Published in final edited form as:

Burns. 2015 December ; 41(8): 1653–1659. doi:10.1016/j.burns.2015.05.020.

The Effect of Lower Body Burns on Physical Function

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Abstract

Objective—To attenuate burn-induced catabolism, patients are often enrolled in a resistance exercise program as part of their physical rehabilitation. This study assessed how lower body burn locations affected strength and cardiopulmonary function.

Methods—Children enrolled in an exercise study between 2003 and 2013, were 7–18 years of age, and burned 30% of their total body surface area were included. Analysis of variance was used to model the relationship of lower body strength (PTW) and cardiopulmonary function (VO_{2peak}) due to burns which traverse the subject's lower body joints.

Results—There was a significant relationship between PTW and burns at the hip and toe joints, showing a 26 Newton-meters/kilogram ($p=0.010$) and 33 Newton-meters/kilogram ($p=0.013$) decrease in peak torque, respectively. Burns at the hip joint corresponded to a significant decrease in VO_{2peak} by $4.9 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ($p=0.010$) in peak cardiopulmonary function.

Conclusion—Physical function and performance are detrimentally affected by burns that traverse specific lower body joints. The most significant relationship on exercise performance was that of hip joint burns as it affected both strength and cardiopulmonary measurements. Ultimately, burns at hip and toe joints need to be considered when interpreting exercise test results involving the lower body.

Keywords

Burn; exercise; lower body; joint

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Authors' contributions

Benjamin, Herndon, Suman are responsible for conception and design of the study; Benjamin, Andersen analyzed the data; Benjamin, Andersen, Herndon, Suman interpreted the results of the experiments; Benjamin, Andersen, Herndon, Suman were involved in drafting the manuscript; Benjamin, Andersen, Herndon, Suman prepared the figures. Benjamin, Andersen, Herndon, Suman revised the manuscript. All authors approved the final version of the manuscript.

Conflicts of interest

Each author declares no conflict of interest or financial affiliation.

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INTRODUCTION

The annual number of burn injuries in the United States requiring medical treatment is approximated at 450,000, of which 40,000 are admitted for acute care. Males comprise nearly 70% of burn patients. The majority of the patients are Caucasian (59%) with African-Americans (20%) and Hispanics (14%) following thereafter. About three-quarters of the patients are injured in the home place with far fewer being work, car, or recreational/sports related. Burn injuries are predominantly flame/fire (43%) and scald (34%), while contact (9%), electrical (4%), chemical (3%), and other (7%) comprise the rest of the patient population. The chance of survival for a burn patient is about 97% [1], leaving an increasingly large number of patients in need of rehabilitation. Burn injuries are most commonly accompanied by stark muscle loss, scarring, and contractures [2], which often benefit from rehabilitation activities including a resistance and cardiopulmonary exercise program [3–5].

Burn injuries result in the highest metabolic rate of any critical injury [6]. Associated with this hypermetabolic state is muscle weakness and cardiopulmonary deconditioning [2, 7], made worse by prolonged inactivity [8, 9]. To attenuate muscle weakness and deconditioning, as well as burn-induced catabolism, patients are often enrolled in a resistance and aerobic exercise program as part of their physical rehabilitation [3]. Such a program implemented post-acute discharge in severely burned children increases muscle strength and cardiopulmonary endurance [3–5].

Diego et al. [10] surveyed licensed physical and occupational therapists who are part of the American Burn Association Physical Therapy/Occupational Therapy Special Interest Group to assess the standard of care for outpatient rehabilitation programs. Of the respondents, 82% claimed their institution offered outpatient therapy after discharge, although 81% of the therapists stated that no cardiopulmonary endurance exercise programs were in place. Additionally, the prescribed and follow-up assessments were found to be diverse among the surveyed institutions. At the time of acute discharge, standard of care at our institution includes recommendations by occupational therapy and physical therapy, which are to be performed at home. Additionally, for patients greater than 7 years of age, standard of care also includes offering patients enrollment into a 12-week supervised resistance and cardiopulmonary exercise program to be completed at our institution.

