

Aerobic exercise training in modulation of aerobic physical fitness and balance of burned patients

ZIZI M. IBRAHIM ALI^{1)*}, BASANT H. EL-REFAY²⁾, RANIA REFFAT ALI³⁾

¹⁾ Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University: Giza, Egypt

²⁾ Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, Egypt

³⁾ Department of Physical Therapy for Science, Faculty of Physical Therapy, Cairo University, Egypt

Abstract. [Purpose] This study aimed to determine the impact of aerobic exercise on aerobic capacity, balance, and treadmill time in patients with thermal burn injury. [Subjects and Methods] Burned adult patients, aged 20–40 years (n=30), from both sexes, with second degree thermal burn injuries covering 20–40% of the total body surface area (TBSA), were enrolled in this trial for 3 months. Patients were randomly divided into; group A (n=15), which performed an aerobic exercise program 3 days/week for 60 min and participated in a traditional physical therapy program, and group B (n=15), which only participated in a traditional exercise program 3 days/week. Maximal aerobic capacity, treadmill time, and Berg balance scale were measured before and after the study. [Results] In both groups, the results revealed significant improvements after treatment in all measurements; however, the improvement in group A was superior to that in group B. [Conclusion] The results provide evidence that aerobic exercises for adults with healed burn injuries improve aerobic physical fitness and balance.

Key words: Aerobic exercise, Aerobic physical fitness, Burn injury

(This article was submitted Aug. 4, 2014, and was accepted Oct. 1, 2014)

INTRODUCTION

A burn injury is one of the most traumatic injuries that a child or adult can experience¹⁾. Advances in acute burn care have improved survival rates after burns, and this highlights the importance of physical therapy rehabilitation programs after recovery from a burn injury in overcoming long-term burn-related complications and extensive physical and functional limitations^{2, 3)}. Pulmonary function (PF) can be compromised as a result of complications caused by smoke inhalation, direct thermal damage to the respiratory tract, pulmonary edema, and respiratory tract infection⁴⁾. Thermal injuries result in a reduction of pulmonary function, which is typified by an initial obstructive pattern of disease lasting up to 2 years and then the restrictive pattern of pulmonary function, which lasts into convalescence, and patients who survive thermal injury might not regain normal cardiopulmonary functions⁵⁾.

The evidence pertaining to the effect of impaired pulmonary function on exercise capacity in burn injury patients is equivocal. Mlcak et al.⁶⁾ reported that burn injury patients with inhalation injuries displayed a ventilatory rather than

a cardiac limitation to exercise. Furthermore, Bourbeau et al.⁷⁾ found that long-term pulmonary function was impaired but not below normal limits, and that exercise tolerance was unchanged in adults following inhalation injury. Conversely, Willis et al.⁸⁾ demonstrated that adults with burn injuries, with and without inhalation injury, had a significantly lower aerobic capacity and greater oxygen desaturation during a maximal oxygen exercise test compared with healthy controls. This deficit in burn injury patients persisted for up to five years following injury, although it was not correlated with PF. The decreased aerobic capacity demonstrated in the burn injury population may be due to periods of prolonged bed rest, as well as to the associated hypermetabolic state that occurs as a result of major burns. The hypermetabolism that follows burn, impacts the cardiovascular system, is characterized by increased oxygen consumption, cardiac output, minute ventilation, and core temperature⁹⁾. The resultant increased energy expenditure can lead to exhaustion, which can have deleterious consequences for aerobic capacity¹⁰⁾. Periods of prolonged bed rest and inactivity experienced during recovery from major burns may further decrease aerobic capacity¹¹⁾.

Balance is impaired in burn survivors. Balance is a function of multiple factors, including tactile sensation, muscle strength, proprioception, joint mobility, and cognition. All of these factors are potentially affected in severe burn injuries. The Berg Balance Scale measures balance by assessing performance of functional tasks. The scale is used in a wide range of populations, including the elderly, stroke patients, and Parkinson's patients and has excellent correlation with

*Corresponding author. Zizi M. Ibrahim Ali (E-mail: zizikahla@yahoo.com)

gait speed^{12–15}).

Burn rehabilitation strategies aim to achieve optimal function and independence in individuals with a burn injury, with the ultimate goal being community reintegration¹⁶.

