Long-term effects of physical exercise during rehabilitation in patients with severe burns

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Background. *We have reported that a 12-week exercise program is beneficial for the exercise performance of severely burned children. It is not known, however, whether the beneficial effects remain at 2 years postburn.*
Methods. *Severely burned children who received no long-term anabolic drugs were consented to this Institutional Review Board–approved study. Patients chose between a voluntary exercise program (EX-group) and no exercise (NoEX-group) after discharge from the acute burn unit. Peak torque per lean leg mass, maximal oxygen consumption, and percent predicted peak heart rate were assessed. In addition, body mass index percentile and lean body mass index were recorded. Both groups were compared for up to 2 years postburn using mixed multiple analysis of variance.*
Results. *A total of 125 patients with a mean age of 12 ± 4 years were analyzed. Demographics between the EX-group (N = 82) and NoEX-group (N = 43) were comparable. In the EX-group, peak torque per lean leg mass, percent predicted peak heart rate, and maximal oxygen consumption increased significantly with exercise (P < .01). Between discharge and 12–24 months, body mass index percentile increased significantly in the EX-Group (P < .05) but did not change in the NoEX-group. There were no significant differences between groups in body mass index percentile, lean body mass index, peak torque per lean leg mass, and maximal oxygen consumption at 24 months postburn.*
Conclusion. *Exercise significantly improves the physical performance of burned children. The benefits are limited to early time points, however, and greatly narrow with further recovery time. Continued participation in exercise activities or a maintenance exercise program is recommended for exercise-induced adaptations to continue. (Surgery 2016;160:781-8.)*

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Over the past decades, advances in burn shock resuscitation, early burn eschar excision, and subsequent wound coverage have significantly reduced mortality in pediatric burns.[1] Hence, patients with severe burns covering more than one third of their total body surface area (TBSA) are expected to survive. The major contributor to the sometimes poor and in most cases late sequelae is the hypermetabolic response to burns, which is modulated by high serum levels of catecholamines, glucocorticoids, and proinflammatory cytokines.[2]

These acute inflammatory and endocrine responses are associated with a vast loss of lean body mass, muscle protein breakdown, and prolonged immobilization.[3] Despite advances in burn care, these systemic responses are still present 2 years postburn and maybe beyond.[4] As the number of burn survivors steadily increases, identification of long-term health problems is essential to determine the medical needs throughout postburn rehabilitation.

Muscle endurance and cardiopulmonary fitness are essential components of health that need to be

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addressed in postburn care as well as during the early postburn rehabilitation phase to reduce hypermetabolism and hasten social reintegration of burn survivors.[5] To improve outcomes after severe thermal trauma, researchers have sought many new treatment approaches, including exercise in combination with long-term medications to reduce postburn morbidity.

However, there have been no investigations comparing participants in a voluntary postburn exercise program with those not participating in any training for up to 2 years postburn. Hence, we compared long-term functional outcomes between pediatric burn survivors either participating or not participating in an exercise-training program in the absence of any long-term anabolic agents.

METHODS

Patients and care. Pediatric patients who were burned between 1997 and 2015 were consented to either an exercise program (EX-group) or no exercise (NoEX-group) in this Institutional Review Board–approved study. Inclusion criteria included patients aged 7–18 years with healed burns covering ≥30% of their TBSA. Exclusion criteria included any of the following: leg amputation, anoxic brain injury, psychological disorder, quadriplegia, severe behavior or cognitive disorder, or receipt of an anabolic agent during acute hospital stay or after discharge from acute hospital stay. Informed consent was obtained from the parent or legal guardian of the patient on the first day of admission to Shriners Hospitals for Children–Galveston (Galveston, TX), and the physical rehabilitation program was initiated after discharge from the acute unit.

For this analysis, we included all pediatric burn patients who participated in a hospital-based, postburn exercise program at our institution regardless of the duration of training. Initially, from 1997 to the end of 2008, patients were randomized to either a 12-week, in-hospital physical rehabilitation program or a nonexercise control group. Starting in 2009, randomization was stopped, and participation in the exercise program was offered to all patients. All patients received standard medical care throughout their hospital admission and were offered standard follow-up care postdischarge. End points for body composition, muscle strength, and cardiopulmonary fitness were assessed at discharge from the acute unit, during the hospital-based exercise program (EX-group only), and at 12 and 24 months postburn.

The hospital-based exercise program was conducted as previously published by our group.[6] Resistance and aerobic exercises were performed under the supervision of an American College of Sports Medicine–certified exercise physiologist or trainer. Children underwent resistance training, which consisted of the following: bench presses, leg presses, shoulder presses, biceps curls, leg curls, triceps curls, toe raises, and abdominal curls. Free weights or resistance machinery were used as applicable.

During the first week of the exercise rehabilitation program, patients were instructed on proper weight-lifting techniques and were educated on the use of the equipment. Weight loads were initially set at 50% of each patient's 3-repetition maximum and were subsequently increased to attain the 3 sets of 12–15 repetitions maximum between weeks 2 and 6 of training. During weeks 6–12, 3 sets of 8–12 repetitions were performed. In addition, aerobic exercise on a cycle ergometer or treadmill was performed 3–5 days a week, with each session lasting 20–45 minutes. No further strength training activities were allowed during the 12-week rehabilitation period, but normal activities and daily routines were encouraged.

Body composition. Height, body mass, lean body mass, and lean leg mass of the dominant leg (kg) were assessed using dual energy x-ray absorptiometry (Discovery DXA system, Hologic, Inc, Bedford, MA) as previously described by our group.[7,8] Generated values were used to calculate lean body mass index (LBMI; kg/m^2), defined as lean body mass (kg)/height $(m)^2$, and body mass index percentile (BMI%) based on the formula used by the Centers for Disease Control and Prevention.[9]

Muscle strength. We prospectively assessed muscle strength as peak torque (Nm) and peak torque per body weight (PTBW; %), examining the dominant leg using a dynamometer (Biodex Isokinetic Dynamometer; Biodex Medical Systems, Shirley, NY) as previously described by our group.[7] Peak torque per leg lean mass (PTLLM; %) was also determined, calculated as peak torque (Nm)/leg lean mass (kg)×100.

Cardiopulmonary fitness. Cardiopulmonary fitness was assessed using the maximal oxygen capacity (VO2max, mL/kg/min), peak heart rate (PHR; beats per minute [bpm]), and resting heart rate (RHR; bpm). VO2max as well as peak and RHR were measured using a metabolic stress testing system (Ultima CPX; MGC Diagnostics Corporation, Saint Paul, MN) and a Medgraphics CardioO_2 combined O_2/ECG exercise system (Ultima CardiO2; MGC Diagnostics Corporation) as previously described.[6,7]