ORIGINAL ARTICLE

Effect of three different exercise trainings on functional capacity in early stage severe burn patients: A randomized controlled trial

Murat Ali Çınar,[1] Kezban Bayramlar,[1] Ahmet Erkılıc,[2] Ali Güneş,[2] Yavuz Yakut[1]

[1]Department of Physiotherapy and Rehabilitation Hasan Kalyoncu University, Gaziantep-*Türkiye*

[2]Gaziantep City Hospital, General Surgery, Burn Center, Gaziantep-*Türkiye*

ABSTRACT

BACKGROUND: This study investigated the effects of three different exercise protocols on functional capacity in early-stage burn patients.

METHODS: A total of 25 patients hospitalized in the Burn Center (wards and intensive care unit) were included in the study. The individuals were divided into three groups by covariate adaptive randomization according to burn percentage and type: 1 - standard treatment, 2 - standard treatment + aerobic exercise training, 3 - standard treatment + combined exercise (aerobic and resistance) determined by metabolic status. Individuals were evaluated weekly for six weeks from the first day of hospitalization using the 6-minute walk test, physiological cost index, and Medical Research Council muscle-strength measurements to assess functional capacity. A portable metabolism tracker device measured the metabolic status of all patients.

RESULTS: Aerobic exercises and combined exercise (aerobic and resistance), when added to standard treatment and determined by metabolic status, were more effective in enhancing functional capacity than standard treatment alone ($p<0.05$). Patients performing the combined exercise (aerobic and resistance) showed faster improvement in functional capacity determined according to metabolic status than those in the other two groups ($p<0.05$).

CONCLUSION: Aerobic exercises, when added to standard treatment and combined with aerobic and resistance exercises based on metabolic status, are more effective at improving functional capacity than standard treatment alone. Further controlled studies are required to explore the potential long-term benefits of this approach.

Keywords: Aerobic exercise; burns; functional capacity; metabolism; physiotherapy.

INTRODUCTION

Burn injuries, a major trauma, significantly affect the musculoskeletal system and functional capacity. They induce profound hypermetabolic and catabolic reactions that can persist for months or even years.[1] A significant loss of plasma fluid occurs due to increased vascular permeability following burn injuries.[2] This is accompanied by an increase in heart rate and peripheral vascular resistance.[2-4] As the severity of these cardiac changes increases, so too does the mortality and morbidity.[2-4] Consequently, conditions such as decreased plasma volume, release of inflammatory cytokines, hypoxia, and hypermetabolic responses contribute to cardiac dysfunction after burns, negatively impacting functional capacity [2-4]. These effects occur as a result of prolonged hospitalization and a posttraumatic hypermetabolic state in all burn patients [3-5]. Therefore, improving functional capacity is a primary goal of rehabilitation in burn patients [3-5]. Although literature re-

Cite this article as: Çınar MA, Bayramlar K, Erkılıc A, Güneş A, Yakut Y. Effect of three different exercise trainings on functional capacity in early stage severe burn patients: A randomized controlled trial. Ulus Travma Acil Cerrahi Derg 2024;30:562-570.

Address for correspondence: Murat Ali Çınar
Hasan Kalyoncu University, Gaziantep, Türkiye
E-mail: muratali.cinar@hku.edu.tr

Ulus Travma Acil Cerrahi Derg 2024;30(8):562-570 DOI: 110.14744/tjtes.2024.59987
Submitted: 04.03.2024 Revised: 27.06.2024 Accepted: 14.07.2024 Published: 02.08.2024

ports suggest that exercise is a safe and effective method for improving functional capacity in burn patients, research in this area is limited.[6] Exercise has strong evidence supporting its effectiveness in minimizing the effects of burn-induced hypermetabolic response, preventing muscle atrophy, improving pulmonary function, enhancing functional capacity, preventing contractures, and aiding in but healing.[5-6] Recent studies on exercise protocols applied in burn patients have shown that the protocols differ among physiotherapists and that there is no standardization at the international level.[1-8]

In light of this information, the present study was planned to evaluate the effects of three different exercise protocols on the functional capacity in the early stages of severe burn patients. Additionally, a weekly evaluation of the effects of three different exercise protocols on patients is another aim of the study.

MATERIALS AND METHODS

A total of 25 patients hospitalized in the Burn Center, wards, and intensive care unit of the Ministry of Health at Hasan Kalyoncu University Hospital were included in the study.

Inclusion Criteria

• Conscious and cooperative (according to Glasgow coma score; eye opening (E) spontaneous: 4, follows motor orders (M): 6, verbal (V) response is oriented: 5, E4M6V5),
• Enterally fed,
• Over 18 years of age,
• Able to use a bicycle ergometer,
• Hemodynamic values and vital signs stable and not requiring inotropic medication.

Exclusion Criteria

• Inhalation burns,
• Having other traumas (fractures, loss of limbs, etc.) in addition to the existing burn trauma,
• Organ dysfunctions or multiple organ failures,
• Chronic diseases that may affect respiratory muscle strength, peripheral muscle strength, and respiratory function such as chronic obstructive pulmonary disease (COPD), heart failure, and respiratory/neurological/orthopedic diseases such as diabetes, cholesterol, and blood pressure,
• Unable to use a bicycle ergometer (such as severe lower extremity burns).

