Burn Injury May Have Age-Dependent Effects on Strength and Aerobic Exercise Capacity in Males

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Whether burn injury affects boys and men differently is currently unknown. To test the hypothesis that burned boys have lower exercise capacity and exercise training–induced responses compared with burned men, 40 young boys (12 ± 4 years, 149 ± 20 cm, 46 ± 18 kg) were matched to 35 adult men (33 ± 9 years, 174 ± 10 cm, 84 ± 16 kg) based on extent of burn injury (total body surface area burned, boys 46 ± 14% vs men 47 ± 30, P = .85) and length of hospital stay (boys 33 ± 23 vs men 41 ± 32 days, P = .23). Strength (peak torque) and cardiorespiratory fitness (peak VO₂) were normalized to kg of lean body mass for group comparisons. Each group was also compared with normative age–sex matched values at discharge and after an aerobic and resistance exercise training (RET) program. A two-way factorial analysis of covariance assessed interaction and main effects of group and time. We found that boys and men showed similar pre-RET to post-RET increases in total lean (~4%) and fat (7%) mass (each P ≤ .008). Both groups had lower age–sex matched norm values at discharge for peak torque (boys 36%; men 51% of normative values) and peak VO₂ (boys: 44; men: 59%; each P ≤ .0001). Boys strength were 13–15 per cent lower than men at discharge and after RET (main effect for group, P < .0001). Cardiorespiratory fitness improved to a greater extent in men (19%) compared with boys (10%) after the RET (group × time interaction, P = .011). These results show that at discharge and after RET, burn injury may have age-dependent effects and should be considered when evaluating efficacy and progress of the exercise program. (J Burn Care Res 2018;39:815–822)

Burns are a major cause of injury in children, third behind motor vehicle accidents and drownings that result in death.1 Notably, poorer outcomes are associated with scalding injuries, younger age, increased burn size, and the presence of inhalation injury, with infants and young children having the greatest risk of death from burn injury.2 In addition, because cognitive development lags behind motor skill development, children lack comprehension of danger and awareness of their environment, increasing risk-taking behavior leading to burn-related injuries.3,4 Most importantly, children are not little adults. Children have about three times the body surface area-to-body mass ratio of adults, owing to the fact that their head and neck are much larger than those of adults. It is also estimated that children sustain burn injury in only a quarter of the time as adults,5,6 possibly leading to a more severe injury.

Burn injury is associated with skeletal muscle catabolism and weakness that are accompanied by hypermetabolism, respiratory injury, and diminished lean body mass (LBM) in both adults and children as well as disturbed growth patterns in children.7–12 These changes have deleterious effects that may alter children’s growth and development. Burn injury also instigates an inflammatory response that appears to differ between children and adults as seen by dissimilar cytokine profiles.13 This difference between children and adults suggests that these populations may benefit from different therapeutic interventions.

We have found that immediately following discharge, a rehabilitation exercise program improves muscle strength, endurance, and LBM.14–21 The effectiveness of resistance training is influenced by multiple factors, including age, maturation, sex, and the frequency, duration, and intensity of the training program.22 However, whether burn injury differentially affects exercise capacity and body composition in adults and children is unknown. Whether the benefits of rehabilitative exercise differ between these populations is also unclear. We designed this study to compare exercise capacity and body composition in adult men and boys before and after a rehabilitative exercise program (RET). We hypothesized that boys with burn injury have lower exercise capacities and greater body composition changes than burn-injured men.

METHODS

Ethical Approval

All experiments were approved by the Institutional Review Board of the University of Texas Medical Branch and were conducted in accordance with the Declaration of Helsinki. Before subjects participated in the study, informed consent was obtained from the burned adults and parents or legal guardians of burned children, in addition to the child assent, as applicable.

Study Design

Subjects were grouped with respect to age (adults and children) and matched for total body surface area (TBSA) burned (Table 1). The study included 40 children aged 7 to
17 years and 35 adults aged 18 to 45 years, with both groups having 30 per cent or greater TBSA burns. Exercise training was initiated immediately after discharge once wounds were at least 95 per cent healed. At discharge, subjects provided written informed consent and underwent testing for body composition, exercise strength, and aerobic capacity. They then completed a 6- to 12-week (6 weeks for >30–59% TBSA burns and 12 weeks for >60% TBSA burns) aerobic and resistance rehabilitative exercise training program. Following the rehabilitative training, they again underwent body composition, exercise strength, and aerobic exercise testing.

