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Assessment of muscle function in severely burned children☆

Shashi M. Alloju [c], David N. Herndon [a,b,c], Serina J. McEntire [a,b], Oscar E. Suman [a,b,c,*]

[a] Shriners Hospitals for Children, 815 Market Street, Galveston, TX 77550, United States
[b] Department of Surgery, The University of Texas Medical Branch, Galveston, TX 77555, United States
[c] School of Medicine, The University of Texas Medical Branch, Galveston, TX 77555, United States

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ABSTRACT

Introduction: The posttraumatic response to a severe burn leads to marked and prolonged skeletal muscle catabolism and weakness, which persist despite standard rehabilitation programs of occupational and physical therapy. We investigated the degree to which the prolonged skeletal muscle catabolism affects the muscle function of children 6 months after severe burn.

Methods: Burned children, with >40% total body surface area burned, were assessed at 6 months after burn in respect to lean body mass and leg muscle strength at 150°/s. Lean body mass was assessed using dual-energy X-ray absorptiometry. Leg muscle strength was assessed using isokinetic dynamometry. Nonburned children were assessed similarly, and served as controls.

Results: We found that severely burned children ($n = 33$), relative to nonburned children ($n = 46$) had significantly lower lean body mass. Additionally they had significantly lower peak torque as well total work performance using the extensors of the thigh.

Conclusions: Our results serve as an objective and a practical clinical approach for assessing muscle function and also aid in establishing potential rehabilitation goals, and monitoring progress towards these goals in burned children.

1. Introduction

Severe burns result in marked and prolonged skeletal muscle catabolism and weakness [1], which persist despite "standard" rehabilitation programs of occupational and physical therapy. This state of catabolism and weakness is made worse by the period of physical inactivity following the burn incident [2]. Despite the extensive amount of literature on the physical effects of a severe burn, there is a lack of individual quantitative data of pediatric burn patients' muscle function. Individual and quantitative assessment of muscle function can be useful information in evaluating functional capability, and the efficacy of rehabilitation strategies. Therefore, in this study, individual isokinetic leg muscle function data in burned children and age matched controls is presented as well as a potential clinical application to assess the rehabilitation in burned patients, and perhaps construct an individually tailored rehabilitative plan.

2. Methods

2.1. Subjects

Children, ages 6–17, were enrolled in this study. The groups consisted of children with burn and children without burn to

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* *Corresponding author at*: The Children's Wellness and Exercise Center, Shriners Hospitals for Children, 815 Market Street, Galveston, TX 77550, United States. Tel.: +1 409 770 6557; fax: +1 409 770 6919.
E-mail address: oesuman@utmb.edu (O.E. Suman).
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serve as age matched controls. Only subjects with ≥40% of total body surface area (TBSA) burned, as assessed by the ''rule of nines'' method [3] during excisional surgery in the acute phase injury, were enrolled. Patients were excluded if they had one or more of the following: leg amputation, anoxic brain injury, psychological disorders, quadriplegia, or severe behavior or cognitive disorders. Informed consent was obtained by the parent or legal guardian. All of the burned subjects received ''standard'' medical care and treatment from the time of admission and acute care of the burn until time of discharge. This standard medical care refers to the typical and reasonable surgical and medical care during the acute phase, as well as after discharge from the acute unit [3–8]. The nonburned group was randomly selected; however the age and exclusion/inclusion criteria were met to match the burned group.

2.2. *Strength measurements*

Strength testing using a Biodex Isokinetic Dynamometer (Shirley, NY) was done at approximately 6 months after the date of burn [9]. The isokinetic test was performed on the dominant leg extensors and tested at an angular velocity of 150 °/s. The children were seated and their position stabilized with a restrained strap over the mid-thigh, pelvis, and trunk in accordance to the *Biodex Advantage Operating Manual*. All children were familiarized with the Biodex test in a similar manner (Fig. 1). First, the procedure was demonstrated by the administrator of the test. Second, the test procedure was explained to the children, and third, the children were allowed to warm-up and practice the actual movement by performing three repetitions without a load. More repetitions were not allowed to prevent the potential onset of fatigue. The anatomical axis of the knee joint was aligned with the mechanical axis of the dynamometer before the test. After the three sub maximal warm-up repetitions, 10 maximal voluntary muscle contractions (full extension and flexion) were performed. The maximal repetitions were performed consecutively without rest in between. Three minutes of rest was given to minimize the effects of fatigue and the test was repeated.

