Rehabilitation Exercise Increases Physical Activity Levels in Severely Burned Children While Improving Aerobic Exercise Capacity and Strength

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This study tested the hypothesis that participation in a rehabilitation exercise program following hospital discharge would increase the level of physical activity in burned children than that seen in free-living nonburned children. Thirty-one severely burned children (12 ± 3 years, 144 ± 18 cm, 42 ± 17 kg, 48 ± 12% TBSA burns) were matched to 31 nonburned children (12 ± 3 y, 147 ± 17 cm, 45 ± 15 kg) based on age and sex. Pedometers were used to track minutes and steps in burned children during their exercise rehabilitation and nonburned children under free-living conditions (healthy control). We found that the average minutes of activity per day was lower in burned children (56 ± 25minutes) than in nonburned children (74 ± 28 minutes, $P < .05$). However, no difference was detected for average steps per day or week or maximal minutes in 1 day or week. At discharge, burn children had peak torque and mean power values that were 61% of nonburned values, and exercise training improved these by 27 and 28%, respectively (88 and 89% of nonburned values; each $P \leq .0001$). Likewise, cardiorespiratory fitness at discharge was 72% of nonburned values, and exercise training improved fitness by 10% (82% of nonburned values, $P < .05$). Percentage TBSA burned was inversely associated with steps ($r = -0.54$, $P = .001$) and minutes of activity ($r = -0.53$, $P = .002$), accounting for 28–29% of the variability in burned children. These results show that, at discharge, burned children are capable of matching steps of physical activity levels seen in nonburned healthy children. Physical activity monitoring may be a viable option for continued improvement of physical exercise capacity when burned children are under free-living conditions. (J Burn Care Res 2018;39:881–886)

Burn trauma affects approximately 486,000 people in the United States[1] and 11 million globally.[2] This trauma causes a systemic inflammatory and endocrine response that negatively affects whole-body metabolism, lean body mass, growth, and cardiopulmonary and skeletal muscle functions.[3] Burn care treatments have improved survival in patients with severe burn injury; however, these advancements have been accompanied by long-term metabolic and cardiovascular complications that can last up to 3 years postburn, thereby reducing physical capacity and quality of life in burned children.[3,4]

We have shown that, at discharge, cardiorespiratory fitness and strength are lower in burned children than in nonburned healthy children and that exercise rehabilitation improves these negative effects.[5–9] For example, early physical rehabilitation exercise that is started at discharge in a hospital setting has been found to improve functional capacity and lean body mass.[7,8] It is also generally recognized that exercise is important in the physical and psychological development of a child. The Physical Activity Guidelines from the U.S. Department of Health and Human Services state that physical activity can improve aerobic capacity, muscle strength and endurance, daily functional capacity, mental health, and bone strength in several nonburned populations.[9] Moreover, the World Health Organization and American Heart Association suggest that children should engage in 60 minutes of moderate-to-vigorous physical activity (about 11,500 steps a day) for optimal health.[10–12]

Physical fragility resulting from tender scars, grafts, and contractures can also affect patients' daily living and mental well-being as they learn to compensate for the reduced range of motion and increased vulnerability.[13] However, burn patient's quality of life and psychological measures have been shown to improve after exercise intervention.[14–16] Thus, physical activity should be encouraged after patients leave the hospital setting. Therefore, we assessed the physical activity level of severely burned children during their participation in an exercise rehabilitation program and compared these levels to those in age- and sex-matched nonburned children using pedometers. Our hypothesis was that burned children completing an exercise rehabilitation program would have activity levels similar to those of active nonburned children while improving their aerobic and strength exercise capacities.

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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 parents or legal guardians and child assent was obtained, as applicable.

Subjects

We enrolled 31 subjects 7–17 years of age with 30% or greater TBSA burns. The patients included in this study were admitted to Shriners Hospitals for Children—Galveston between February 2013 and June 2015 for flame (n = 22), scald (n = 1), and electrical/flame injury (n = 8). TBSA burned and TBSA third-degree burns were calculated by nursing staff. On admission, TBSA burned was documented in Lund and Browder charts and adjusted accordingly on demarcation of third-degree burns. Once discharged from acute hospital care, patients were enrolled in an exercise program and underwent body composition, strength, and aerobic capacity testing as described below. The information gathered was compared with that collected from nonburned healthy children. Because of positive benefits from exercise in burned populations,[9] ethical limitations prevented us from having a burned no-exercise group. The healthy nonburned pediatric reference group comprised children from the local community. The individuals within the control group were compensated for their participation.