Randomization

The individuals included in the study were divided into three groups by a covariate adaptive randomization method according to burn percentage and burn type.[9]

Participants

A total of 25 patients were included in the study: 9 in Group 1, 8 in Group 2, and 8 in Group 3 (Fig. 1).
Group 1 received standard treatment. Group 2 underwent aerobic exercise training with a bicycle ergometer in addition to standard treatment, and Group 3 received both resistance

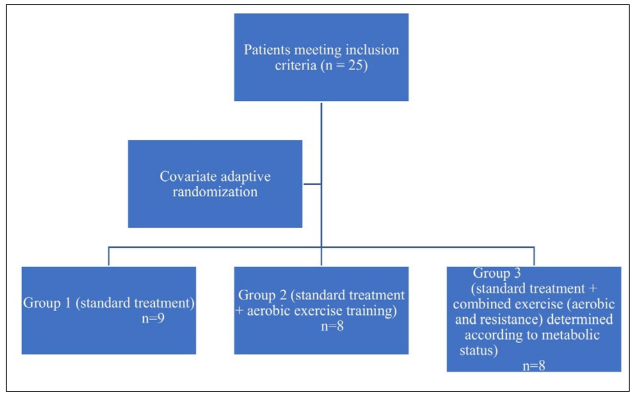

Figure 1. Study flow chart.

and aerobic exercises in addition to standard treatment. The type of exercise (aerobic or resistance) added to the standard treatment was determined based on the metabolic status of each patient (details of this exercise program are provided in the exercise section).

Individuals were evaluated weekly for six weeks from the first day of hospitalization, with treatment protocols applied five days a week. Functional capacity was assessed using the 6-minute walk test (6MWT), Physiological Cost Index (PCI), and the Medical Research Council (MRC) muscle-strength measurement scale. Medical Research Council muscle strength measurements are typically used in intensive care patients. These measurement methods consist of the values of shoulder abduction, elbow flexion, and wrist extension of the upper extremity, and hip flexion, knee extension, and ankle dorsiflexion of the lower extremity. According to the MRC scale, each muscle is scored from 0 to 5, with scores of 48 and below indicating serious muscle weakness.[10]

General information about burn damage, such as burn percentage and type, along with demographic data like age and gender, was recorded.

The 6MWT, PCI, and MRC muscle-strength measurement scores were used to assess functional capacity. The 30-meter corridor of the State Hospital Burn Center was used for the 6MWT, and the distances walked in six minutes were recorded weekly. For PCI, the resting heart rate and walking heart rate of the patients were evaluated with the Adecon DK-8000S device. The PCIs of the patients were calculated and recorded weekly using the formula ([walking heart rate] − [resting heart rate] / [walking speed]). The MRC muscle-strength measurement scale assessed the general muscle strength of the patients.[11-16]

The metabolic status of individuals in Group 3 was evaluated daily using a metabolism tracker device (Lumen®, Metaflow Ltd., Tel Aviv, Israel, registered in the USA).[17-19]

Exercise Interventions

In addition to routine medical care, medical treatment, and surgical treatment, the following exercise programs were applied to all patients included in the study.

Group 1 (Standard Treatment)

Standard physiotherapy exercises, in addition to medical and surgical treatment, were administered five days a week in 30-45-minute sessions. These included normal joint movement exercises, general breathing exercises, bronchial hygiene techniques, ankle pumping exercises, in-bed isometric exercises, isotonic strengthening exercises, and early mobilization starting from the first day.[20-22] (Table 1)

Group 2 (Standard Treatment + Aerobic Exercise Training)

In addition to standard exercises, bicycle ergometry was administered for 20 minutes, five days a week. Patients were asked to pedal a bicycle while seated on the edge of the bed. The Hausse Portable Exercise Pedal Bike, a portable bicycle with an adjustable pedal system, was placed beside the bed for this group. The intensity of bicycle pedaling during aerobic activity was determined using the Rating of Perceived Exertion (RPE) scale, with the pedal resistance set between 10-12 according to the RPE value.[23]

Group 3 (Standard Treatment + Combined Exercise (Aerobic and Resistance) Determined According to Metabolic Status)

In addition to standard exercises, patients performed additional exercises based on their daily measured metabolic status of the patients.

Measurements were taken daily before exercise training while patients were in a 90-degree sitting position on the edge of the bed (Fig. 2).[24] A handheld metabolism tracker device, specifically an exhaled CO2 measurement device, provided accurate assessments of metabolic fuel usage.[24] A device score of 1 or 2 indicated that the body was using fats as the metabolic fuel for energy, ranging from 60% to 100%.[24]

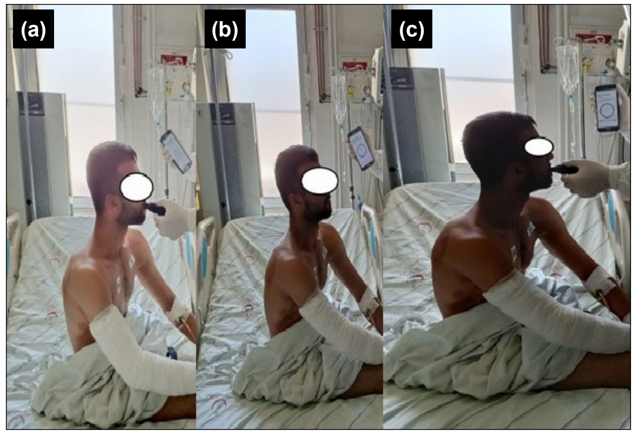

Figure 2. Using the Metabolism Tracker Device. **(a)** Inspiration with the device, **(b)** 10 seconds breath holding process, **(c)** Exhalation with the device.