### Rehabilitative Exercise Program

Subjects underwent supervised aerobic and resistance exercise 3 to 5 days per week for 6 to 12 weeks at 60–75 per cent of peak VO₂. Aerobic exercise intensity was maintained at 60 to 85 per cent of the patient’s peak heart rate for 20- to 40-minute sessions (five metabolic equivalents at ~75 per cent of the volume of peak expired oxygen [peak VO₂]) for at least 150 minutes per week by weeks 6 to 12. During the first week, an aerobic warmup of 10 minutes would start the main exercise session and a cool down would end the session. Patients complete as much as they could due to open skin graft wounds that may have limited limit mobility and the ability to exercise on the treadmill or cycle ergometer. The strength training program consisted of at least 3 days per week of whole-body resistance exercise on free weights, such as bench, leg, and shoulder presses; leg extension; biceps, leg, and triceps curls; and toe raises. During the first week of training, the patients were familiarized with equipment and proper technique with minimal weights or loads. Weights or loads were then gradually increased over time from 50 to 60 per cent of the patient’s 3-repetition maximum to a goal of 80 to 85 per cent of the 3-repetition maximum by weeks 6 to 12.

### Cardiorespiratory Capacity

Cardiorespiratory capacity was determined by measuring VO₂ during a modified Bruce treadmill test. The treadmill test consisted of progressive, 3-minute increases in speed and incline until volitional exhaustion. Expired gases were analyzed by indirect calorimetry (MedGraphics Cardi O2 metabolic cart, St. Paul, MN, USA). Gasses and air flow were calibrated using known gasses (O₂ and CO₂) and a 3-l syringe before each test. In all cases, subjects were considered to have reached peak oxygen consumption when they signaled to stop and met three of the following criteria: a respiratory exchange ratio ≥ 1.05, a leveling off in VO₂ with increasing workloads (<2 ml kg min⁻¹), final heart rate ≥ 190 bpm, or a final test time of 8 to 15 minutes.

### Muscle Strength

Muscle strength was measured using an isokinetic test performed on dominant leg extensors. The Biodex System 4 dynamometer (Biodex Medical Systems Inc., Shirley, NY, USA) measured maximal voluntary muscle contractions at an angular velocity of 150°/s, and information was recorded to obtain peak torque. All subjects were familiarized to this procedure before each test using visual and verbal explanations.

Table 1. Subjects’ physical and exercise characteristics

|                  | Boys         | Men         | P     |
|------------------|--------------|-------------|-------|
| n (male)         | 40           | 35          |       |
| Age (y)          | 11.9 ± 3.9*  | 32.7 ± 9.2  | <.0001|
| Length of hospital stay (days) | 33 ± 23      | 41 ± 32     | .25   |
| Body morphology  |              |             |       |
| Height (cm)      | 148.7 ± 20.1*| 173.6 ± 9.6 | <.0001|
| Weight (kg)      | 46.4 ± 18.6* | 84.0 ± 16.1 | <.0001|
| Fat mass (kg)    | 11.6 ± 7.1*  | 23.7 ± 7.9  | <.0001|
| Fat mass (% total body) | 29.8 ± 7.5 | 27.8 ± 6.3  | .21   |
| Lean mass (kg)   | 17.7 ± 3.3*  | 31.2 ± 11.3 | <.0001|
| Lean mass (% total body) | 69 ± 6     | 67 ± 7      | .20   |
| TBSA burn (%)    | 46 ± 14      | 47 ± 30     | .85   |
| TBSA 3rd-degree burn (%) | 35 ± 17    | 30 ± 19     | .14   |

Aerobic exercise capacity

|                  | Boys         | Men         | P     |
|------------------|--------------|-------------|-------|
| Absolute peak VO₂ (mLO₂·min⁻¹) | 981.9 ± 430.2* | 2171.8 ± 771.3 | <.0001|
| Normalized peak VO₂ (mLO₂·kg⁻¹TBM·min⁻¹) | 20.7 ± 5.4* | 26.3 ± 9.0 | ≤.005 |
| Normalized peak VO₂ (mLO₂·kg⁻¹LBM·min⁻¹) | 30.4 ± 6.8* | 37.5 ± 12.2 | ≤.006 |