Comments occasionally made in manuscript reviews and grant proposals note concern about burn location and its effect on exercise performance. These comments have included, concerns that patients with severe burns will have varying burn areas and that the effect of these varying burn locations on physical function and performance is unknown. Thus, the current study was undertaken to assess how burns over lower body joints affected strength and cardiopulmonary endurance. To our knowledge, there have been no previous reports of the effects of burn location on physical function or more specifically, compensatory strategies for lower body movements when multiple lower body parts are impacted by a severe burn.

MATERIALS AND METHODS

Burned Subjects

Children who were randomized and consented to take part in a program consisting of resistance and aerobic exercise (EX) between 2003 and 2013 were included in this study. The children were 7–18 years of age and had a 30% or greater total body surface area (TBSA) burn as assessed by the Lund and Browder method [11] during excisional surgery in the acute phase of injury. Patients were excluded from this analysis if they had 1 or more of the following: leg amputation, anoxic brain injury, psychological disorders, quadriplegia, severe behavior or cognitive disorders, or consented to an institutional review board (IRB) approved study in which they were randomized to receive the active form of a research drug. IRB approval was obtained for this study, as well as informed consent/assent from parents/child subjects for each study participant.

As shown in Figure 2, there were 260 patients who agreed to participate in a randomized study to receive a research drug between 2003 and 2013. Of the 260 enrolled patients, 84 were identified as control patients (taking the non-active form of the research drug). Because this study reviewed measurements taken only at or shortly after discharge, 47 patients who had PTW measurements were analyzed. However, only 36 of those patients had VO_{2peak} measurements and could be included in the subsequent analysis. This was due to the presence of facial burns, as they could not use the mouthpiece to measure VO_{2peak} .

Subjects and Clinical Care

All subjects were admitted to “de-identified” Hospital and treated in a similar manner by the same team of burn surgeons. Standard treatment included early excision of full thickness burn wounds, treatment with systemic antibiotics, and continuous enteral feeding. Early excision involves patients undergoing total burn wound excision and grafting within 48 hours of admission for any full thickness burns. Patients returned to the operating room as donor sites healed and allowed for reharvesting of the unburned skin (usually 7 to 10 days). Additional surgical procedures for excision and grafting were undertaken until all wounds were covered and healed.

All patients received similar standard of medical treatment from the time of hospital admission until time of discharge. In addition, both groups were discharged with similar standard of medical and rehabilitation care. After discharge, patients who consented to participate in EX were tested at “de-identified” Hospital within a week of discharge. Only measurements gathered after discharge from the acute unit, and prior to initiation of an exercise program were used for this study. Measurements were completed in an individualized and supervised manner during leg strength and cardiopulmonary endurance treadmill testing. It should be noted that both measurements rely mainly on lower body function and stability.

Assessment of Burn Location

A Lund and Browder [11] burn diagram was completed for each acutely admitted patient using similar methods of assessment by the same team of burn surgeons during the first

excisional surgery. At this time, the physicians were able to identify burned areas and depth based on the type of excision performed and a Lund and Browder [11] burn diagram was subsequently completed. For consistency purposes, a single author then determined the presence of burns over joints based on the patient's completed Lund and Browder [11] diagram. When a burn traversed or extended over a joint the presence of a burn was noted. Conversely, if there was no burn that traversed the joint, then a burn was marked as absent. Joints included were hips, knees, ankles, and toes.