A score of 3 indicates that the body uses fats and carbohydrates in approximately equal amounts for energy.[24]

The device score of 4 or 5 indicates that the body uses carbohydrates as metabolic fuel for energy at a rate of 60%-100%.[24]

Resistance exercises were preferred when patients used fat as energy. The goal was to use carbohydrates for energy and to create a more balanced metabolic state. If patients used carbohydrates for energy, aerobic exercise was preferred, aiming to use fats for energy and achieve a balanced metabolic state.[24] The details of this exercise algorithm are shown in Figure 3.

A bicycle ergometer for 20 minutes, 5 days a week, was the chosen aerobic exercise training protocol (the same as in Group 2).

Nine exercises identified as resistance exercises were knee

Table 1. Exercises delivered as part of standard treatment[20-22]

	Treatment Properties	Scope of Treatment
Duration of Treatment	30-45 min	
Number of Sessions per Week	5 days	
Mobilization	From the first day of admission onwards	
Ambulation	From the first day of admission onwards	
Post-graft Exercise	Active mobilization after day 3	1. Normal joint mobility (NJM) exercises for non-graft sites for the first 3 days. 2. Breathing exercises
Respiratory Physiotherapy	Breathing exercises based on burn size	1. Bronchial hygiene techniques, coughing training 2. 45° optimal position 3. Diaphragmatic breathing
Exercises	From the first day of admission onwards	1. Active or passive NJM exercises depending on the patient's condition 2. Distal joint mobility exercises 3. In-bed isometric exercises for all upper and lower extremities 5. Isotonic strengthening exercises 6. Posture exercises

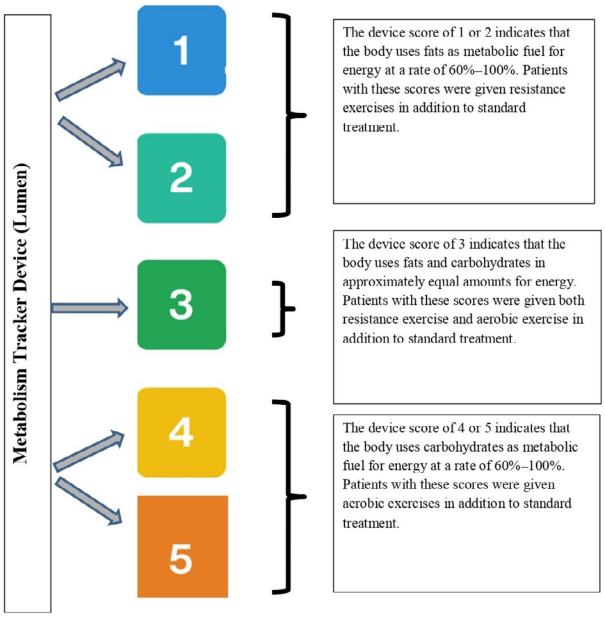

Figure 3. Exercise algorithm for Group 3.

extension, knee flexion, trunk flexion, trunk extension, hip extension, hip flexion, hip abduction, shoulder flexion, and shoulder abduction.[9] SPORDELTA1462-2X1 brand wrist straps with a sandbag set weighing 1-5 kg were used for the exercises. The weights of the sandbags were set at an intensity of 12-14 according to RPE.[22]

Statistical Analysis

The data obtained in the study were analyzed using SPSS Statistics (Statistical Package for Social Sciences) for Windows, version 25.0. Descriptive statistical methods (number, percentage, median, mean, standard deviation) were used to evaluate the data. It was investigated whether the measurement tools showed a normal distribution according to the Shapiro-Wilk test. Accordingly, parametric tests were used when the variables were normally distributed, and nonparametric tests were used when they were not. In the comparison of quantitative data that was normally distributed, one-way analysis of variance was used for differences between more than two independent groups, and the Kruskal-Wallis test was used when the data were not normally distributed. The Friedman test was applied when more than two dependent stages were not normally distributed in the comparison. In the event of a difference, Bonferroni, one of the post hoc pairwise comparison methods, was used. The results of the normality analysis of the scales and their dimensions used in the study are presented in Table 2. According to the Shapiro-Wilk test, a p-value greater than 0.05 indicates normal distribution, while a value less than 0.05 indicates non-normal distribution (Table 2). The power of the study was calculated