Measuring Physical Activity With Pedometers

Physical activity was quantified using pedometers (Lifecorder EX, NL-2200, LC; Suzuken, Nagoya, Japan) and the Physical Activity Analysis Software (PAAS) Lifestyle Coach program. Activity monitors were distributed at the time of hospital discharge and were worn during outpatient hospital-based exercise and rehabilitation. Patients and their parents were instructed to keep the pedometers clipped onto patients at all times, except during bathing and sleeping. Physical activity levels were determined by analyzing the number of effective days, the number of calories burned, the minutes of activity, and the number of steps. Pedometers have been found to be viable method of determining the physical activity levels in pediatric populations.[17,18]

Rehabilitative Exercise Training

Immediately on discharge, subjects were enrolled in rehabilitative exercise training once their wounds were at least 95% healed. American College of Sports Medicine-certified trainers worked with each individual in a personalized 6- to 12-week exercise training program. Children with ≤60% TBSA burns were placed in a 6-week training program, while those with ≥60% TBSA burns were enrolled in a 12-week program. The exercise rehabilitation program started immediately after discharge, was performed in a hospital setting (Shriners Hospitals for Children—Galveston), and entailed up to five sessions per week of aerobic exercise and two sessions per week of resistance exercise. All exercise was performed under the guidance and supervision of an American College of Sports Medicine-certified exercise specialist.

Body Composition

Dual-energy x-ray absorptiometry (QDR-4500-W; Hologic, Bedford, MA) was used to determine bone mineral content, total body mass, total body fat, total body lean mass, and visceral fat mass. The machine was calibrated daily for increased accuracy of results.

Aerobic Exercise Capacity (Modified Bruce Treadmill Test)

Aerobic exercise capacity was determined by measuring oxygen consumption (VO_2) during a modified Bruce treadmill test. The modified test involved 3-minute stages of speed and grade increases until volitional exhaustion. Children with facial burns wore a gas mask rather than a mouthpiece, as it was less irritating to their injuries. Respiratory gasses were analyzed using breath-by-breath data using an automated MedGraphics Cardi O_2 metabolic cart (St. Paul, MN) after O_2 and CO_2 gas and airflow were calibrated using known gasses and a 3-L syringe. Peak values were determined by meeting three of the following criteria: a respiratory exchange ratio ≥1.05, a leveling off in VO_2 with increasing workloads (<2 ml $O_2 \cdot kg^{-1}$/min), volitional fatigue, final exercise heart rate ≥190 bpm, or a final test time of 8 to 12 minutes.

Strength

Strength was determined using isokinetic dynamometry. The Biodex System 4 dynamometer (Biodex Medical Systems, Shirley, NY) measured peak torque and average power generated by a 150° extension of the knee joint in the dominant leg.

Data and Statistical Analyses

Subjects' physical activity levels and exercise characteristics were compared between nonburned and burned children using unpaired t-tests. Pre to post-exercise time was assessed by Student's paired t-test. To control for age and sex between groups, we matched each burned child with a nonburned child of similar age and sex. Peak torque, mean power, and peak VO_2 were assessed as a relative percentage of that in the nonburned counterpart. Relative percentages of values in nonburned controls were analyzed using Student's paired t-test. Pearson correlations were used for relationships between TBSA burned and minutes and steps of physical activity. Data from burned children were analyzed and compared before and after rehabilitative exercise training using paired two-tailed t -tests. Figures were created with GraphPad Prism (6, GraphPad Software, La Jolla, CA). Significance was set at $P < .05$, and all data were reported as mean ± SD.

RESULTS

Subjects' Physical Characteristics

Age was comparable in both burned and nonburned groups (P = .73) (Table 1). Likewise, groups were matched for body morphology characteristics (height, weight, body mass index, body mass index percentile, and normalized fat mass and lean mass; each $P > .5$). Of the 31 children with burn injuries, 9 received treatment with a combination of oxandrolone and propranolol, 3 received metformin, 9 received propranolol alone, and 10 were placebo controls.