Values of peak torque and total work were calculated by the Biodex software system (see Table 1 for definitions of peak torque and total work). The highest peak torque (expressed as Newton-meters (N m)) and total work (expressed as Joules (J)) between the two trials were selected. Peak torque was corrected for gravitational moments of the lower leg and the lever arm. Corrections for differences in leg lean mass (LLM) were made by dividing peak torque and total work by LLM.

Table 1 – Definitions of muscle function

Peak torque	Highest muscular force output at any moment during a repetition. Indicative of a muscle's strength capabilities (reported in Newton-meters; N m)
Total work	Total muscular force output for the repetition with greatest amount of work. Work is indicative of a muscle's capability to produce force throughout the range of motion (reported in Joules; J)

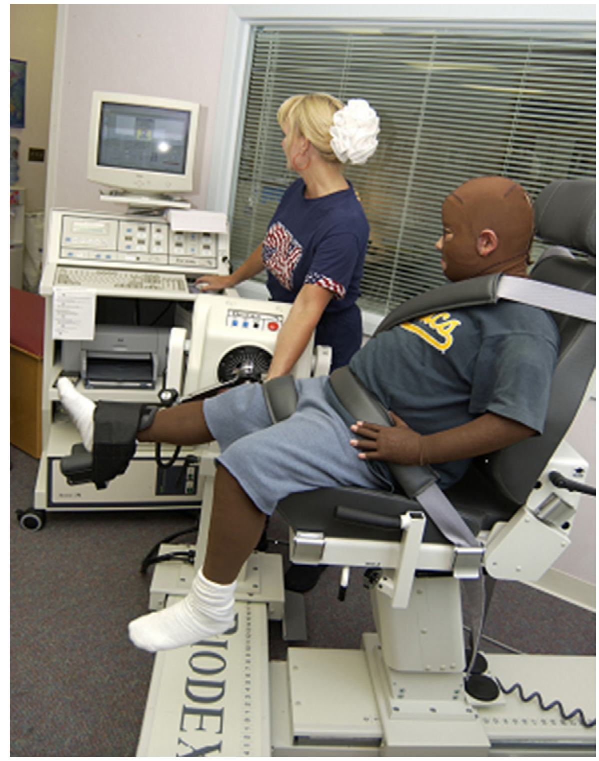

Fig. 1 – Image showing the Biodex Isokinetic Dynamometer. Subjects are seated upright with seat height, distance from ankle to knee and distance from knee to back recorded.

2.3. *Lean body mass measurements*

Total lean body mass (TLBM) and LLM measurements were made for both groups using the dual-energy X-ray absorptiometry (DEXA) using the QDR 4500A software (Hologic, Waltham, MA). Scans were taken with the patient lying supine on the scanning table. The protocol for obtaining a whole body scan was done according to the manufacturer's instructions and has been described by our group. DEXA with pediatric software can measure the attenuation of two X-ray beams, one which is high energy and other which is low energy. These measurements are then compared with standard models of thickness used for bone and soft tissue. Subsequently, the calculated soft tissue is separated into TLBM, and fat mass. Lean mass whether it is TLBM or LLM is reported in kilograms.

2.4. *Data analysis*

Differences in LLM and TLBM between burn and unburned were assessed using Student's *t*-test. Effects of burn on peak torque and total work corrected for LLM were evaluated using a two-way ANOVA followed by Tukey's test when appropriate. Relationships between variables such as LLM and peak torque were evaluated using Pearson's correlation coefficient and linear regressions. Results are presented as mean ± S.E.M. Statistical significance was accepted at the $p < 0.05$ level.