Aerobic exercise is any activity that uses large muscle groups that overload the heart and lungs and causes them to work harder than at rest for a period of 15 to 20 minutes or longer¹⁷. Maximum aerobic capacity is the gold standard measurement of cardiovascular fitness. It provides an objective and reproducible assessment of a patient's functional capacity or exercise capacity¹⁸.

Aerobic exercises are considered an important component of rehabilitation programs, as they improve the patient's functional status, and if the intensity of training is adequate, they result in a physiological training effect^{19–21}.

Therefore, the current study aimed to assess whether a 12-week exercise program consisting of a traditional rehabilitation program and/or aerobic exercise would improve aerobic capacity and balance in adults after a burn injury.

SUBJECTS AND METHODS

Thirty adult burn injury patients (both sexes) participated in this trial. They were recruited from the outpatient clinic of the Faculty of Physical Therapy, Cairo University, which is where the study was conducted. The inclusion criteria included age 20–40 years, thermal burns covering 20–40% of the total body surface area (TBSA) as assessed by the rule of nines method²², second degree burns, and at least 3 months after burn injury. The exclusion criteria included the presence of diabetes, neuropathy, psychiatric disorders, cardiopulmonary diseases, quadriplegia, certain behavior or cognitive disorders (e.g., aggressive behavior, impulsivity, and dementia), leg amputation, any limitation in the ROM of joints of the lower limbs, and participation in any rehabilitation program prior to the study that may prevent adequate participation in exercise activities or affecting the results. Patients were randomized into two groups: a study group (group A), which included 15 patients who participated in an aerobic exercise program in addition to a traditional rehabilitation program, and control group (group B), which included 15 patients who participated in a traditional rehabilitation program.

All variables were collected for all participants at baseline and after 3 months, which was the length of the intervention period.

Aerobic capacity assessment was used to determine maximum oxygen consumption (VO₂max), and participants underwent a Graded Exercise Test (GXT) performed on treadmill using the modified Bruce protocol. This test has been well validated with respect to evaluation and assessment of cardiovascular fitness and for testing maximal aerobic endurance on a treadmill⁸. The protocol required participants to walk at increasingly higher workloads, with the speed and the inclination of the treadmill increased incrementally every three minutes until the participant could no longer continue because of volitional exhaustion, despite strong verbal encouragement of the investigators. During GXT, subjects breathed through a face mask (Hans Rudolph Inc, Kansas City, MO, USA) connected to a calibrated ex-

Table 1. Statistical analysis of demographic characteristics of patients in both groups

Variables	Group (A)	Group (B)	t-value
Age (years)	27.9±7.3	29.5±6.6	0.6584
Weight (kg)	68.1±5.1	69.5±5.1	0.7555
Height (cm)	167.8±6.6	170.1±6.7	0.9272
TBSA (%)	32.9±6.6	29.5±5.1	1.6022

Data are presented as the mean ± SD. t-value: Unpaired t value. *Significant.

pired gas analysis system (Zan-680 Ergospiro Ergospirometry System), which is manufactured by ZAN Me Bgerate GmbH, Germany. Expired gas passed through a flowmeter, an oxygen analyzer, and a carbon dioxide analyzer. The flow meter and gas analyzers were connected to a computer, which calculated breath-by-breath minute ventilation, oxygen uptake, carbon dioxide production, and the respiratory exchange ratio (RER) from conventional equations. Heart rate (HR) was monitored continuously during the graded exercise test. Absolute maximum aerobic capacity (VO₂max) was taken as the average value over the last 30 seconds during the exercise test²³.

Treadmill time measurement was done by calculating the maximum time that a patient could walk on the treadmill.

Balance assessment was done by using the Berg Balance Scale (BBS), which is a valid and reliable clinical tool for assessing balance in individuals. It is a 14-item battery of tasks related to activities of daily living (ADLs). The tasks address the subject's ability to maintain positions of increasing difficulty by progressively diminishing the base of support. There are three dimensions to the test: maintenance of a position, postural adjustment to voluntary movements, and reaction to external perturbations. Each task is scored from zero to four, with zero the lowest and four the highest functional level. A composite score of 0–20 is categorized as a high fall risk, 21–40 is categorized as a medium fall risk, and 41–56 is categorized as a low fall risk^{24–27}. Subjects with missing or incomplete Berg Balance Scale assessments were excluded from the analysis.