Table 1. Subjects' physical characteristics

Characteristics*	Burned		Nonburned
	At Discharge	After Exercise Training	
N (men/women)	31 (19/12)	31 (19/12)	31 (19/12)
Age (yr)	12 ± 3	12 ± 3	12 ± 3
Length of acute care stay (days)	29 ± 14	—	—
Height (cm)	144.2 ± 18.3	147.0 ± 17.5	146.9 ± 16.7
Weight (kg)	41.8 ± 16.6	43.5 ± 14.2	45.2 ± 15.1
BMI (kg/m)	19.6 ± 5.4	19.7 ± 3.8	20.5 ± 4.6
BMI (%ile)	58.3 ± 33.5	58.0 ± 31.8	62.4 ± 28.5
Normalized fat mass (kg/m)	5.8 ± 2.3	6.1 ± 2.5	6.3 ± 2.9
Normalized lean mass (kg/m)	12.8 ± 1.5	13.2 ± 1.8	13.8 ± 2.3
TBSA burn (%)	48 ± 12	—	—
TBSA third-degree burn (%)	33 ± 16	—	—

*Data reported as mean ± SD.
BMI, body mass index; BMI %tile, body mass index percentile for age.

Table 2. Subjects' daily physical activity and peak exercise characteristics

Characteristic*	Burned		Nonburned
	At Discharge	After Exercise Training	
Physical activity			
Number of days worn	—	36 ± 17†	14 ± 14
Average minutes of activity	—	56 ± 25†	74 ± 28
Average activity calories	—	83 ± 38†	133 ± 48
Average steps	—	5215 ± 2542	6852 ± 2646
Maximal steps in 1 day	—	11798 ± 5524	12663 ± 4258
Average total calories in 1 week	—	1658 ± 265	1724 ± 302
Maximal minutes of activity in 1 day	—	122 ± 57	135 ± 43
Maximal activity calories in 1 day	—	206 ± 90	258 ± 88
Maximal total calories in 1 week	—	1865 ± 348	1900 ± 327
Peak aerobic capacity			
Peak VO_2 ($ml{\cdot}O_2{\cdot}kg^{-1\ TBM}/min$)	23.7 ± 5.3†	28.0 ± 6.2†‡	34.9 ± 10.0
Peak VO_2 ($ml{\cdot}O_2{\cdot}kg^{-1\ LBM}/min$)	36.3 ± 11.3†	39.7 ± 11.0†‡	50.4 ± 10.8
RER	1.1 ± 0.2	1.0 ± 0.1	1.1 ± 0.1
Peak Strength			
Peak torque (N-M)	35.8 ± 15.1†	55.6 ± 22.4‡	65.3 ± 25.2
Peak torque ($N{\text -}M{\cdot}kg^{-1\ LBM}$)	1.3 ± 0.3†	1.8 ± 0.3†‡	2.1 ± 0.3
Average power ($W{\cdot}kg^{-1}$)	44.9 ± 23.0†	70.5 ± 32.7‡	79.7 ± 36.1
Average power ($W{\cdot}kg^{-1\ LBM}$)	1.6 ± 0.5†	2.3 ± 0.6‡	2.6 ± 0.5

*Data reported as mean ± SD.
†Statistically different from age- and sex-matched nonburned children.
‡Statistically different from discharge time.
LBM, lean body mass; RER, respiratory exchange ratio; VO_2, volume of oxygen; TBM, total body mass.