Table 2. Results of normality analysis of variables used in the research

Variable	Measurement Time	Shapiro-Wilk		Situation
		Statistic	p	
6MWT	6MWT 1	0.808	0.000	Not normal
	6MWT 2	0.818	0.000	Not normal
	6MWT 3	0.872	0.005	Not normal
	6MWT 4	0.861	0.003	Not normal
	6MWT 5	0.887	0.010	Not normal
	6MWT 6	0.923	0.059	Normal
PCI	PCI 1	0.727	0.000	Not normal
	PCI 2	0.641	0.000	Not normal
	PCI 3	0.686	0.000	Not normal
	PCI 4	0.287	0.000	Not normal
	PCI 5	0.446	0.000	Not normal
	PCI 6	0.237	0.000	Not normal
MRC	MRC_1	0.928	0.078	Normal
	MRC 2	0.971	0.668	Normal
	MRC 3	0.977	0.813	Normal
	MRC 4	0.957	0.359	Normal
	MRC 5	0.917	0.044	Not normal
	MRC 6	0.906	0.025	Not normal

Table 3. Distribution of participants according to their sociodemographic characteristics

	Group 1		Group 2		Group 3		Total		Test Value	p
Variables	n	%	n	%	n	%	n	%		
Sex										
Female	3	33.3	2	25.0	2	25.0	7	28.0	0.365**	1.000
Male	6	66.7	6	75.0	6	75.0	18	72.0		
Percentage of Burn (TBSA)										
25	0	0.0	1	12.5	1	12.5	2	8.0	10.386**	0.364
30	1	11.1	2	25.0	2	25.0	5	20.0		
35	2	22.2	2	25.0	2	25.0	6	24.0		
40	4	44.4	0	0.0	3	37.5	7	28.0		
45	0	0.0	2	25.0	0	0.0	2	8.0		
50	2	22.2	1	12.5	0	0.0	3	12.0		
Type of Burn										
Flame	8	88.9	7	87.5	5	62.5	20	80.0	2.102**	0.590
Electrical	1	11.1	1	12.5	2	25.0	4	16.0		
Chemical	0	0.0	0	0.0	1	12.5	1	4.0		
Age ($\bar{X}$±SD, 31.20±10.34)										
31 age ↓	7	77.8	5	62.5	3	37.5	15	60.0	2.773**	0.271
31 age and ↑	2	22.2	3	37.5	5	62.5	10	40.0		
Total	9	100.0	8	100.0	8	100.0	25	100.0		

using the "Power-3.1.9.2" program. As a result of the analysis applied to 25 participants: (first group=9 patients, second group=8 patients, third group=8 patients), the effect size was found to be 0.6818 at the α=0.05 level, and the power of the study calculated post hoc was 0.819. The minimum power value required for post hoc analysis is 0.67. In this case, the power generated is at an acceptable level and the number of data is sufficient.[25]

RESULTS

A total of 25 patients, 18 males and 7 females between ages 19-56 years, were included in our study. Descriptive characteristics of the individuals are shown in Table 3.

When the 6MWT values were compared according to the groups of the participants, a statistically significant difference was observed between the 4th and 6th measurement 6MWT values (Table 4) ($p<0.05$).

When the in-group 6MWT measurements of the participants were compared, the 4th, 5th, and 6th measurement 6MWT values of Group 3 participants were higher than the 1st measurement (Table 4) ($p<0.05$).

When the PCI values were compared according to the groups of the participants, a statistically significant difference was observed between the PCI values of the 4th and 5th measurements (Table 4) ($p<0.05$). The 4th and 5th measurement PCI values of Group 1 participants were higher than those of Group 3 participants.

When the six measurements of the participants within the group were compared, a statistically significant difference was found between the PCI values of Group 1 and Group 3 (Table 5) ($p<0.05$). The 1st and 2nd measurement PCI values of Group 3 participants were higher than the 6th measurement (Table 5) ($p<0.05$).

When the MRC values were compared according to the groups of the participants, a statistically significant difference was observed between the 1st, 2nd, and 6th measurement MRC values (Table 6) ($p<0.05$). The 1st measurement MRC values of Group 2 participants were higher than those of Group 1 participants. The 2nd and 6th measurement MRC values of Group 3 participants were higher than those of Group 1 participants. When the six measurements of the participants were compared, a statistically significant difference was determined between the MRC values of Groups 1, 2, and 3 (Table 6) ($p<0.05$). The details of the changes within the groups themselves are shown in Table 6.

Table 4. Comparison of the 6-minute walk test (6MWT) values according to participant groups

	Group 1			Group 2			Group 3			Test Value	p	Bonferroni
	Med	X̄	SS	Med	X̄	SS	Med	X̄	SS			
6MWT 1	10.00	26.39	41.64	124.00	102.38	85.49	40.88	64.70	67.37	5.098***	0.078	
6MWT 2	15.00	66.33	90.30	180.00	251.50	231.18	120.60	144.65	136.54	4.684***	0.096	
6MWT 3	15.00	102.89	136.59	102.50	172.00	147.82	148.50	170.88	167.99	2.340***	0.310	
6MWT 4	10.00	117.00	163.57	174.38	218.97	150.09	271.25	247.33	168.87	6.128***	**0.047***	1>3
6MWT 5	30.00	144.44	194.09	193.75	223.38	120.98	130.50	222.72	160.89	3.287***	0.193	
6MWT 6	45.00	156.44	193.30	280.50	287.63	128.22	321.00	356.25	81.49	4.218**	**0.028***	1>3
Test Value		25.996****			13.406****			25.036****				
p		**0.000***			**0.020***			**0.000***				
Bonferroni		**5>1, 6>1**			**6>3**			**4>1, 5>1, 6>1**				

*p<0.05. **One-way analysis of variance (ANOVA). ***Kruskal-Wallis test. ****Friedman test.

