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Anthropometry, muscular strength and aerobic capacity up to 5 years after pediatric burns

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ABSTRACT

Objective: Physical functioning is of major importance after burns in many areas of life, in both the short and the long term. This cross-sectional study aimed to describe anthropometry, muscular strength and aerobic capacity in children and adolescents between 0.5–5 years after burns over 10% TBSA.

Procedures: Assessments took place in a mobile exercise lab. Demographics, burn characteristics and anthropometrics were recorded. Muscular strength in six muscle groups was measured using hand-held dynamometry and aerobic capacity was measured with a graded cardiopulmonary exercise test. Subjects' scores were compared with Dutch age- and gender-matched norm values and converted to Z-scores.

Results: The assessments were completed by 24 subjects with pediatric burns ranging from 10 to 41% TBSA and time after burn from 1 to 5 years (58.3% male; 6–18 years). On group level, no significant differences between the subjects' scores and norm values were found. No trends were seen indicating an effect of extent of burn or time after burn. Individually, eight subjects (33.3%), mostly aged 6 or 7, showed significantly low performance on at least one variable: seven for strength, one for aerobic capacity and one for both.

Conclusion: Anthropometry, muscular strength and aerobic capacity are adequate in the majority of Dutch children and adolescents 1–5 years after 10–41% TBSA burns.

1. Introduction

Burns can have a major impact on physical functioning in both the short and long term. Patients with burns are at risk of getting into the so-called negative spiral of deconditioning [1], where a condition leads consecutively to inactivity, ongoing deconditioning, deterioration of functioning and, finally, to possible disability [1]. This is highly undesirable considering functioning and participation in daily life, especially in

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pediatric burn survivors since childhood is a critical life period for development during which also a basis is laid to prevent deficits and disease throughout life [2].

Deconditioning after pediatric burns is a serious concern, as physical fitness was shown to be significantly affected in children with extensive burns (>40% total body surface area [TBSA]) ([3–6]; for review see Disseldorp et al. [7]).

Deconditioning after burns is assumed to be induced by (the combination of) prolonged hospitalization and the consequences of the injury itself [8]. Hospitalization (i.e. prolonged bed rest, immobilization, inactivity) after burns can result in a decrease in heart and lung capacity and in peripheral effects like muscle atrophy, osteoporosis and contractures. Furthermore, severe burns result in a variety of both local and systemic physiological responses. This pathophysiologic response to burns is characterized by hypermetabolism, increased catabolism (e.g. of muscle and bone minerals) and insulin resistance [9,10] and can negatively impact physical fitness.

The current paper is specifically focused on components of physical fitness that the combination of inactivity and pathophysiological consequences of burns interfere with. Firstly, several pediatric studies indicated growth delays in both height and weight up to 3 years after extensive burns, due to altered energy expenditure, indicating that anthropometry is affected [11,12]. Secondly, muscular strength is affected after burns as the increased protein demand leads to catabolism and results in loss of muscle mass [13,14]. Recent studies additionally suggest impact on mitochondrial function [9] and gene expression [15] in skeletal muscle in a non-burned limb, but full comprehension of these processes is still lacking. Aerobic capacity, lastly, can be affected by a combination of, for example metabolic, muscular and cardiorespiratory, effects [3,12,16,17].

However, the current knowledge on physical outcomes is limited and can therefore hardly be generalized [7]. First, all this information is based on children with extensive burns, whereas the impact of less extensive burns on physical outcomes is hitherto neglected in the literature. The studies on pediatric burns solely included children with burns covering >40% of the total body surface area (%TBSA). Such major pediatric burns are rare in the Netherlands and the US [18,19], i.e. represent <5% of cases, and this will probably also apply for other developed countries. Since the current knowledge is based on a selection with respect to extent of burn, it is not representative for the general pediatric burn population. Second, the assessments were performed relatively short after burn, considering the severity of the injuries plus long hospitalization. Hence, the results are not necessarily representative for longer term outcomes. Furthermore, the physical outcomes after pediatric burns depend on more factors than burn characteristics only [20].

All in all, it is yet unknown whether physical fitness is affected in pediatric burn patients with less extensive burns and/or at a longer period after burn. The current paper therefore aims to describe anthropometry, muscular strength and aerobic capacity in Dutch children and adolescents with a wide range of burn characteristics, also in comparison to norm values of non-burned peers.

2. Methods

2.1. Subjects

Between August and December 2012, children and adolescents aged 6 up to and including 18 years were invited to participate if they had been admitted to one of the three Dutch burn centers between 0.5 and 5 years ago with burns of at least 10% TBSA or had a length of stay at the burn center of more than 6 weeks. Extensive (pre-existing) comorbidity or (mental) disabilities and insufficient Dutch language proficiency were criteria for exclusion. Informed consent, signed by the participant aged 18 years or by parents/legal representatives and children 12 years and older, was required for participation, as well as a signed pediatric Exercise Pre-participation Screening questionnaire [21]. The Medical Ethical Committee of the University Medical Center Groningen approved this study (NL40183.042.12).

2.2. Data collection

As the protocols and instruments for data collection were described in detail previously [22], a brief description is provided here. Anthropometry, muscular strength and aerobic capacity were assessed in a mobile exercise lab and all data collection has been done by the same researcher.

Subject characteristics: Age, gender, extent of burn, location of burns, presence of inhalation injury, number of surgeries and dates of the burn incident, admission and discharge were obtained from the Dutch Burn Repository for all subjects. These data were also obtained, anonymously, for non-participants to enable a non-response analysis.

Anthropometry: Body height [cm] and weight [kg] were assessed and BMI [kg m^{-2}] was calculated. Waist circumference [cm] was measured between the lowest rib and the hipbone [23] and skinfold thicknesses [mm] at the triceps, biceps, subscapular and supra-iliacal site [24].

Muscular strength: A hand-held dynamometer (Citec, type CT 3001, CIT Techniques, Groningen, The Netherlands) was used to assess muscular strength [N] in shoulder abductors, knee flexors and extensors and elbow flexors and extensors [25]. Norm values from Beenakker et al. were available for a large number of joints [25], but for the sake of feasibility of the study this selection was chosen, including the largest joint areas with large muscle groups that are important to physical activities in daily living and at risk in pediatric burns. Grip strength was included because it is related to total muscle strength [26]; for the grip strength assessments a special full-fist applicator was used [26].

Aerobic capacity: Aerobic capacity was assessed with a graded cardiopulmonary exercise (cycling) test. The instrumented participants started with three minutes sitting in rest, followed by a three minutes warming-up of unloaded cycling. Thereafter, the work rate (WR [W]) increased with 10, 15 or 20 W min^{-1}, dependent on body height according to the Godfrey protocol [27,28]. Participants were instructed to maintain a pedaling rate of 60–80 revolutions·min^{-1} and verbal encouragement was given during the test until the patient stopped due to volitional exhaustion. Peak exercise oxygen uptake (VO_2) was calculated by averaging the values