Subjects' Physical Activity and Peak Exercise Characteristics

Children with burns wore their pedometers for more days than their nonburned counterparts (36 vs 14 days, $P < .0001$) (Table 2). During the course of rehabilitative exercise training, burned children showed a trend toward having fewer average minutes of activity than nonburned children ($P = .05$). Average activity calories were lower in burned children than in nonburned children ($P < .001$). However, other physical activity characteristics such as average and maximal steps and average and maximal activity calories were not different between the two groups (each $P > .05$). At discharge, peak aerobic capacity expressed as oxygen uptake per kilogram of total body mass or lean body mass was lower in burned children than age- and sex-matched nonburned children (each $P \leq .001$). Exercise training improved these measures of cardiorespiratory fitness (pre-exercise to postexercise vs at discharge, $P \leq .007$); however, they remained lower than nonburned values (after exercise training vs nonburned, $P < .01$). Respiratory exchange ratio was similar between groups ($P > .05$), suggesting that both groups reached volitional exhaustion for the peak exercise test. Likewise, both absolute and lean body mass-normalized strength measures at discharge were lower than nonburned values (peak torque and mean power, each $P \leq .0001$). Exercise rehabilitation training improved strength in burned children (pre to post, each $P \leq .0001$). Exercise training improved absolute and normalized average power, which were similar to values seen in nonburned children ($P \leq .12$).

Exercise Rehabilitation Partially Restores Strength and Cardiorespiratory Fitness to Nonburned Levels

At discharge, burn children's normalized peak torque and mean power were 61% of nonburned values, and exercise training improved these by 27–28% (88 and 89% of nonburned values, respectively; each $P \leq .0001$) (Figure 1). Normalized cardiorespiratory fitness at discharge was 72% of nonburned values, and exercise training improved fitness by 10% (82% of nonburned values, $P < .05$) (Figure 1).

TBSA Burned Correlates With Physical Activity Levels

Figure 2 shows the correlation between severity of burn injury (TBSA burned) and physical activity (steps or minutes of activity per day). Burn trauma was inversely associated with steps ($r = -0.54$, $P = .001$) and minutes of activity ($r = -0.53$, $P = .002$), accounting for 28–29% of the variability in children with burn injury.

DISCUSSION

The objective of this study was to assess physical activity levels in severely burned children completing an exercise rehabilitation program and to compare these levels with those in nonburned children using pedometers. The results showed that burned children participating in a rehabilitation exercise program had slightly fewer minutes and active calories than free-living age- and sex-matched nonburned children; however, maximal and average steps per day or week did not differ between the groups.In addition, the rehabilitation program was found to improve strength and cardiorespiratory fitness. Finally, the severity of burn injury was found to inversely correlate with activity level. We are the first to report the physical activity level during a rehabilitation program, and given that the majority of burn centers around the world do not offer exercise rehabilitation programs, these results may provide useful physical activity guidelines for patient activity levels at discharge.

Our group has consistently found that, at discharge, children with severe burn injury have lower strength and cardiorespiratory exercise capacity than nonburned children, and the current results are in agreement with our previous work.[5-7,9,19-22] Burned children's' exercise aerobic capacity, compared with normative data, were in very poor (<25 $mL{\cdot}O_2{\cdot}kg^{-1}/min$)-to-poor (25–31 $mL{\cdot}O_2{\cdot}kg^{-1}/min$) range relative to nonburned children.[9,23] Although we did not have a burn group that did not complete the exercise training, we have previously shown that when exercise training was compared with the standard of care at our hospital (that did not involve exercise), exercise was far superior in regard to improving lean body mass, strength, and aerobic exercise capacity [9]. The current results are also in agreement with our previous work showing that exercise rehabilitation improves lean body mass, exercise capacity.[7-9,21,24-26] Furthermore, when strength and cardiorespiratory fitness were compared between burned children and age- and sex-matched nonburned children,