The treatment procedures were started three months after the patients were discharged from the hospital and lasted for 12 weeks in both groups. Patients in both groups had received standard rehabilitation therapy. Burn patients in group A had also participated in an aerobic exercise program at a rate of 3 sessions/week, with each session lasting from 20–40 minutes. A RAM model 770 CF electronic treadmill was used for aerobic exercise. Each participant exercised at 70–85% of his previously determined individual VO₂max²⁸. Treadmill running exercises began and ended with warming-up and cooling down periods in the form of walking on the treadmill for about 5–10 minutes at a speed of 1–1.5 kilometers/hour with zero inclination. In the cooling down period, the speed was gradually decreased until reaching zero^{29, 30}. Participants were regularly monitored throughout the exercise program, and their heart rates were recorded during the exercise sessions.

The traditional physical therapy program for both groups was in the form of stretching and strengthening exercises

Table 2. Statistical analysis of aerobic capacity variables and Berg Balance Scale scores within each group

Variable	Groups	Pre	Post	Percentage of improvement
VO ₂ max (ml/m/kg)	Study (n=15)	21.8 (2.3)	33.9 (3.8)*	55.6
	Control (n=15)	22.4 (1.9)	25.8 (2)*	14.9
Treadmill time (minutes)	Study (n=15)	11.1 (1.8)	18.7 (1.8)*	68.2
	Control (n=15)	10.9 (1.7)	13.8 (1.2)*	26.5
Berg Balance Scale	Study (n=15)	27 (24–29)	48 (45–51)*	77.8
	Control (n=15)	27 (24–29)	40 (34–43)*	48.2

Data are presented as the mean (SD) for aerobic capacity variables and median (interquartile range) for Berg Balance Scale scores. VO₂max: maximum aerobic capacity. *Significant.

for all areas involved, in addition to diaphragmatic breathing exercises, 3 days/week, while activities of daily living were performed daily.

Ethical considerations were taken into account by explaining the study protocol in detail to each patient before the initial assessment, and signed informed consent was obtained from each patient (or his family) before enrollment in the study. This study was approved by the Institutional Review Board of the Faculty of Physical Therapy, Cairo University.

Data analysis was performed with SPSS version 16.0 (SPSS, Inc., Chicago, IL, USA). Data were tested for normality using the Kolmogorov-Smirnov test. The quantitative variables were expressed as the mean \pm standard deviation (SD). Comparison of variables before and after the intervention was done using the paired t-test. Comparison between 2 different groups was done using the unpaired t-test. Non-parametric statistical analysis was used for the Berg Balance Scale including the Wilcoxon Signed Rank test for variable comparison within groups and the Mann-Whitney U test for comparison between groups. All p-values in the analysis were considered statistically significant when $p \leq 0.05$.

RESULTS

Table 1 shows demographic data for the patients, and it demonstrates that there were no significant differences between the groups regarding patient age, weight, height TBSA, and sex distribution.

Table 2 shows the results for aerobic capacity, and it demonstrates that there were no statistically significant differences in mean VO₂ max and treadmill time values in the two groups before the intervention ($p > 0.05$). After implementation of the intervention, patients in the study and control groups exhibited significant differences in VO₂ max and treadmill time in the paired t-test between pre- and posttreatment values, as the mean pretreatment values for VO₂ max were 21.75 ± 2.25 and 22.44 ± 1.9 ml/m/kg, respectively, and the mean posttreatment values for VO₂ max were 33.85 ± 3.76 and 25.78 ± 2.03 ml/m/kg, respectively; the p-value was 0.001 in both groups. Regarding treadmill time, the mean pretreatment values for the study and control groups were 11.1 ± 1.82 and 10.89 ± 1.72 minutes, respectively, while the mean posttreatment mean values were 18.66 ± 1.78 and 13.78 ± 1.23 minutes, respectively; the p-value was 0.001 in

Table 3. Statistical analysis of post treatment values of aerobic capacity variables and Berg Balance Scale scores between groups

Variable	Study group (n=15)	Control group (n=15)
VO ₂ max (ml/m/kg)	33.9 (3.8)*	25.8 (2)
Treadmill time (minutes)	18.7 (1.8)*	13.8 (1.2)
Berg Balance Scale	48 (45–51)*	40 (34–43)

Data are presented as the mean (SD) for aerobic capacity variables and median (interquartile range) for Berg Balance Scale scores. *Significant.

both groups. Upon comparing the VO₂ max and treadmill time results between the 2 groups post intervention, there was a significant difference in the mean posttreatment values favoring the study group ($p = 0.0001$ and 0.001 , respectively; Table 3).

