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Children with severe burns display no sex differences in exercise capacity at hospital discharge or adaptation after exercise rehabilitation training

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ABSTRACT

Background and objective: Females have a 50% increased risk of death from burn injury compared to males. However, whether exercise capacity and exercise induced training adaptations differ between burned boys and girls is unknown. This project tested the hypothesis that girls with burns have lower exercise capacity and different exercise induced training adaptations.

Methods: Twenty-five girls were matched to 26 boys (mean, 95%CI; years 13 [12,14], cm 151 [143,161], kg 54 [45,63]; each $P > 0.05$) for burn injury (% total body surface area burn, 54 [45,62]; $P = 0.82$). Lean body mass (LBM), strength (peak torque) and cardiorespiratory fitness (peak VO_2) were normalized to kg LBM and compared as a percentage of age-sex matched non-burned children (n = 26 boys, years 13 [12,14]; n = 25 girls, years 13 [12,14]) at discharge (DC) and after aerobic and resistance rehabilitation exercise training (RET).

Results: Using a 2-way factorial ANOVA (group × time), we found both groups had similar 11% change in LBM (87.3% of non-burned values [82.2,92.3]) and after the RET (92.8% [87.2,98.3]; main effect, time $P < 0.0001$). Peak torque increased similarly by 16% in both groups (% of age-sex matched non-burned DC, 55.9 [51.3,60.5]; after RET, 77.5 [72.1,82.9]; main effect, time $P < 0.0001$). Likewise, peak VO_2 increased in both groups by 15% (% of age-sex matched non-burned DC, 56.8 [52.4,61.2] to RET, 72.2 [67.6,76.8]; main effect, time; $P < 0.0001$). Burned children exercise at greater percentage of their peak VO_2 and peak HR compared to non-burned children (Interaction, group × time, $P < 0.0001$).

Conclusion: The burn injury does not have sex-dependent effects on LBM or exercise capacity in severely burn injured children. Differences in relative peak VO_2 and peak HR suggest the need for burn specific exercise programs for improving the efficacy of a rehabilitation program.

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1. Introduction

Thermal burns are a leading cause of preventable hospitalization and accidental death worldwide [1]. An estimated 265,000 deaths are caused by burns each year and have an economic impact of $211 million. According to the World Health Organization, females and males have similar rates of burn injury [1]; however, the American Burn Association has reported that burns affect 69% of males and 32% of females [2]. Notably, children are at greater risk of burn injury because of differences in body morphology. The head and neck are much larger in children than adults, and children have about three times the body surface area-to-body mass ratio of adults. Children are also thought to sustain burn injury in only a quarter of the time as adults [3,4], possibly leading to more severe injury. Studies show that boys are more likely to experience a burn injury than girls, possibly because of behavioral differences [5,6]. Moreover, in children, the severity and outcome of burn injury vary by age, region, income category, and sex [1,2,7]. Evidence suggests that sex differences in mortality exist after burn injury, with females having a greater risk of death in all age groups from 10 to 70 years old [8–10]. Why this difference exists is not clear, although female sex hormones may play a role [8–11]. Jeschke et al. found no differences in mortality between burned boys and girls but did observe sex differences in the inflammatory and hypermetabolic response [12,13].

Advances in the treatment of severe burns have improved survival; however, greater survival has been accompanied by body composition changes as well as metabolic and cardiovascular complications. All can last up to 3 years postburn, diminish physical capacity and quality of life, and contribute to mortality in burned children [14–16]. We have shown that, at hospital discharge, cardiorespiratory fitness and strength are lower in burned children than nonburned healthy children and that rehabilitation exercise training improves these measures of physical capacity [17–21]. Although studies have shown exercise training to be beneficial, whether body composition, exercise capacity, and adaptations to exercise training differ between boys and girls is unknown. Therefore, we investigated the effect of a rehabilitative exercise training (RET) program on body composition, strength, and cardiorespiratory fitness in burned boys and girls. We hypothesized that sex differences would be present in RET adaptations related to body composition, strength, and aerobic exercise capacity.

2. Methods

2.1. Study design

This was a retrospective study approved by the University of Texas Medical Branch IRB in which children with burn injury were matched with respect to age and total body surface area (TBSA) burned (see Table 1). A large database at Shriners Hospitals for Children (Galveston, TX) was queried for patients who were admitted from 2005 to 2016 and who met the following inclusion criteria: 7–18 years of age, 30% or greater TBSA burned, and completion of a 6- or 12-week RET program. All patients provided written informed consent and completed a concurrent aerobic and resistance RET program that was dependent on burn severity (6 weeks for >30–59% TBSA burns and 12 weeks for >60% TBSA burns). All underwent testing for body composition, exercise strength, and aerobic capacity both before and after RET. Data for nonburned healthy children collected between 2001 to 2017 were also obtained from the database. All were volunteers in the Galveston community. Each burned child was matched to a nonburned child for sex and age. The nonburned child did not complete RET and was used only as a nonburn reference for body composition, strength, and cardiorespiratory fitness.

2.2. Rehabilitative exercise training

RET began at discharge from the intensive care unit, when burn injuries were at least 95% wound healed. Aerobic and resistance exercise training was supervised by an American College of Sports Medicine-certified exercise specialist. The RET regimen consisted of alternating resistance and aerobic exercise training up to 5 days per week. Aerobic exercise consisted of 3–5 sessions per week of training on a treadmill, stationary bicycle, or cycle arm ergometer. Patients exercised at 60–85% of the peak heart rate for 20–40 min (5 metabolic equivalents at ~75% of the volume of peak expired oxygen) for at least 150 min per week.

Table 1 – Subject characteristics.

Characteristic[a]	Boys		Girls		P value
	Burned	Nonburned	Burned	Nonburned	
n	26	26	25	25	
Age (y)	12.9 [11.5,14.3]	12.7 [11.2,14.1]	12.7 [11.5,14.0]	12.8 [11.5,14.0]	0.99
Hospitalization (days)	29 [24,40]	–	*43 [33,53]	–	**0.02**
Height (cm)	152.4 [143.6,161.2]	155.7 [147.3,164.0]	150.4 [144.3,156.6]	149.8 [145.2,154.3]	0.64
Weight (kg)	54.0 [44.9,63.1]	53.4 [45.3,61.5]	53.0 [45.4,60.6]	45.7 [40.7,50.6]	0.35
TBSA burn (%)	54 [49,59]	–	53 [47,59]	–	0.82
TBSA 3rd-degree burn (%)	37 [29,45]	–	40 [32,49]	–	0.59

TBSA, total body surface area.
* $P < 0.05$.
[a] Data reported as mean [95% CI] burned boys vs burned girls.

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