Table 5. Comparison of Physiological Cost Index (PCI) values according to participant groups

	Group 1			Group 2			Group 3			Test Value	p	Bonferroni
	Med	X̄	SS	Med	X̄	SS	Med	X̄	SS			
PCI 1	3.50	11.71	11.94	1.59	2.77	2.93	2.15	4.40	4.41	3.543**	0.170	
PCI 2	1.80	6.30	8.83	0.76	1.60	2.25	1.06	3.86	4.71	2.999**	0.223	
PCI 3	2.30	5.09	6.41	0.56	1.80	3.34	1.23	2.42	2.47	2.198**	0.333	
PCI 4	4.76	24.78	58.21	0.49	2.44	5.39	0.63	0.76	0.79	6.323**	**0.042***	1>3
PCI 5	3.00	4.98	7.82	0.86	1.15	0.85	0.17	0.36	0.37	7.507**	**0.023***	1>3
PCI 6	2.10	4.20	6.33	0.41	38.46	106.89	0.12	0.20	0.21	5.550**	0.062	
Test Value		33.597***			4.857***			18.929***				
p		**0.000***			**0.434**			**0.002***				
Bonferroni		**1>6, 2>6, 1>5**						**1>6, 2>6**				

*p<0.05. **Kruskal-Wallis test. ***Friedman test.

DISCUSSION

In the present study, the effect of three different exercise protocols on functional capacity was investigated in the early stages of severe burn patients. It was found that aerobic exercises given in addition to standard treatment and standard treatment + combined exercise (aerobic and resistance) determined according to metabolic status were more effective in recovering functional capacity than standard treatment alone. Improvement in functional capacity was faster in patients given the combined exercise (aerobic and resistance) (Group 3) determined according to metabolic status than in the other two groups. We are of the opinion that changes in metabolic status should also be taken into account when creating an exercise protocol for burn patients.

Various tests such as the 6MWT, shuttle walk test, 2-minute walk test, and stair climbing are frequently used for functional capacity measurements in the literature.[26] However, there are limited studies on functional capacity in burn patients. Itakussu et al. used the 6MWT test for burn patients but evaluated the participants after discharge from the hospital.[27] In a study using the shuttle walk test as an evaluation tool, the test was performed once, and the physiological results were recorded.[28] Kakitsuka et al. evaluated the effectiveness of 6MWT and stated that it is reliable and safe for burn patients. However, in the same study, 6MWT measurements were performed close to the patients' discharge.[29] In this study, 6MWT tests were performed weekly until discharge. We believe that the 6MWT is a reliable and usable test in the early period for burn patients.

Table 6. Comparison of the Medical Research Council (MRC) values according to participant groups

	Group 1			Group 2			Group 3			Test Value	p	Bonferroni
	Med	X̄	SS	Med	X̄	SS	Med	X̄	SS			
MRC 1	40.00	41.00	3.74	46.00	46.88	3.64	44.00	46.00	5.13	4.904**	0.017*	2>1
MRC 2	43.00	43.00	4.00	48.00	47.88	3.76	47.00	48.13	4.02	4.670**	0.020*	3>1
MRC 3	48.00	44.67	4.47	49.00	49.13	3.23	48.00	49.13	5.22	2.972**	0.072	
MRC 4	48.00	46.22	4.74	51.00	51.13	2.85	49.00	49.63	5.80	2.523**	0.103	
MRC 5	50.00	48.67	6.46	53.50	53.38	3.54	54.00	54.00	3.38	4.013***	0.134	
MRC 6	50.00	48.67	5.89	55.50	55.00	2.78	57.00	56.00	3.21	9.095***	0.011*	3>1
Test Value	38.489****			36.718****			35.795****					
p	0.000*			0.000*			0.000*					
Bonferroni	**4>1, 5>1, 6>1, 5>2, 6>2**			**4>1, 5>1, 6>1, 5>2, 6>2, 6>3**			**5>1, 6>1, 5>2, 6>2, 6>3**					

*p<0.05. **One-way analysis of variance (ANOVA). ***Kruskal-Wallis test. ****Friedman test.

In a study conducted by Veldema et al. in 2019 on intensive care patients, they stated that aerobic exercises performed with a bicycle ergometer positively affected the muscle strength of the patients.[24] In this study, the addition of a bicycle ergometer in Group 2 and the combined aerobic and resistance exercises in Group 3 resulted in more pronounced improvements compared to Group 1. However, the most effective improvement was observed in Group 3.

Upon examining these differences among groups, we believe that combining aerobic and resistance exercises can enhance functional capacity more rapidly and effectively in burn patients. These findings underscore the importance of considering the patient's physiological status when selecting exercise regimens. Particularly, the combination exercises in Group 3 are believed to play a critical role in enhancing functional capacity beyond standard treatment.