Assessment of Leg Strength

Strength testing was conducted using the Biodex System 3 dynamometer (Biodex Medical Systems Inc, Shirley, NY), as shown in Figure 1a. The isokinetic test was performed on the dominant leg extensors at an angular velocity of 150°/s, without regard to location of burns. This speed (vs lower or higher angular speeds) was chosen because children of all ages tolerated it well. In accordance with the Biodex System 3 manual, patients were seated and stabilized with a restraining strap placed over the mid-thigh, pelvis and trunk. The anatomic axis of the knee joint was aligned with the mechanical axis of the dynamometer before testing. The Biodex test was presented to all the patients in the same manner. First, the procedure was demonstrated by the test administrator, then a verbal explanation followed, after which the patients were able to practice the movement, sans weight or resistance, by doing 3 submaximal repetitions. To prevent fatigue, the number of repetitions was restricted.

After the warm-up repetitions, subjects performed 10 maximal voluntary muscle contractions (full extension and flexion) consecutively without resting between contractions. The test was repeated after 3 minutes of rest to minimize the effects of fatigue. While the patient was tested, the test administrator encouraged the patient to kick out and retract their leg as hard as they could. The Biodex software calculated peak torque values and corrected for gravitational moments of the lower leg and lever arm. The highest value of the 2 trials was chosen and this was divided by the patient's body weight as a method to standardize and compare measurements, giving peak torque per body weight (PTW), expressed in Newton-meters/kilogram or N·m/kg.

Assessment of Cardiopulmonary Endurance

Subjects underwent a standardized treadmill exercise test using the modified Bruce protocol as part of their standard clinical outpatient evaluation. Heart rate and oxygen consumption (VO_2) were measured and analyzed by using continuous breath-by-breath analysis of inspired and expired gases, flow, and volume [12]. Breath-by-breath analysis were made using a Medgraphics Cardio₂ combined VO_2 /ECG exercise system (Medgraphics, St. Paul, MN), as shown in Figure 1b. The mouthpiece used in this assessment prevented some patients with facial burns from participating in this part of the testing. Speed and angle of elevation started at 1.7 miles/hour and 0%, respectively. Thereafter, the speed and level of incline were increased every 3 minutes to fit the standards of the modified Bruce treadmill test. Subjects were constantly encouraged to complete as many 3-minute stages as possible, and the test was terminated once peak volitional effort ($\text{VO}_{2\text{peak}}$) was achieved. The $\text{VO}_{2\text{peak}}$ and peak heart rate were used to establish the intensity at which patients exercised and assess cardiopulmonary endurance.

Assessment of Pain

As pain scale data were not measured concurrently with exercise activities, data from a separate study were used. This study was conducted within the same time frame of post-acute discharge, was conducted under an approved IRB protocol, and patients were consented prior to participation. The study included dispersion of questionnaires to patients at the time of discharge. The questionnaire was filled out and returned within two weeks of discharge (within one week of exercise testing). A subsequent questionnaire was given at six months post-burn for comparison. Patients completed this questionnaire themselves or with the help of parents if needed, such as age or physical limitations. A portion of this questionnaire is with regard to the level of pain. The question considered for the current study asks the respondent to rate the level of pain experienced by the patient in the last week on a scale of 0–10, where 0 = no pain and 10 = unbearable, excruciating pain. Patients were included in data analysis if the question under consideration was answered at both time points (discharge and six months post-discharge). Additionally, patients must have completed the questionnaire between 2006 and 2013, as questionnaires prior to 2006 did not include this question. Thus, the pain scale data of 137 patients were included in the analysis, with some overlap in the patient population of this exercise study.

Data Analysis

Analysis of variance (ANOVA) for multiple linear regression was used to model the relationship to the outcomes, VO_{2peak} , and PTW, due to the presence or absence of burns about the subjects' joints at the toes, ankle, knee, and hip. A multiple linear regression ANOVA fits a model to the outcome by using more than one variable, such as the multiple joints. This statistical method allows for each joint to be viewed independent from the other joints. The results of each patient are compared to the entire post-burn group of patients and accounting for variances within the group. Thus, each patient may have multiple burned joints, but the model accounts for the differences in outcomes by comparing to patients within the post-burn group, including patients with and without burns over the same joints. The power associated with each predictor was estimated by resampling and modeling the data 10000 times, and estimating the power as the proportion of times the predictor was significant. Statistical analyses were performed using R statistical software (version 3.0.1, R Core Team 2013) [13]. Pain scale data were assessed using a paired two-tailed Student's t-Test in Microsoft Excel 2010 (Microsoft, Redmond, Washington) comparing pain scale data collected at discharge and at six months post-burn. A 95% level of confidence was assumed, and significance was set at $p < 0.05$.

