanical ventilation and vasoactive agents were not considered to be exclusion criteria. When vasoactive agents were used, patients were considered to be hemodynamically stable if there was no need to increase the infusion rate before the intervention.

Study protocol

Patients were initially positioned in a seated position with the spinal column supported, and a cycle ergometer (Cajumoro®, São Paulo, Brazil) was connected to the LLs. At the command of one of the researchers, the patients actively pedaled the cycle ergometer for 5 minutes. While a specific pace was not specified, every patient was asked to pedal as fast as possible and to maintain the same pace for 5 minutes. The protocol was conducted only once during the patients' hospitalization. If hemodynamic instability occurred or discomfort was reported by a patient,⁽¹⁰⁾ the exercise was stopped and the data were recorded.

Using a Dixtall DX2020 monitor (Manaus, Brazil), the following variables were measured before, during (halfway through) and immediately after the exercise: heart rate (HR), respiratory rate (RR), blood pressure (BP), peripheral oxygen saturation (SpO₂) and the modified Borg dyspnea scale score (Borg) (as a rate of perceived exertion). Following the exercise, the patients completed a 5-question questionnaire (Table 1).

Statistical analysis

The statistical analysis was performed with the program *GraphPad Prism 5.0 for Windows*. The variables HR, RR, BP, SpO₂ and Borg were analyzed using an

Table 1 - Questionnaire applied to the participants

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| <ol style="list-style-type: none"> 1) Do you think you can pedal? (Asked before the exercise) 2) On a scale of 0 to 10, how much did you enjoy this activity? 3) Between pedaling and free leg movement, which one do you prefer? 4) Would you like to perform this activity on your next physical therapy session? 5) Did you feel any discomfort during this activity? Describe it. |
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analysis of variance (ANOVA) for repeated measures, and Bonferroni correction or the Friedman test with Dunn's post hoc testing were applied according to the normality of the data distribution (Kolmogorov-Smirnov test). The correlation analyses of the HR, RR and Borg variables were performed using Spearman's correlation test. The other variables, such as the questionnaire results, were presented descriptively. P-values <0.05 were considered to be significant.

RESULTS

During the sampling period, 38 patients (65% male) with a mean age of 48.4±16.5 years participated in the study. For the positioning of the activity, 11% of the patients performed the exercises in their own beds and 89% of the patients performed the exercises in an armchair or chair. Most patients were hospitalized for clinical reasons (70%) and did not use oxygen or ventilation support at the time of the study (55%). The median hospitalization time for the intervention was 4 days (Table 2). Only one patient was using a vasoactive drug (1 mL/h), and the protocol never needed to be stopped because of hemodynamic instability or discomfort.

Table 3 shows the behavior of the HR, BP, systolic BP, mean BP and Borg variables. After 5 minutes of cycle ergometer exercise, the HR, RR and Borg values increased (p<0.05). This pattern was not observed for systolic BP, mean BP or SpO₂. The mean HR increase was 3% above the initial values, and only one patient experienced an HR increase of more than 20%. The mean RR increase was 20%, and in nine patients, the RR increased by more than 40%. For the Borg variable, the patients initially showed

Table 2 - Sample characterization

Variables	
Age (years)	48.4±16.5
Male	65
Length of hospital stay (days)	4 (1-22)
Respiratory status	
Room air	55
Oxygen therapy	29
Mechanical ventilation	16
Cause of hospitalization	
Clinical	70
Surgical	30
Hemoglobin (g/dL)	9.2 (7-15)
LL muscle strength (MRCS - addition)	29 (18-30)
SOFA	2 (0-5)

LL - lower limbs; MRCS - Medical Research Council Score; SOFA - Sequential Organ Failure Assessment Score. Results expressed as percentages, means±standard deviations or medians (minimum and maximum values).