Strength exercise capacity

|                  | Boys         | Men         | P     |
|------------------|--------------|-------------|-------|
| Absolute peak torque (NM) | 42.5 ± 24.3* | 87.1 ± 35.3 | <.0001|
| Normalized peak torque (NM·kg⁻¹TBM) | 0.91 ± 0.35 | 1.04 ± 0.35 | .18   |
| Normalized peak torque (NM·kg⁻¹LBM) | 1.3 ± 0.5 | 1.5 ± 0.5 | .09   |
| Absolute average power (W) | 48.7 ± 30.6* | 104.6 ± 48.0 | <.0001|
| Normalized average power (W·kg⁻¹TBM) | 1.0 ± 0.5 | 1.3 ± 0.5 | .05   |
| Normalized average power (W·kg⁻¹LBM) | 1.5 ± 0.6* | 1.8 ± 0.7 | ≤.04  |

TBSA, total body surface area; VO₂, volume of oxygen; TBM, total body mass; LBM, lean body mass.

†Data reported as mean ± SD. *Statistically different from burned men, P < .05.
Body Composition

Body composition was determined using dual x-ray absorptiometry (DXA, Hologic model QDR-4500-W, Hologic, Inc., Marlborough, MA, USA). Subjects underwent low-energy whole-body x-ray scans using pediatric and adult software for the measurement of LBM and fat mass. The DXA instrument was calibrated using the procedures provided by the manufacturer.

Statistical Analysis

Unpaired t-tests were performed to compare demographics between burned boys and men. Two-way (group × time) analysis of covariance (ANCOVA) was performed for body composition, peak strength, and peak VO\textsubscript{2} test. Additionally, a two-way (training × stage) ANOVA was performed to examine differences between pre- and post-training for percent peak heart rate and percent peak oxygen uptake at three stages of the modified Bruce exercise test. Post hoc test was performed using Sidak’s multiple comparisons test. To control for growth and body morphology variations between men and boys, we normalized oxygen uptake (VO\textsubscript{2}) to kg of total body mass (TBM) and LBM. Nonburn normative data for peak VO\textsubscript{2} were obtained from previously published norms.\textsuperscript{23} Slopes and intercepts for percent peak heart rate and percent peak VO\textsubscript{2} were compared between men and boys and Pearson product-moment correlation coefficient determined the strength of the linear association. Nonburned normative data for peak torque were obtained from our database and our previous published studies.\textsuperscript{14–20} Data were analyzed and figures generated using GraphPad Prism (Version 6.0, La Jolla, CA, USA), with significance set at \( P < .05 \). All data are reported as mean ± SD.

RESULTS

Physical and Exercise Characteristics at Discharge

Physical and exercise characteristics of subjects at discharge (pre-exercise) are presented in Table 1. Men’s burn injuries were flame (78%), scald (5%), and electrical (17%), whereas boys’ were flame (80%), scald (6%), electrical (8%), and chemical (6%). Men were white-Hispanic (55%), white-Caucasian (40%), and black (5%). The boys were all white-Hispanic. Inhalation injury was present in 17 per cent of men and 22 per cent of boys. Additionally, both groups were matched for drugs to control for the effects of these agents. Both groups had an equal number of participants taking oxandrolone or propranolol (6%), propranolol only (57%), and placebo (37%). Length of stay from admission to discharge was similar between groups (men: 41 ± 32 days vs boys: 33 ± 23 days, \( P > .05 \)). Men were about 20 years older than boys \( (P < .0001) \), were taller, weighed more, and had more absolute fat mass and LBM than boys (each \( P < .0001 \)). Both groups were matched for percent TBSA burns and percent third-degree burns \( (P > .05) \). Based on their TBSA, both groups had similar exercise training \( (men 7.0 \pm 2; boys 6.7 \pm 2.3 weeks, P > 0.49) \). Cardiorespiratory fitness (peak VO\textsubscript{2}) was significantly lower in boys than in men when expressed as an absolute value (55%) and when normalized to kg of TBM (22%) or LBM (19%; each \( P < .006 \)). Similarly, absolute strength measures were lower in boys than in men (peak torque 51%; average power 53%). Peak torque normalized to kg of TBM or LBM was similar between boys and men \( (P > .05) \); however, LBM-normalized average power was lower in boys than men \( (by 53%, P \leq .04) \).