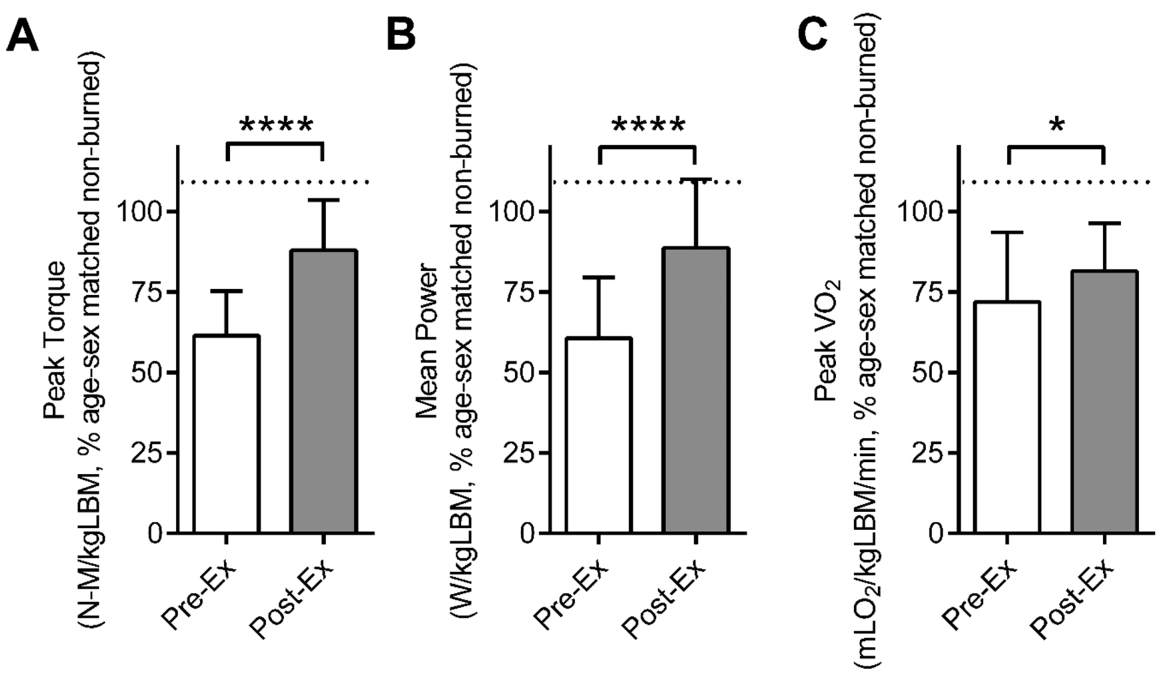

Figure 1. Strength (A, peak torque and B, mean power) and cardiorespiratory fitness (Peak VO_2) expressed as a relative percentage of values from age- and sex-matched nonburned children. Strength and cardiorespiratory fitness measures are shown at discharge (Pre-Ex) and after completion of an exercise rehabilitation program (Post-Ex). All values are mean ± SD. *$P < .05$ and ****$P < .0001$ for pre-exercise vs postexercise training.

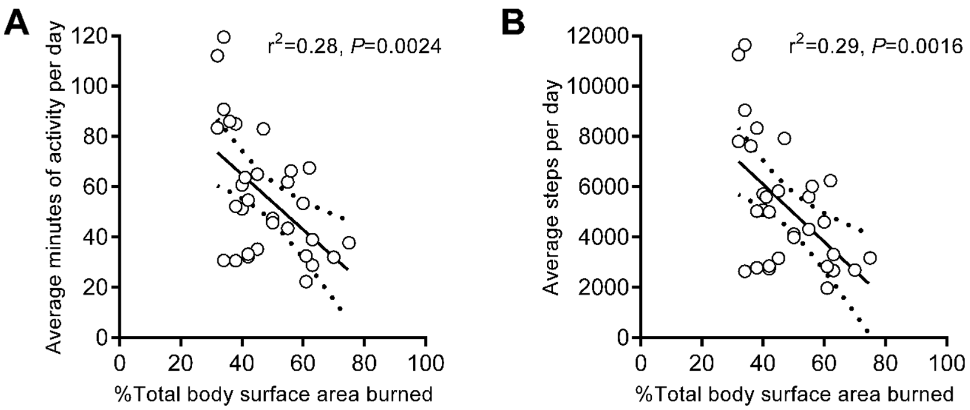

Figure 2. Pearson correlations between TBSA burned and physical activity levels in burned children. Dashed lines represent 95% CIs.

we found that exercise capacity was improved but still remained lower than that seen in nonburned children. This underscores the need for continued activity while under free-living conditions. In addition, given that the majority of trauma centers do not offer rehabilitation programs, activity tracking via pedometer or telehealth monitoring may be a viable option and offer similar advantages.[27,28]