RESULTS

Effects on Leg Strength

To determine if burns that traverse lower body joints had an effect on PTW, 47 patients were studied. These patients were approximately 12 years of age, majority male with an average TBSA burned of 55% (Table 1). Significant relationships with burns at the hip joint ($p = 0.010$, power = 77%) and toe joints ($p = 0.013$, power = 75%) were found, with an associated 26 N·m/kg and 33 N·m/kg decrease in torque, respectively (Fig. 3). In contrast, there was no evidence of ankle or knee burns effecting PTW.

Effects on Cardiopulmonary Endurance

A subset of patients used to study leg strength was used in the analysis of cardiopulmonary endurance. This subset included 36 of the original 47 patients. To assess the effects on cardiopulmonary endurance, $\text{VO}_{2\text{peak}}$ was analyzed with lower body joint burns. The subset of patients was on average 13 years of age, predominately male, and had an average TBSA burned of 55% (Table 1). Figure 4 demonstrated that burns at the hip joint corresponded to a significant decrease of $4.9 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, ($p = 0.010$, power = 80%). There was no significant difference in the age of patients with hip burns and without hip burns in this analysis ($p = 0.50$) and no evidence of a significant relationship due to burns of the toes, ankles, or knees on $\text{VO}_{2\text{peak}}$.

Pain

To determine the level of pain at discharge and six months post-discharge, pain scale (0–10) data were analyzed and presented as average $\pm$ standard deviation. At discharge, patients noted a pain level of 3.9 ± 2.8 , while at six months post-discharge the pain level decreased to 2.0 ± 2.1 . A significantly different level of pain was demonstrated at these two time points ($p < 0.001$).

DISCUSSION

Our results show that burns traversing the hip joint significantly reduce exercise performance, as both $\text{VO}_{2\text{peak}}$ and PTW are detrimentally affected. Additionally, burns that traverse the toe joints have a significantly negative effect on PTW.

It is important to note that the test subjects are children who are newly discharged from the intensive care unit and some are therefore still experiencing pain and tenderness over some areas of the body that were burned. Understandably, walking with hip pain decreases a person's ability and motivation to move freely and results in walking at a slower speed than someone without hip pain. It follows that walking at a slower speed results in a lower $\text{VO}_{2\text{peak}}$ as the patient is unable or unwilling to exert themselves as much as someone who can walk faster without experiencing pain.

On the other hand, when measuring PTW using the Biodex machine, although the knee is the primary joint requiring movement, there are muscle groups over other joints that are used to kick. The momentum gained by utilizing additional muscle groups in the hip may improve the torque of the kick. An injured hip may lead to a decreased ability to kick and, therefore, a decrease in torque. A burn injury present over a hip joint is associated with decreased physical function.

Although the toe joints are not actively involved in the kicking motion, it is suspected that the strap across the shin may create a pulling sensation on the skin when the patient kicks out. This tension may resonate as pain, resulting in a decreased desire to kick hard in order to avoid the impending pain. Moreover, sometimes the amount of pain that can result from an injured toe is underestimated. Consider past experiences involving a stubbed or broken toe and the amount of pain that results. It is common for this kind of discomfort to detrimentally affect a person's ability to move. A similar conclusion can be drawn regarding

kicking with injured toes, especially when combined with a strap that creates tension on sensitive skin.