Rehabilitative Exercise Training Changes Body Composition Similarly in Burned Boys and Men

The percent change in fat mass and LBM from discharge (pre-exercise) to the end of the rehabilitative training is presented in Figure 1. The percent increase in lean and fat mass did not differ between boys and men \( (P > .05) \). In boys, LBM increased by 3 ± 6% and fat mass by 6 ± 9%, whereas in men LBM increased by 4 ± 7% and fat mass by 8 ± 14% (each \( P \leq .008 \)).

Burn Injury Affects Strength and Aerobic Exercise Capacity to a Greater Extent in Boys Than in Men, Whereas Rehabilitative Exercise Training Improves These in Both

LBM-normalized peak torque and LBM-normalized cardiorespiratory fitness (peak VO\textsubscript{2}) at discharge (pre-exercise) and after rehabilitative training are reported in Figure 2. Both were lower in boys than men at discharge and after rehabilitative training \( (pre-training: peak torque 15\% lower and peak VO\textsubscript{2} 20\% lower; post-training: peak torque 16\% lower and peak VO\textsubscript{2} 23\% lower; main effect for group, \( P < .0001 \)) \). At discharge, both boys and men had peak torque and peak VO\textsubscript{2} values that were lower than age- and sex-matched normative values \( (peak \text{torque by 36–51% and peak VO}_{2} \text{ by 44–59%; } P < .0001) \). Peak torque expressed relative to normative values was lower in boys than men at discharge \( (15\% lower) \) and after exercise training \( (13\% lower; \text{main effect for group, } P < .0001) \). Cardiorespiratory fitness improved to a greater extent in men \( (19\% increase in peak VO_{2} \text{ than in boys (10\% increase}) \) after the rehabilitative training \( (group \times \text{time interaction, } P = .011) \).

Exercise Rehabilitation Improves Relative Submaximal Heart Rate and Oxygen Uptake in Burned Boys and Burned Men

Pre- and post-exercise training responses for relative (percentage of peak values) heart rate and VO\textsubscript{2} during the first three stages of the modified Bruce cardiorrespiratory test in boys and
men with severe burn injury are presented in Figure 3. Men showed reductions in exercise oxygen consumption during the first three stages after exercise training (training × stage interaction, $P = .0001$). Boys also showed reductions in relative submaximal exercise oxygen consumption after exercise training (training × stage interaction, $P = .32$); however, only in stages 2 and 3 were reduced (each, $P < .01$). Both men and boys showed similar reductions in relative heart rates at each of the first three stages of the Bruce protocol after exercise training (training × stage interaction, $P = .0001$).

The Relative Relationships Between Heart Rate and Oxygen Uptake Differ Between Burned Boys and Burned Men

Pre- and post-exercise training response for relative (percentage of peak values) relationships between heart rate and oxygen uptake did not differ and were combined to form one linear regression for each group that are presented in Figure 4. Both men and boys had a strong positive relationship between percent peak heart rate and percent oxygen uptake ($r \leq .89$). However, the slopes were significantly different between groups ($P = .0004$). The regression equation for estimating percent peak VO$_2$ from percent peak heart rate for men was as follows: 

$$\%\text{Peak VO}_2 = 1.274 \times \%\text{Peak heart rate} - 33.39$$

and for boys: 

$$\%\text{Peak VO}_2 = 1.608 \times \%\text{Peak heart rate} - 64.94$$

The explained variance for these regression equations was strong for both, which was $r^2 = .81$ for men and $r^2 = .79$. In Table 2, we present a summary of these estimations for prescribing oxygen uptake intensity from relative heart rate values between men and boys.

**DISCUSSION**

The purpose of this study was to compare the effects of burn injury on strength, aerobic exercise capacity, and body composition in adults and children from discharge until after rehabilitative exercise training. Our results show that both men and boys have similar relative body composition changes at discharge and that lean and fat mass similarly increase after rehabilitative exercise training. We found consistent reductions in strength and aerobic exercise capacity in men and boys when these were normalized to kg of LBM and expressed relative to age- and sex-matched normative values. However, boys had greater reductions than men at discharge and after exercise training. Additionally, we found that submaximal oxygen uptake was improved after rehabilitative training only in men. To the best of our knowledge, we are the first to report that burn injury may differentially affect measures of strength and cardiorespiratory fitness in young boys and men.