Berg Balance scale (BBS) scores were obtained for all patients. There were no statistically significant differences in the median BBS values in the two groups before the intervention ($p > 0.05$). There were significant differences between the median pre- and posttreatment values of the BBS for the study and control groups ($p = 0.001$ in both groups). Statistical analysis of the median posttreatment values of both groups showed a significant difference ($p < 0.0001$) favoring the study group (Tables 2 and 3).

DISCUSSION

Scientific evidence has dramatically changed our ideas about the relationships among physical activity, rest, and fatigue. Several studies have reported that exercise can prevent the manifestation of fatigue and reduce its intensity in burn patients during and after treatment. This approach may appear counterintuitive; however, physical activity produces adaptive changes such as gains in muscle mass and plasma volume, improved lung ventilation and perfusion, increased cardiac reserve, and a higher concentration of oxidative muscle enzymes. Furthermore, resistance exercises have been shown to reduce the loss of muscle mass related to corticoid treatment^{31, 32}.

The current study aimed to evaluate the effect of addition of aerobic exercise to a traditional rehabilitation program for

burn patients on their aerobic capacity and balance.

The results of the current study pointed out that there was a reduction in the exercise capacity of burn patients represented by a reduction in the VO₂max compared with the normal values before application of the treatment procedure. This finding is supported by the results achieved by Suman and his colleagues²⁸⁾, who reported abnormal cardiopulmonary functions in a patient who survived a thermal injury. In addition, our results showed that there was improvement in the exercise capacity, treadmill time, and balance of the burn patients after 12 weeks of exercise training. The study group, which performed training using aerobic exercise in addition to the traditional program, showed more significant improvement in both VO₂ max and BBS compared with the control group. Improvement in the aerobic capacity variables may be due to an increase in the blood flow to the active muscle mass because of an increase in maximal cardiac output, and the changes within the muscle also contribute to this increase, primarily the increases in capillarization, myoglobin, and oxidative enzyme activity³³⁾.

In addition, it was suggested that the significant increase in aerobic capacity might be related to the effect of aerobic exercise in improving respiratory function and to an increase in the stroke volume of the heart by the effect of regular exercise. These respiratory adaptations facilitate oxygen supply to tissues and add further evidence to the improvement of respiratory fitness³⁴⁾.

Similarly, a study was previously done to compare the efficacy and effects of an exercise program versus traditional outpatient therapy in children with burn injuries, and it concluded that an exercise program may be safely included in rehabilitation programs for children with severe burns and that it can be effective in increasing muscular strength and functional outcome³¹⁾.

Suman et al.²⁸⁾ reported that a 12-week exercise program, when implemented six months post injury, improved both aerobic exercise capacity and PF in children with severe burns, which supports the current study results.

De-Lateur et al.³⁾ have also been established that a 12-week aerobic treadmill exercise program improved aerobic capacity in adult burn survivors, when implemented between 9 and 122 days post injury, which is consistent with our results.

Grisbrook et al.³⁵⁾ evaluated the effects of exercise training on aerobic capacity and PF in adults with long-term burns (at least two years post burn). The exercise training consisted of interval training (combination of high- and low/moderate-intensity exercise) and resistance exercises for 12 weeks. Exercise training did not result in PF improvements, but there were improvements in aerobic capacity and clinically relevant achievement towards occupational performance goals, which is in agreement with the results of the current study.

The effect of aerobic exercise on balance in burn patients and on the BBS have not been widely studied in burn patients. In this study, patients demonstrated increases in both the raw BBS Score (mean: 17 points) and fall risk categories. Studies have found that a change of eight points in the BBS Score correlates with a meaningful clinical change³⁶⁾. However, evaluation of balance with more objective tools is

recommended. The results of a study by Schneider et al.¹⁵⁾, which suggested an overall functional improvement in balance with inpatient rehabilitation therapy for burn injury, are similar to ours.