To our knowledge, there have been no previous reports of the effects of burn location on exercise performance. There are, however, studies done on joints of nonburned individuals with other impairments that are often painful or result in limited movement with similar results. For instance, a study comparing healthy people and people with knee osteoarthritis, found there was no difference in patients with osteoarthritis when exposed to challenging perturbations [14], such as kicking with a large torque or running. When walking at high speeds, the kinematic changes of the forefoot made while walking at normal speeds are not seen in individuals with rheumatoid arthritis [15]. These results support our results, showing that no difference is seen in patients with and without burns over the toe joints while running on the treadmill.

It was suggested that increased ankle pushoff while walking may compensate for hip muscle weakness or injury, and thus the forces of the hip. It was shown that with increased ankle pushoff, lower hip flexion and extension are observed [16]. It follows that a burned hip joint may be compensated for by increased movement or force from the ankle. One reason this may not be seen in our study is because the ankle may also be burned and may not be able to compensate for the hip. On the other hand, the muscles surrounding the hip joint are large and powerful. Thus, the other leg joints and muscle groups may not be able to completely compensate, which leaves the effects of an injured hip noticeable.

In addition, we evaluated the effect of upper body burned joints on lower body strength and cardiopulmonary function. No significant relationship was found, which was to be expected as both the lower body strength and cardiopulmonary function rely on lower body physical function and stability. Similarly, there was no significant relationship found when burned surfaces, specifically the areas between joints were compared to lower body strength and cardiopulmonary function. The burned surfaces were divided in the same manner as the Lund and Browder diagram [11].

As the presence of a hip burn is detrimental in both the lower body strength test and the cardiopulmonary function test, it should be the primary consideration when designing exercise programs and interpreting results. Consequently, we reviewed our most recent study published by Hardee et al. to determine the location of burns. For consistency purposes, the same author and methodology was used to determine location of burns in the Hardee et al. [17] study as was used in this study- a single author reviewed Lund and Browder [11] burn diagrams completed by a faculty physician at the time of the first excisional surgery. The number of patients with hip burns in the two groups of the Hardee et al. [17] study, standard of care and exercise, were found to be the same. It can be concluded, that the outcomes described in the paper are a result of the exercise program in which the patients participated and not due to an unequal number of patients with hip burns in the standard of care group.

Pain data were not concurrently collected with exercise testing, although we speculate that patients presented with pain, as prescriptions for pain medicine at acute discharge are

pervasive. Nearly every patient who is discharged from our hospital after an acute admission with over 30% TBSA burned is prescribed medicine to help regulate pain. In burn survivors, Ullrich et al. [18] noted a negative relationship between pain and physical function, concluding that in the presence of pain physical function is compromised. After an acute burn, the whole body is in a state of hypersensitivity and pain is commonly experienced and reported [18–20]. Based on previous studies and our own experience, we speculate that the presence of an increased level of pain at discharge and subsequently during exercise testing will have a significantly detrimental effect on the patient's ability to exercise. Studies concurrently assessing pain and exercise are needed to answer this question specifically. Future studies will be done by our group to collect visual analog pain scale data during exercise testing with a baseline pain score taken prior to the start of exercise as a reference. Thus, a more accurate account of pain due to exercise can be obtained.

Finally, we recognize that the possibility of a type I error in this study cannot be ruled out and that the number of subjects is small. Through power analysis, we attempted to account for these limitations. The regression models implicitly assume that the effects due to burns at each joint contributed independently to the outcome, and that the independent contributions sum to a cumulative effect on the outcome. With additional patients, more nuanced models may be explored.

As future studies on physical function are designed, care should be taken to ensure a similar number of patients with burns that traverse the hips are in each group. This may be achieved by good randomization to treatment. If this cannot be arranged, then the results should be statistically corrected to account for the detrimental effect described. Ultimately, burns that traverse the hip joint should be considered when developing exercise programs or interpreting exercise test results involving the lower extremities.

Acknowledgments

The authors would like to thank the staff of the wellness center at “de-identified” Hospital for their valuable assistance, especially “de-identified.” In addition, the authors would like to thank the staff collecting questionnaires providing pain data. This work was presented in abstract form at the “de-identified” conference in 2014.