Veldema et al. stated in the same article that aerobic exercises performed with a bicycle ergometer were beneficial to general intensive care patients and should be applied until the patient is discharged.[24] In this study, we think that aerobic exercise can be applied in the early period for burn patients and can provide potential benefits in the rehabilitation process. Additionally, we believe that changes in the metabolic status of patients can play a critical role in exercise selection. In particular, we observed that changes in metabolic status in some weeks affected the effectiveness and safety of aerobic exercises. The variability of metabolic response in burn patients requires the individualization of exercise programs and adaptation according to the current condition of the patient. Therefore, it may be important to regularly monitor and evaluate the metabolic status of patients while providing aerobic exercise. In conclusion, our findings regarding the early applicability of aerobic exercise in burn patients may provide an important contribution to optimizing exercise selection in clinical practices. Future research will further contribute to the literature by examining in more detail how exercise programs can be improved by considering the metabolic status and physiological responses of the patient.

Increased sympathetic activity and inflammatory response after a burn injury are critical for cardiovascular and hemodynamic compensation, and increased heart rate and blood pressure are the most common cardiac changes in burn patients.[30] In a study published by Williams et al., it was stated that heart rate remained high for two years after burn injuries and was especially highest in the fourth week after hospitalization.[31] The physiological expenditure index is a parameter frequently used in the evaluation of functional capacity along with the 6MWT and provides information about energy expenditure.[12,13,15] In this study, we investigated the effects of applying three different exercise protocols on PCI in burn patients. According to the findings, it is thought that different exercise protocols at certain time points may cause changes in the metabolic responses of burn patients, and these changes may be clinically important in terms of changes in PCI (Table 5). Especially, the fact that Group 2 patients had lower PCI values in the second week suggests that exercise protocols including the addition of a bicycle ergometer may negatively affect the metabolic status for a certain period. Similarly, the fact that the patients in Group 3 had lower PCI values in the 4th week provides clues about how protocols combining aerobic and resistance exercises may change their metabolic effects in the long term. Additionally, when the first and last measured PCI values of the groups were compared, we believe that combined exercise protocols, created considering metabolic status, may be more effective in increasing functional capacity in burn patients due to the improvement seen in the individuals in Group 3.

In patients exposed to burn trauma, peripheral muscle strength is directly affected and is associated with functional capacity.[32-34] In the evaluation of peripheral muscle strength in burn patients, hand dynamometer and the MRC scale are frequently used and accepted as reliable methods.[32-34] In this study, the MRC scale was used in the evaluation of muscle strength of patients, and it was observed that the initial values of the patients were low. When the groups were compared, it was determined that there was an improvement in the MRC scale of patients in all groups (Table 6). We think that the improvement in the MRC scale in all groups is a result of the medical and surgical treatments included in the standard treatments of the patients and that this is seen due to the natural healing course of the disease. When the groups were compared, the improvement levels in the MRC scale in the patients in the second and third groups may have affected the muscle strength and motor functions of the patients more positively. Maintaining the results of the MRC score for a longer period of time may contribute more to the literature. We believe that the short follow-up period in the study is a limitation in terms of the evaluation of the MRC score.

CONCLUSION

The 6MWT, PCI, and MRC scales can be reliably and safely used for evaluating functional capacity in burn patients. The use of the 6MWT in burn patients in the early period is more feasible than other methods. In addition, weekly evaluation of these parameters from day one is important for the clinical follow-up of the patients. Evaluating these parameters only at discharge is not sufficient for clinical follow-up.

A bicycle ergometer can be used for aerobic training in burn patients, but those with lower extremity burns may not feel comfortable with it. For patients who cannot use a bicycle ergometer due to lower extremity burns, new studies using arm ergometry will contribute to the literature.

It was concluded that the exercise to be administered in burn trauma, which directly affects the metabolism of the patient, should be given by evaluating the metabolic status. This assessment can guide the selection of exercises tailored to enhance the physiological benefits patients derive from exercise. The findings obtained in the present study highlight the importance of personalized exercise protocols for burn patients and may make important contributions to the literature. In addition, although it is appropriate to perform randomization with the "covariate adaptive randomization method according to burn percentage and burn type" when conducting scientific research on burn patients, randomization taking into account the metabolic changes in the patients may be important for the literature.

The limitations of the study include the difficulties in the participation of patients with high burn degrees of burns in exercise programs and the inability to evaluate the long-term effects of the exercise programs. These limitations should be taken into account when interpreting the results of the study, and it is thought that future studies should focus more on these issues.