Table 3 - Variables before, during and after exercise

Variable	Before	During	After
HR (beats/min)	92.4±17.3	95.3±18.2	95.5±18.5 ^p
SBP (mmHg)	119.4±24.3	123±26	120±25
MBP (mmHg)	84 (61-136)	86 (59-162)	88 (68-133)
SpO ₂ (%)	95 (87-98)	95 (88-100)	95 (90-97)
RR (breaths/min)	19 (10-57)	22 (11-57) ^p	23 (14-60) ^p
Borg	1.3±1.7	2.1±1.8 ^p	2.8±2.2 ^{p†}

HR - heart rate; SBP - systolic blood pressure; MBP - mean blood pressure; SpO₂ - peripheral O₂ saturation; RR - respiratory rate; Borg - Borg dyspnea scale; ^p p<0.05 when compared to before; [†] p<0.05 when compared to during. Results expressed as the means±standard deviations or medians (minimum and maximum values).

mild dyspnea and reported moderate dyspnea after the exercise. There was a weak positive correlation between the final Borg and RR variables (r=0.333; p=0.04).

The questionnaire showed that before performing the exercise, 90% of the patients believed that they could pedal. In question 2, the patients were asked about their satisfaction from performing the exercise (0-10 scale). For 84.5% of the patients, the exercise scores were between 8 and 10, and for 15.5% of the patients, the scores were between 4 and 7. For question 3, 95% of the patients reported that they would rather pedal than perform free movements with their legs. According to question 4, 100% of the patients wanted to perform this type of activity in their next physical therapy session. Finally, 26% of the patients reported some type of discomfort during the activity (question 5). The types of discomfort included back pain (n=2), leg pain (n=1), dyspnea (n=3), fatigue (n=3), dizziness (n=1) and discomfort because of the small size of the device (n=1).

DISCUSSION

The present study found that the cycle ergometer exercise in the ICU caused small increases in HR and RR and a slight increase in the sensation of dyspnea. In addition, this type of activity had a high level of acceptance by the patients.

The increased HR in the present study is consistent with previous studies and represents a normal response to physical exercise. Until now, few studies have evaluated the hemodynamic changes that are caused by physical therapy interventions in the ICU. For critical patients, Stiller et al. found that activities such as sitting, standing up and ambling may increase the heart rate by 10% compared to the resting HR.⁽¹⁹⁾ Active and passive LL ambulation exercises increase the HR by 4 to 10%,^(20,21) which are similar values to the 3% increase observed in the present study.

After the exercise, the patients showed a 20% increase

in RR. Like HR, only a few studies have considered increased RR after exercise in ICU patients.⁽¹²⁾ However, the comparison with other ICU studies is difficult, as activities such as active and passive ambulation are usually performed as a series with pauses, whereas the present study focused on continuous activity. The 6-minute walking test is an assessment of individuals' submaximal capacity and is widely used in COPD patients.^(22,23) During the test, the RR increased, and in some cases, there was a positive relationship between RR and perceived exertion.⁽²⁴⁾ In the present study, the variation in RR was similar to that of individuals with recently exacerbated COPD who experienced muscle weakness from hospitalization.⁽²³⁾ Considering that most patients from the present study (60%) had lung disease, the limitations of performing the exercises and the individuals' perceived exertion were likely related to their respiratory capacity (RR) rather than their heart capacity.⁽²⁴⁾ However, the correlation between the final RR and Borg values was weak, and the clinical changes in the variables were small but significant. The patients were instructed to pedal as fast as possible and to maintain the same pace, but their actual pace was not controlled. Thus, they likely pedaled at a speed that was lower than their respiratory capacity could manage, which could explain why the Borg scale and other cardiorespiratory factors did not exhibit greater variation.