This work is supported by grants from UTMB BP Remembering the 15, Burn Research Education (565450), SHC Special Shared Facility for Clinical Research (84080), National Institutes of Health (P50-GM60338, R01-GM56687, and R01-HD049471), Shriners Hospitals for Children (71006, 71008, 71009, 84080), National Institute for Disabilities and Rehabilitation Research (H133A070026 and H133A120091), Clinical and Translational Science Award (UL1TR000071). The funding source had no role in the preparation or decision to submit the article for publication.

References

1. American Burn Association National Burn Repository (2013 Report). American Burn Association; 2013. Available from: http://www.ameriburn.org/resources_factsheet.php [Accessed on February 2015]
2. Hart DW, Wolf SE, Mlcak R, Chinkes DL, Ramzy PI, Obeng MK, et al. Persistence of muscle catabolism after severe burn. *Surgery*. 2000; 128:312–9. [PubMed: 10923010]
3. Suman OE, Spies RJ, Celis MM, Mlcak RP, Herndon DN. Effects of a 12-wk resistance exercise program on skeletal muscle strength in children with burn injuries. *J Appl Physiol* (1985). 2001; 91:1168–75. [PubMed: 11509512]

4. Suman OE, Thomas SJ, Wilkins JP, Mlcak RP, Herndon DN. Effect of exogenous growth hormone and exercise on lean mass and muscle function in children with burns. *J Appl Physiol* (1985). 2003; 94:2273–81. [PubMed: 12588788]
5. Przkora R, Herndon DN, Suman OE. The effects of oxandrolone and exercise on muscle mass and function in children with severe burns. *Pediatrics*. 2007; 119:e109–16. [PubMed: 17130281]
6. Wilmore DW. Nutrition and metabolism following thermal injury. *Clin Plast Surg*. 1974; 1:603–19. [PubMed: 4154156]
7. Hart DW, Wolf SE, Chinkes DL, Gore DC, Mlcak RP, Beauford RB, et al. Determinants of skeletal muscle catabolism after severe burn. *Ann Surg*. 2000; 232:455–65. [PubMed: 10998644]
8. Ferrando AA, Lane HW, Stuart CA, Davis-Street J, Wolfe RR. Prolonged bed rest decreases skeletal muscle and whole body protein synthesis. *Am J Physiol*. 1996; 270:E627–33. [PubMed: 8928769]
9. Ferrando AA, Tipton KD, Bammann MM, Wolfe RR. Resistance exercise maintains skeletal muscle protein synthesis during bed rest. *J Appl Physiol* (1985). 1997; 82:807–10. [PubMed: 9074967]
10. Diego AM, Serghiou M, Padmanabha A, Porro LJ, Herndon DN, Suman OE. Exercise training after burn injury: a survey of practice. *J Burn Care Res*. 2013; 34:e311–7. [PubMed: 23511288]
11. Lund CC, Browder NC. The estimation of areas of burns. *Surg Gynecol Obstet*. 1944; 19:352–8.
12. Jones, NL. *Clinical Exercise Testing*. Philadelphia, PA: Saunders; 1997.
13. R Core Team. [Accessed on February 2015] R: a language and environment for statistical computing. R Foundation for Statistical Computing. 2013. Available from: <http://www.R-project.org>
14. Kumar D, Swanik CB, Reisman DS, Rudolph KS. Individuals with medial knee osteoarthritis show neuromuscular adaptation when perturbed during walking despite functional and structural impairments. *J Appl Physiol* (1985). 2014; 116:13–23. [PubMed: 24072409]
15. Laroche D, Ornetti P, Thomas E, Ballay Y, Maillefert JF, Pozzo T. Kinematic adaptation of locomotor pattern in rheumatoid arthritis patients with forefoot impairment. *Exp Brain Res*. 2007; 176:85–97. [PubMed: 16915399]
16. Lewis CL, Ferris DP. Walking with increased ankle pushoff decreases hip muscle moments. *J Biomech*. 2008; 41:2082–9. [PubMed: 18606419]
17. Hardee JP, Porter C, Sidossis LS, Borsheim E, Carson JA, Herndon DN, et al. Early rehabilitative exercise training in the recovery from pediatric burn. *Med Sci Sports Exerc*. 2014; 46:1710–6. [PubMed: 24824900]
18. Ullrich PM, Askay SW, Patterson DR. Pain, depression, and physical functioning following burn injury. *Rehabil Psychol*. 2009; 54:211–6. [PubMed: 19469612]
19. Dauber A, Osgood PF, Breslau AJ, Vernon HL, Carr DB. Chronic persistent pain after severe burns: a survey of 358 burn survivors. *Pain Med*. 2002; 3:6–17. [PubMed: 15102213]
20. Summer GJ, Puntillo KA, Miaskowski C, Green PG, Levine JD. Burn injury pain: the continuing challenge. *J Pain*. 2007; 8:533–48. [PubMed: 17434800]