There is no consensus on physical activity requirements in burned children once they leave the hospital. In a survey given to licensed physical and occupational therapists as part of the American Burn Association Special Interest Group, 81% of the 103 surveyed indicated that they do not provide these important services. Here in our study, physical activity data obtained using pedometers showed that burned children participating in an outpatient rehabilitation exercise program were able to return to normal physical activity, as measured by the number of steps and minutes of activity per day. We found that the average and maximal steps per day and per week were not different between burned and their nonburned age-/sex-matched counterpart. However, burned children had 24% fewer minutes of activity compared with nonburned children. Because the average steps in burned children were similar to nonburned, but the time of activity was less suggest differences in length of stride and/or cadence (ie, burned children may have shorted steps per time of exercise). We speculate that these difference may be caused by burn injury affecting contracture, lower endurance, or burn induced hypermetabolic state in burned compared with nonburned children; however, require further study. This is the first study to monitor activity in recovering burned children and in the future, could be built on to help establish physical activity guidelines for patients who have been discharged from facilities that do or do not include exercise rehabilitation programs in their standard of care.

The debilitating effects of burn injuries considerably affect patients' quality of life. Patients develop various disfigurements that include, but are not limited to, deep scarring, amputations, and severe contractures, all of which affect mental and physical health. The change in body image alters patients' perception of their identities and creates feelings of fear and shame that affect personal relationships, work life, and self-esteem.[29] Recognition of people staring or pointing also creates a lost sense of anonymity and normalcy, making going to public places a challenge.[29,30] We found an inverse correlation between the severity of burn injury and physical activity. However, burn injury accounted for only about 28–29% of the variability in the model. Nevertheless, rehabilitative exercise may lessen these debilitative effects. For example, in studies using the Burn-Specific Health Scale-Brief questionnaire, patients with burn reported improvement in their quality of life and psychological measures after an exercise intervention.[31] Physical activity alone also correlates with improved self-concept in nonburned healthy children and adolescents.[21]

CONCLUSION

In summary, children with burn injury have reduced strength and cardiorespiratory fitness relative to age- and sex-matched nonburned children, and exercise helps restore physiological function. The fact that physical exercise function is only partially restored on completion of exercise program suggests that exercise should be continued beyond the hospital setting. In addition, given that the majority of trauma centers do not provide structured exercise rehabilitation programs, the use of activity monitoring for at-home exercise prescriptions may be a viable approach for continued fitness improvements under free-living conditions. With the many long-term risk factors that may predispose burned children to cardiovascular disease from sedentary behaviors, the promotion of physical activity after burn injury is important for restoring lean body mass, exercise capacity, and quality of life.[7,9,26,32] Our data clearly show that, immediately after discharge, children with burn injury can match the average and maximal steps of physical activity levels seen in free-living nonburned children. Future work should be directed toward implementing telehealth and activity monitoring for continued improvements in physical exercise and health in burn populations.