There are some limitations to this study like the small sample size and lack of follow-up over the following months after the intervention period, which reflect the need for future research with a larger sample of patients and follow-up measurements. In spite of that, statistically significant improvements were observed across all outcome measures in both groups, suggesting that these outcomes would be reflected in a larger sample. Also, this study lacked a standardized therapy. Standardization of rehabilitation program is difficult, as no two burn injuries are identical and physical therapy programs are tailored to each patient's individualized lesions. However, this study underscores the importance of addition of aerobic exercises to burn rehabilitation programs as an approach to improve aerobic capacity and balance in the burn population.

ACKNOWLEDGEMENTS

The authors would like to express their appreciation to all patients who participated in this study and to our colleagues at the Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University.

REFERENCES

- 1) Saxe GN, Stoddard F, Hall E, et al.: Pathways to PTSD, part I: Children with burns. *Am J Psychiatry*, 2005, 162: 1299–1304. [[Medline](#)] [[CrossRef](#)]
- 2) van Baar ME, Essink-Bot ML, Oen IM, et al.: Functional outcome after burns: a review. *Burns*, 2006, 32: 1–9. [[Medline](#)] [[CrossRef](#)]
- 3) de Lateur BJ, Magyar-Russell G, Bresnick MG, et al.: Augmented exercise in the treatment of deconditioning from major burn injury. *Arch Phys Med Rehabil*, 2007, 88: S18–S23. [[Medline](#)] [[CrossRef](#)]
- 4) Jeschke MG, Chinkes DL, Finnerty CC, et al.: Pathophysiologic response to severe burn injury. *Ann Surg*, 2008, 248: 387–401. [[Medline](#)]
- 5) Mlcak RP, Desai MH, Robinson E, et al.: Increased physiological dead space/tidal volume ratio during exercise in burned children. *Burns*, 1995, 21: 337–339. [[Medline](#)] [[CrossRef](#)]
- 6) Mlcak R, Desai MH, Robinson E, et al.: Lung function following thermal injury in children—an 8-year follow up. *Burns*, 1998, 24: 213–216. [[Medline](#)] [[CrossRef](#)]
- 7) Bourbeau J, Lacasse Y, Rouleau MY, et al.: Combined smoke inhalation and body surface burns injury does not necessarily imply long-term respiratory health consequences. *Eur Respir J*, 1996, 9: 1470–1474. [[Medline](#)] [[CrossRef](#)]
- 8) Willis CE, Grisbrook TL, Elliott CM, et al.: Pulmonary function, exercise capacity and physical activity participation in adults following burn. *Burns*, 2011, 37: 1326–1333. [[Medline](#)] [[CrossRef](#)]
- 9) Johnson C: Pathologic manifestations of burn injury. In: *Burn care and rehabilitation: principles and practice*. Philadelphia: F.A. Davis Company, 1994, pp 29–48.
- 10) Hart DW, Wolf SE, Mlcak R, et al.: Persistence of muscle catabolism after severe burn. *Surgery*, 2000, 128: 312–319. [[Medline](#)] [[CrossRef](#)]
- 11) Adams RB, Tribble GC, Tafel AC, et al.: Cardiovascular rehabilitation of patients with burns. *J Burn Care Rehabil*, 1990, 11: 246–255. [[Medline](#)] [[CrossRef](#)]
- 12) Jacobson BH, Thompson B, Wallace T, et al.: Independent static balance training contributes to increased stability and functional capacity in community-dwelling elderly people: a randomized controlled trial. *Clin Rehabil*, 2011, 25: 549–556. [[Medline](#)] [[CrossRef](#)]
- 13) Kim CS, Wontae G, Shin GK: The effects of lower extremity muscle strengthening exercise and treadmill walking exercise on the gait and balance of stroke patients. *J Phys Ther Sci*, 2011, 23: 405–408. [[CrossRef](#)]
- 14) Suzuki M, Fujisawa H, Machida Y, et al.: Relationship between the Berg