Ethics Committee Approval: This study was approved by the Hasan Kalyoncu University Ethics Committee (Date: 28.08.2020, Decision No: 2020/063).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: M.A.Ç., K.B.; Design: M.A.Ç., K.B.; Supervision: A.E., A.G., M.A.Ç.; Resource: A.E., A.G.; Materials: M.A.Ç., A.E.; Data collection and/or processing: Y.Y., K.B., M.A.Ç.; Analysis and/or interpretation: Y.Y., M.A.Ç.; Literature search: M.A.Ç., K.B.; Writing: M.A.Ç., K.B., A.E.; Critical review: M.A.Ç., K.B., A.E., Y.Y., A.G.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. da Silva MMM, Travensolo CF, Probst VS, Felcar JM. Quantification of changes in functional capacity and muscle strength in patients: a burn intensive care unit cohort study. Burns 2022;48:833–40. [CrossRef]
2. Abu-Sittah GS, Sarhane KA, Dibo SA, Ibrahim A. Cardiovascular dysfunction in burns: review of the literature. Ann Burns Fire Disasters 2012;25:26–37.
3. Greenhalgh DG. Management of burns. N Engl J Med 2019;380:2349–59. [CrossRef]
4. Romero SA, Moralez G, Jaffery MF, Huang M, Cramer MN, Romain N, et al. Progressive exercise training improves maximal aerobic capacity in individuals with well-healed burn injuries. Am J Physiol Regul Integr Comp Physiol 2019;317:R563–70. [CrossRef]
5. Mandell SP, Gibran NS. Early enteral nutrition for burn injury. Adv Wound Caref 2014;3:64–70. [CrossRef]
6. Martini WZ, Holcomb JB, Yu YM, Wolf SE, Cancio LC, Pusateri AE. et al. Hypercoagulation and hypermetabolism of fibrinogen in severely burned adults. J Burn Care Res 2020;41:23–9. [CrossRef]
7. Flores O, Tyack Z, Stockton K, Paratz JD. The use of exercise in burns rehabilitation: A worldwide survey of practice. Burns 2020; 46:322–32.
8. Young A, Davies A, Tsang C, Kirkham J, Potokar T, Gibran N, et al. Establishment of a core outcome set for burn care research: development and international consensus. BMJ Med 2022;1:e000183. [CrossRef]
9. Kang M, Ragan BG, Park JH. Issues in outcomes research: an overview of randomization techniques for clinical trials. J Athletic Training 2008;43:215–21. [CrossRef]
10. Vanhoutte EK, Faber CG, Van Nes SI, Jacobs BC, Van Doorn PA, Van Koningsveld R, et al. Modifying the Medical Research Council grading system through Rasch analyses. Brain 2012;135:1639–49. [CrossRef]
11. American Thoracic Society-ATS Statement: Guidelines for the Six-Minute Walk Test. Am J Respir Crit Care Med 2002;166:111–7. [CrossRef]
12. Berkman AM, Goodenough CG, Durakiewicz P, Howell CR, Wang Z, Easton J, et al. Associations between mitochondrial copy number, exercise capacity, physiologic cost of walking, and cardiac strain in young adult survivors of childhood cancer. J Cancer Surviv. 2024 Apr 18. doi: 10.1007/s11764-024-01590-7. [Epub ahead of print]. [CrossRef]
13. Chan WLS, Pin TW. Reliability, validity and minimal detectable change of 2-minute walk test, 6-minute walk test and 10-meter walk test in frail older adults with dementia. Exp Gerontol 2019;115:9–18. [CrossRef]

14. Shulman MA, Cuthbertson BH, Wijeysundera DN, Pearse RM, Thompson B, Torres E, et al; Measurement of Exercise Tolerance for Surgery Study Investigators. Using the 6-minute walk test to predict disability-free survival after major surgery. Br J Anaesth 2019;122:111–9. [CrossRef]
15. Rana BS, Pun M. Estimation of physiological cost index as an energy expenditure Index using MacGregor's Equation. JNMA J Nepal Med Assoc 2015;53:174–9. [CrossRef]
16. Vanhoutte EK, Faber CG, van Nes SI, Jacobs BC, van Doorn PA, van Koningsveld R, et al; PeriNomS Study Group. Modifying the Medical Research Council grading system through Rasch analyses. Brain 2012;135:1639–49. [CrossRef]
17. Roberts J, Dugdale DD, Lillis J, Pinto JM, Willmott A, Yeshurun S, et al. The efficacy of a home-use metabolic device (Lumen) in response to a short-term low and high carbohydrate diet in healthy volunteers. J Int Soc Sports Nutr 2023;20:2185537. [CrossRef]
18. Buch A, Yeshurun S, Cramer T, Baumann A, Sencelsky Y, Zelber Sagi S, et al. The effects of metabolism tracker device (Lumen) usage on metabolic control in adults with prediabetes: pilot clinical trial. Obes Facts 2023;16:53–61. [CrossRef]
19. Lorenz KA, Yeshurun S, Aziz R, Ortiz-Delatorre J, Bagley JR, Mor M, et al. A handheld metabolic device (Lumen) to measure fuel utilization in healthy young adults: device validation study. Interact J Med Res 2021;10:e25371. [CrossRef]
20. Çınar MA, Bayramlar K, Erkılıç A, Güneş A, Yakut Y. The effects of early physiotherapy on biochemical parameters in major burn patients: A burn center's experience. Ulus Travma Acil Cerrahi Derg 2019;25:461–6.
21. Zoubine N, Okhovation F. A comparative between two burn rehabilitation protocols. Burns 2007;34:429–34. [CrossRef]
22. Çınar MA, Bayramlar K, Erkılıç A, Güneş A, Yakut Y. The effect of early physiotherapy on fibronectin levels in patients with major burns: A pilot study. J Exerc Ther Rehabil 2017;4:105–10.
23. Veldema J, Bösl K, Kugler P, Ponfick M, Gdynia HJ, Nowak DA. Cycle ergometer training vs resistance training in ICU-acquired weakness. Acta Neurol Scand 2019;140:62–71. [CrossRef]
24. Hargreaves M, Spriet LL. Skeletal muscle energy metabolism during exercise. Nature Metabolism 2020;2:817–28. [CrossRef]
25. Cohen Jacob. Statistical power analysis for the behavioral sciences. Revised ed. New York Academic press; 2013. p. 463–17.
26. Ceylan E. Cardiopulmonary exercise tests. J Clin Exp Investig 2014;5:504–9. [CrossRef]
27. Itakussu EY, Valenciano PJ, Fujisawa DS, Anami EHT, Trelha CS. Aerobic capacity, physical activity and pain in adult victims of moderate to severe burns after discharge. Acta Sci Health Sci 2017;39:37–44. [CrossRef]
28. Ozkal O, Yurdalan SU, Seyyah M, Acar HA. The effect of burn severity on functional capacity in patients with burn injury. J Back Musculoskelet Rehabil 2019;32:215–21. [CrossRef]
29. Kakitsuka EE, Morita AA, Itakussu EY, Kuwahara RM, Anami EHT, Pitta F, et al. Six-minute walk test in burned subjects: Applicability, reproducibility and performance at hospital discharge. Burns 2020;46:1540–7. [CrossRef]
30. Tapking C, Popp D, Herndon DN, Branski LK, Hundeshagen G, Armenta AM, et al. Cardiac dysfunction in severely burned patients: current understanding of etiology, pathophysiology, and treatment. Shock 2020;53:669–78. [CrossRef]
31. Williams FN, Herndon DN, Suman OE, Lee JO, Norbury WB, Branski LK, et al. Changes in cardiac physiology after severe burn injury. J Burn Care Res 2011;32:269–74. [CrossRef]
32. Danielsson A, Willén C, Sunnerhagen KS. Measurement of energy cost by the physiological cost index in walking after stroke. Arch Phys Med Rehabil 2007;88:1298–303. [CrossRef]
33. Fan E. Critical illness neuromyopathy and the role of physical therapy and rehabilitation in critically ill patients. Respir Care 2012;57:933–44.
34. Mc Kittrick A, Kornhaber R, Harats M, Cleary M, Visentin DC, Haik J. Critical care polyneuropathy in burn injuries: an integrative review. Burns 2017;43:1613–23. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Erken dönem yanık hastalarında üç farklı egzersiz eğitiminin fonksiyonel kapasite üzerine etkisi: Randomize kontrollü çalışma