Severe burn injuries are associated with skeletal muscle catabolism accompanied by hypermetabolism, inflammatory responses, respiratory injury, and loss of LBM in both adults and children as well as disturbed growth patterns in children. It is important to understand that, unlike adults, children are in the process of reaching developmental milestones. Nonburned children and adolescents may differ in their hormonal and metabolic responses to physical activity. Specific hormones such as growth hormone (GH), insulin-like growth factors, and steroid sex hormones increase growth velocity and assist in cellular growth and proliferation, bone and muscle maturation, metabolic adaptation, and functional ability. Exercise-induced development of physical capacity and performance may, therefore, be greatly influenced by these changes in childhood and adolescence. Current research on this topic is lacking, though our data suggest that exercise rehabilitation regimens should follow age-specific guidelines for maximal benefits. This study builds on our previous work showing that a rehabilitative exercise program started immediately after discharge improves muscle strength, muscle endurance, and LBM in children with burn injury.
Why strength and aerobic exercise capacity are affected to a greater degree in boys than men is not entirely clear. We have previously reported that the cardiovascular response to submaximal exercise is diminished in burned children compared with nonburned age- or sex-matched children. Thus, burn trauma may have a more pronounced effect in children than adults, and this requires further understanding. Notably, adults have important body morphology characteristics that differ from those of children in early stages of development. One important difference is a child’s body surface area-to-mass ratio. Children are also less economical than adults (use greater oxygen at similar exercise workloads) during submaximal exercise. Moreover, the cardiovascular system is proportionally smaller in children than adults. Healthy nonburned children have smaller hearts, less blood volume, and during exercise lower stroke volume. Reynolds et al found that, in children, burn injury causes cardiac failure, particularly left ventricular myocardial depression, and that this outcome that was likewise different from that seen in burned adults. We have recently reported that, during submaximal exercise, burned children have exercise intolerance and attenuated peak heart rate values compared with nonburned age- or sex-matched children; however, this type of investigation has not been conducted in burned adults to date.

**Figure 3.** Relative submaximal heart rate (row A) and peak oxygen uptake (row B) during the first three stages of the modified Bruce exercise in men and boys at discharge (pre-training) and after rehabilitation training (post-training) in men and boys. **P < .01, ****P < .0001 for pre- to post-rehabilitative training.

**Figure 4.** Comparison of the relative relationship between percent peak oxygen uptake (VO₂) and percent peak heart rate between burned men and burned boys. Dotted lines represent 95% confidence intervals.

**Table 2.** Comparison of men and boys’ estimations of percent oxygen uptake from percent heart rates

| % Peak heart rate | % Peak VO₂ for men | % Peak VO₂ for boys |
|------------------|--------------------|---------------------|
| 50               | 30                 | 15                  |
| 60               | 43                 | 32                  |
| 70               | 56                 | 48                  |
| 80               | 69                 | 64                  |
| 90               | 81                 | 80                  |
| 95               | 88                 | 96                  |
Cardiorespiratory fitness (peak VO₂) is a strong predictor of all-cause mortality. Others have reported that, at 5 or more years after burn injury, adults have reduced aerobic exercise capacity, suggesting that long-term cardiorespiratory impairments may be present. However, whether this is due to cardiovascular dysfunction or reduced physical activity postburn is not entirely clear. Ganio et al reported that, after at least 10 years after sustaining a burn injury, 88 per cent of adults had cardiorespiratory values below the American Heart Association’s age-adjusted normative values. We found that, when cardiorespiratory fitness was normalized to kg of LBM, adult men had values that were 59 per cent of age- or sex-matched normative values at discharge and that these improved to 78 per cent after training. On the other hand, cardiorespiratory fitness was at 44 per cent of normative values in young boys at discharge, and this improved to only 54 per cent after rehabilitative training. Additionally, when we compared strength (peak torque) between adult males and young boys, men were at 51 per cent at discharge and 58 per cent after training, whereas boys were at 36 per cent at discharge and 45 per cent after exercise training.