The present study may be the first to evaluate patients' acceptance and satisfaction related to performing a cycle ergometer activity in the ICU. A total of 26% of the patients presented complaints about the activity (most often related to the muscle deconditioning in the ICU, which was spontaneously reversed after a few minutes of rest). However, 100% of the individuals wanted to perform the exercise again. Individuals' acceptance and satisfaction with their treatment increases their adherence to a treatment regimen and their persistence regarding the exercise.⁽²⁵⁾ Thus, the introduction of a new exercise, such as the cycle ergometer, that pleases patients may improve active participation in physical therapy sessions and contribute to the hospital rehabilitation process. In the present study, even patients who did not believe that they had the capacity to pedal (10%) performed the activity with no interruptions.

Another interesting finding was that 95% of the patients reported that they would rather pedal than perform free movements with their legs. This question intended to compare a familiar activity that was performed in every session (active LL movements) with the new activity (pedaling). Considering that

patients do not use their LLs across their range of motion (ROM) when pedaling, the replacement of free active movements is not recommended. Rather, physical therapists should add the cycle ergometer as an adjuvant treatment in the ICU.

Some limitations of the present study must be considered. First, the study was developed in only one center, with a small number of patients and no sampling calculation. Most of the sample was comprised of low severity patients, and only one patient was using vasoactive drugs. Thus, the physiological/behavioral data cannot be extrapolated to all ICU patients, especially to patients with more complex or severe conditions. Second, the primary reasons for not including patients in the present study were neurological diagnoses that prevented active movements and palliative care. However, although the data collection was performed consecutively, there are no records of the reasons for not including patients in the study. Third, the short period of exercise evaluation may not be compatible with the evaluation times in other ICUs. Additionally, the real clinical benefits of this activity are not known, as assessing the clinical benefits was not included among the study objectives. Fourth, there was no accurate control of the patients' pace during the 5 minutes of exercise. Thus, the present results may be underestimated. However, the activity is similar to free active exercises (without load) that are routinely performed in ICUs and also have low cardiorespiratory repercussions.

CONCLUSION

In the evaluated patients, the active cycle ergometer caused minor cardiorespiratory changes. This activity is feasible for cooperative ICU patients and was highly accepted by the present patients. All of the patients who performed the cycle ergometer activity in the present study wanted to repeat the activity in future physical therapy sessions.

RESUMO

Objetivo: Analisar as alterações cardiorrespiratórias de pacientes durante o exercício ativo com um cicloergômetro e verificar a aceitação dos pacientes para realizar esse tipo de atividade.

Métodos: Foi realizada uma única intervenção de exercício ativo de membros inferiores no cicloergômetro (sem carga) durante 5 minutos. As variáveis frequência cardíaca, pressão arte-

rial, frequência respiratória, saturação periférica de oxigênio e escala de dispneia de Borg foram avaliadas em três momentos: antes, durante e imediatamente após o exercício. Ao final, o paciente respondia um questionário avaliando sua satisfação em relação a esse tipo de atividade.

Resultados: Participaram do estudo 38 pacientes (65% masculino) com 48 ± 16 anos e SOFA=2 (0-5). Durante o exercício, 55% estavam em ar ambiente e 16% utilizaram algum tipo de suporte ventilatório. Comparando-se os valores iniciais e finais das variáveis analisadas, verificou-se um aumento apenas nas variáveis frequência cardíaca (92 ± 17 e 95 ± 18 ; $p < 0,05$), frequência respiratória (19 ± 8 e 23 ± 8 ; $p < 0,05$) e Borg ($1,3 \pm 1,8$

e $2,8 \pm 2,2$; $p < 0,05$). Além disso, 85% dos pacientes gostaram muito de realizar esse tipo de atividade. Apenas 25% dos pacientes relataram algum tipo de desconforto, entretanto 100% dos pacientes gostariam de repetir esse tipo de atividade em um próximo atendimento.

Conclusão: Nos pacientes estudados, verificaram-se pequenas alterações cardiorrespiratórias durante o exercício com o cicloergômetro. Os pacientes avaliados relataram alta satisfação com esse tipo de atividade.

Descritores: Fisioterapia; Unidades de terapia intensiva; Deambulação precoce; Exercício; Dispneia; Hemodinâmica

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