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REFERENCES

1. Association AB. Burn Incidence Fact Sheet. http://ameriburn.org/who-we-are/media/burn-incidence-fact-sheet/. Accessed May 22, 2017.
2. World Health Organization. Burns. http://www.who.int/news-room/fact-sheets/detail/burns Accessed May 22, 2017.
3. Jeschke MG, Gauglitz GG, Kulp GA, et al. Long-term persistance of the pathophysiologic response to severe burn injury. *PLoS One* 2011;6(7):e21245.
4. Porter C, Tompkins RG, Finnerty CC, Sidossis LS, Suman OE, Herndon DN. The metabolic stress response to burn trauma: current understanding and therapies. *Lancet* 2016;388(10052):1417–26.
5. 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(6):2273–81.
6. 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(3):1168–75.
7. Suman OE, Herndon DN. Effects of cessation of a structured and supervised exercise conditioning program on lean mass and muscle strength in severely burned children. *Arch Phys Med Rehabil* 2007;88(12 Suppl 2):S24–9.
8. Porter C, Hardee JP, Herndon DN, Suman OE. The role of exercise in the rehabilitation of patients with severe burns. *Exerc Sport Sci Rev* 2015;43(1):34–40.
9. Hardee JP, Porter C, Sidossis LS, et al. Early rehabilitative exercise training in the recovery from pediatric burn. *Med Sci Sports Exerc* 2014;46(9):1710–6.
10. SERVICES TSOHAH. *Physical Activity Guidelines for Americans.* 2008
11. Association AH. *The AHA's Recommendations for Physical Activity in Children.*
12. Adams MA, Johnson WD, Tudor-Locke C. Steps/day translation of the moderate-to-vigorous physical activity guideline for children and adolescents. *Int J Behav Nutr Phys Act* 2013;10:49.
13. Abrams TE, Ogletree RJ, Ratnapradipa D, Neumeister MW. Adult survivors' lived experience of burns and post-burn health: A qualitative analysis. *Burns* 2016;42(1):152–62.
14. Conn AS, Hall MS, Quinn K, Wiggins B, Memmott C, Brusseau TA Jr. An Examination of a Yoga Intervention With Pediatric Burn Survivors. *J Burn Care Res* 2017;38(1):e337–42.
15. Grisbrook TL, Reid SL, Edgar DW, Wallman KE, Wood FM, Elliott CM. Exercise training to improve health related quality of life in long term survivors of major burn injury: a matched controlled study. *Burns* 2012;38(8):1165–73.
16. Paratz JD, Stockton K, Plaza A, Muller M, Boots RJ. Intensive exercise after thermal injury improves physical, functional, and psychological outcomes. *J Trauma Acute Care Surg* 2012;73(1):186–94.
17. Clemes SA, Biddle SJ. The use of pedometers for monitoring physical activity in children and adolescents: measurement considerations. *J Phys Act Health* 2013;10(2):249–62.
18. Rowlands AV, Eston RG. The Measurement and Interpretation of Children's Physical Activity. *J Sports Sci Med* 2007;6(3):270–6.
19. Suman OE, Mlcak RP, Herndon DN. Effect of exercise training on pulmonary function in children with thermal injury. *J Burn Care Rehabil* 2002;23(4):288–93; discussion 287.
20. Clayton RP, Wurzer P, Andersen CR, Mlcak RP, Herndon DN, Suman OE. Effects of different duration exercise programs in children with severe burns. *Burns* 2017;43(4):796–803.
21. Wurzer P, Voigt CD, Clayton RP, et al. Long-term effects of physical exercise during rehabilitation in patients with severe burns. *Surgery* 2016;160(3):781–8.
22. 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(1):e109–16.
23. Heyward VH, Gibson AL. *Advanced fitness assessment and exercise prescription.* 7th ed. Champaign, IL: Human Kinetics; 2014.
24. Peña R, Ramirez LL, Crandall CG, Wolf SE, Herndon DN, Suman OE. Effects of community-based exercise in children with severe burns: A randomized trial. *Burns* 2016;42(1):41–7.
25. Benjamin NC, Andersen CR, Herndon DN, Suman OE. The effect of lower body burns on physical function. *Burns* 2015;41(8):1653–9.
26. Rosenberg M, Celis MM, Meyer W, III, et al. Effects of a hospital based Wellness and Exercise program on quality of life of children with severe burns. *Burns* 2013;39(4):599–609.
27. Cerdan J, Catalan-Matamoros D, Berg SW. *Online communication in a rehabilitation setting: Experiences of patients with chronic conditions using a web portal in Denmark.* Patient Educ Couns; 2017;100(12):2283-2289.
28. Kizony R, Weiss PL, Harel S, et al. Tele-rehabilitation service delivery journey from prototype to robust in-home use. *Disabil Rehabil* 2017;39(15):1532–40.
29. Bergamasco EC, Rossi LA, da C G Amancio A, de Carvalho EC. Body image of patients with burns sequellae: evaluation through the critical incident technique. *Burns* 2002;28(1):47–52.
30. Moi AL, Vindenes HA, Gjengedal E. The experience of life after burn injury: a new bodily awareness. *J Adv Nurs* 2008;64(3):278–86.
31. Murphy ME, Holzer CE, III, Richardson LM, et al. Quality of Life of Young Adult Survivors of Pediatric Burns Using World Health Organization Disability Assessment Scale II and Burn Specific Health Scale-Brief: A Comparison. *J Burn Care Res* 2015;36(5):521–33.
32. 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(3):1168–75.