In addition to having morphological differences, children and adults greatly differ in metabolic efficiency. The influence of exercise on growth is an important question that remains to be answered in nonburn populations. In adults, the magnitude of the endocrine response that regulates adaptations to exercise is intensity dependent. For example, in adults, the GH response after aerobic exercise occurs at work rates as low as 40 per cent of peak aerobic capacity (peak VO₂) but are the greatest at 75 to 90 per cent. Likewise, resistance exercise produces a greater GH response with high total work and short rest intervals at moderate power (70% or greater). Pediatric exercise responses rely more on aerobic system and less on glycolytic metabolism. Thus, children rely more on fat oxidation during exercise than adults because children’s glycolytic capacity is not fully developed, as supported by the finding that children produce less lactate during exercise than adults. Additionally, children and young adults oxidize exogenous carbohydrates and fat at higher rates than adults. These differences may alter the counterregulatory hormones involved in the response to exercise in nonburned populations. Furthermore, children reportedly have a higher proportion of slow twitch, or type I, fibers in the quadriceps than adults. Thus, burn injury likely affects children to a greater degree than adults because of their maturation and growth, which may negatively affect their ability to adapt to exercise training through increasing contractile proteins and proliferation of mitochondria. However, this is speculative, and whether burn injury differentially affects these regulators of exercise adaptation in burned children and adults is unknown and requires further study.

In nonburned children, it has been reported that aerobic exercise training may produce relatively less of an improvement in aerobic capacity (peak VO₂), which is also confounded by the rate of growth and development. However, our previous work has found that burned children do improve aerobic and strength capacities. Further, our results have consistently shown that the burned men group responded to a greater degree than our burned children. It is not clear why there are differences, but we do show (in Figure 3 and Table 2) that the relative relationship between heart rate and oxygen uptake differs between groups. The American College of Sports Medicine (ACSM) generally recommends calculations of 50 to 65 per cent of your maximum heart rate for beginners, 60 to 75 per cent for intermediate level exercisers, and 70 to 85 per cent for established aerobic exercisers. We typically use a prescribed target heart rate of 60 to 85 per cent peak heart rate. It may be that the intensity of exercise in which we prescribe may not be providing the same training stimulus in children as it is in adults. In Table 2, we highlight that at lower intensities, burned children are working at a lower percentage of their peak VO₂ compared with men. In this regard, this reduced exercise work load (percentage of peak VO₂) may be a reason. It maybe that children need to work at a greater relative heart rate than adults due to these differences. For example, a prescribed intensity of 70 per cent peak VO2 would require a relative intensity of heart rate at 85 per cent for men and 87 per cent for children. At lower intensities where we initially start at 60 per cent peak heart rate, men are training at 43 per cent of their peak VO₂ while children are at 48 per cent, well below the ACSM-recommended guidelines. Further research should determine the dose response of both resistance and aerobic training adaption for obtaining optimal improvements specific to burn populations. Our regression equation provides clear heart rate–based guidelines for men and boys with severe burn injury.

An important limitation of our study is that only boys were tested. Whether girls have similar exercise characteristics as women after burn injury is unknown. Of the individuals admitted to our institution, only about 30 per cent are female, in agreement with an American Burn Association report that burns affect 69 per cent males and 32 per cent females. Others have reported that sex differences in mortality exist after burn injury and that women have a greater risk of death in all age groups from 10 to 70 years old. However, whether female children are affected to a greater degree than women with regard to strength and aerobic exercise capacity is unclear. Another limitation of the study is the racial makeup of the groups, which differed and may have affected the results. Moreover, over 60 per cent of the groups were taking propranolol alone or with oxandrolone. We controlled for the effects of drugs by matching adults and children taking similar drugs. We have previously reported that exercise in isolation or with oxandrolone increases LBM in children. Propranolol likewise improves lean mass, strength, and peak VO₂ in children. However, whether these drugs affect adult men after an exercise training program and offer greater improvements in strength and aerobic exercise capacity is unknown. It bears mentioning that, as we have recently reported, administration of the resting beta blocker, propranolol, does not affect exercise heart rate response and therefore burn children on propranolol can appropriately maintain the prescribed intensity of exercise during training sessions when heart rate is used to guide exercise intensity during exercise rehabilitation.

In summary, we found that boys with burn injury have similar relative body composition as burn-injured men at
discharge and exercise training increases both lean and fat mass in both. We also found that, at discharge, boys experience a greater reduction in strength and cardiorespiratory fitness, with exercise training improving strength to a similar degree in boys and men and aerobic exercise capacity to a greater degree in men. Further studies should determine whether understanding these differential responses can be exploited to improve the rehabilitative process, particularly with regard to tailoring exercise regimens to children and adults with burn injury.

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