HIGHLIGHTS

- Hypermetabolism, and consequently muscle wasting, often accompanies severe burns.
- A resistance and aerobic exercise program attenuate catabolism.
- Burns traversing the hip joint detrimentally affect lower body physical function.
- Understanding the effects of burns over the hip joints is important for rehab.

Figure 1.

a) To measure strength, isokinetic dynamometry was performed on the dominant leg at an angular velocity of 150 degrees per second. As shown, the patient's leg was strapped to a lever on the Biodex machine and the patient was encouraged to extend and retract their leg with as much effort as they could. The value returned was peak torque and this was divided by their body weight as a method to standardize and compare patient measurements, giving peak torque per body weight or PTW. b) Measuring a patient's aerobic ability during exercise was done using a modified Bruce treadmill test. This test has standardized stages to be done in 3-minute increments. Each stage corresponds to a specific treadmill speed and elevation and patients are encouraged to complete as many stages as possible. While on the treadmill $\text{VO}_{2\text{peak}}$ is assessed by measuring oxygen consumption utilizing a mouth piece, as shown in the picture on the right. From these measurements peak cardiorespiratory function is determined.

Figure 2.
Consort diagram showing the number of patients enrolled in the study and those whose measurements were analyzed.

Figure 3.

Burned joints compared to peak torque per body weight (PTW) at 150°/s. Peak torque per body weight is expressed in Newton-meters/kg. Values are means $\pm$ SE. * $p = 0.01$ for PTW in burn patients with toe and hip burns compared to patients without toe and hip burns.

Figure 4.

Burned joints compared to peak cardiopulmonary function (VO_{2peak}). Peak cardiopulmonary function is expressed in milliliters/kilogram/minute. Values are means $\pm$ SE. * $p < 0.01$ for VO_{2peak} in burn patients with hip burns compared to patients without hip burns.

Table 1

Demographics of patients who completed lower body Biodex torque test (PTW) and a treadmill test with indirect calorimetry testing ($\text{VO}_{2\text{peak}}$).

Variable	PTW	$\text{VO}_{2\text{peak}}$
Number of subjects	47	36
Age, years	12 $\pm$ 3	13 $\pm$ 3
Gender, males (%)	36 (77%)	29 (81%)
Ethnicity, n (%)		
African American	2 (4%)	--
Hispanic	43(92%)	34 (94%)
Caucasian	2 (4%)	2 (6%)
Burn type, n (%)		
Flame	40 (85%)	29 (80%)
Scald	2 (4%)	2 (6%)
Electric/Flame	5 (11%)	5 (14%)
TBSA burn, %	55 $\pm$ 12	55 $\pm$ 12
3rd burn, %	39 $\pm$ 22	35 $\pm$ 21

TBSA = total body surface area. Data presented as means $\pm$ SD, or counts (%).