Murat Ali Çınar,[1] Kezban Bayramlar,[1] Ahmet Erkılıc,[2] Ali Güneş,[2] Yavuz Yakut[1]

[1]Hasan Kalyoncu Üniversitesi, Fizyoterapi ve Rehabilitasyon Bölümü, Gaziantep, Türkiye

[2]Gaziantep Şehir Hastanesi, Genel Cerrahi, Yanık Merkezi, Gaziantep, Türkiye

AMAÇ: Bu çalışma, erken dönem yanık hastalarında üç farklı egzersiz protokolünün fonksiyonel kapasite üzerine etkisini araştırmak amacıyla planlandı.

GEREÇ VE YÖNTEM: Yanık Merkezinde (servis ve yoğun bakım ünitesinde) yatan toplam 25 hasta çalışmaya dahil edildi. Çalışmaya dahil edilen bireyler yanık yüzdesi ve yanık tipine göre kovaryant adaptif randomizasyon yöntemi ile üç gruba ayrıldı: 1-standart tedavi, 2-standart tedavi + aerobik egzersiz eğitimi, 3-standart tedavi + hastanın metabolik durumuna göre belirlenen kombine egzersiz (aerobik ve dirençli egzersiz). Bireyler hastaneye yatışlarının ilk gününden itibaren altı hafta boyunca haftalık olarak değerlendirildi. Fonksiyonel kapasiteyi değerlendirmek için 6 dakikalık yürüme testi, fizyolojik tüketim indeksi ve Tıbbi Araştırma Konseyi kas gücü ölçümleri kullanıldı. Tüm hastaların metabolik durumlarını ölçmek için taşınabilir metabolizma takip cihazı kullanıldı.

BULGULAR: Standart tedaviye ek olarak verilen aerobik egzersizler ve metabolik duruma göre belirlenen kombine egzersiz (aerobik ve direnç) fonksiyonel kapasite üzerinde standart tedaviye göre daha etkiliydi ($p<0.05$). Metabolik duruma göre belirlenen kombine egzersizi (aerobik ve direnç) yapan hastalarda fonksiyonel kapasitedeki iyileşme diğer iki gruba göre daha hızlıydı ($p<0.05$).

SONUÇ: Standart tedaviye ek olarak verilen aerobik egzersizler ve metabolik duruma göre belirlenen kombine egzersiz (aerobik ve direnç), fonksiyonel kapasiteyi geliştirmede standart tedaviye göre daha etkilidir. Bu yaklaşımın potansiyel uzun vadeli faydasını belirlemek için daha fazla kontrollü çalışmaya ihtiyaç vardır.

Anahtar sözcükler: Aerobik egzersiz; fizyoterapi; fonksiyonel kapasite; metabolizma; yanıklar.

Ulus Travma Acil Cerrahi Derg 2024;30(8):562-570 DOI: 10.14744/tjtes.2024.59987