- Balance Scale and Static Balance Test in Hemiplegic Patients with Stroke. *J Phys Ther Sci*, 2013, 25: 1043–1049. [[Medline](#)] [[CrossRef](#)]
- 15) Schneider JC, Qu HD, Lowry J, et al.: Efficacy of inpatient burn rehabilitation: a prospective pilot study examining range of motion, hand function and balance. *Burns*, 2012, 38: 164–171. [[Medline](#)] [[CrossRef](#)]
 - 16) Spires MC, Kelly BM, Pangilinan PH Jr: Rehabilitation methods for the burn injured individual. *Phys Med Rehabil Clin N Am*, 2007, 18: 925–948, viii. [[Medline](#)] [[CrossRef](#)]
 - 17) Panton LB, Golden J, Broeder CE, et al.: The effects of resistance training on functional outcomes in patients with chronic obstructive pulmonary disease. *Eur J Appl Physiol*, 2004, 91: 443–449. [[Medline](#)] [[CrossRef](#)]
 - 18) Opasich C, Criffo A, DeFeo S: Cardiopulmonary exercise test for patients with heart failure. *Am Heart J*, 2002, 142: 465–475.
 - 19) Cheng YJ, Macera CA, Addy CL, et al.: Effects of physical activity on exercise tests and respiratory function. *Br J Sports Med*, 2003, 37: 521–528. [[Medline](#)] [[CrossRef](#)]
 - 20) Lee SH, Seo BD, Chung SM: The effect of walking exercise on physical fitness and serum lipids in obese middle-aged women: pilot study. *J Phys Ther Sci*, 2013, 25: 1533–1536. [[Medline](#)] [[CrossRef](#)]
 - 21) Pantelić S, Popović M, Miloradović V, et al.: Effects of short term exercise training on cardiorespiratory fitness of male adults with myocardial infarction. *J Phys Ther Sci*, 2013, 25: 929–935. [[Medline](#)] [[CrossRef](#)]
 - 22) Herndon DN, Rutan RL, Alison WE, et al.: Management of the burn injury. In: *Pediatric trauma: prevention, acute care and rehabilitation*. St. Louis: Mosby Year Book, 1993, pp 570.
 - 23) Rochester CL: Which pulmonary rehabilitation program is best for your patient? *J Respir Dis*, 2000, 21: 535–546.
 - 24) Riddle DL, Stratford PW: Interpreting validity indexes for diagnostic tests: an illustration using the Berg balance test. *Phys Ther*, 1999, 79: 939–948. [[Medline](#)]
 - 25) Kraemer MD, Jones T, Deitch EA: Burn contractures: incidence, predisposing factors, and results of surgical therapy. *J Burn Care Rehabil*, 1988, 9: 261–265. [[Medline](#)] [[CrossRef](#)]
 - 26) Major MJ, Fatone S, Roth EJ: Validity and reliability of the Berg Balance Scale for community-dwelling persons with lower-limb amputation. *Arch Phys Med Rehabil*, 2013, 94: 2194–2202. [[Medline](#)] [[CrossRef](#)]
 - 27) Bennie S, Bruner K, Dizon A, et al.: Measurements of balance: Comparison of the timed “up and go” test and functional reach test with the Berg Balance Scale. *J Phys Ther Sci*, 2003, 15: 93–97. [[CrossRef](#)]
 - 28) Suman OE, Mlcak RP, Herndon DN: Effect of exercise training on pulmonary function in children with thermal injury. *J Burn Care Rehabil*, 2002, 23: 288–293, discussion 287. [[Medline](#)] [[CrossRef](#)]
 - 29) Perna F, Bryner R, Donley D, et al.: Effect of diet and exercise on quality of life and fitness parameters among obese individuals. *J Physiol*, 1999, 70: 125–131.
 - 30) San Juan AF, Fleck SJ, Chamorro-Viña C, et al.: Early-phase adaptations to intrahospital training in strength and functional mobility of children with leukemia. *J Strength Cond Res*, 2007, 21: 173–177. [[Medline](#)] [[CrossRef](#)]
 - 31) Cucuzzo NA, Ferrando A, Herndon DN: The effects of exercise programming vs. traditional outpatient therapy in the rehabilitation of severely burned children. *J Burn Care Rehabil*, 2001, 22: 214–220. [[Medline](#)] [[CrossRef](#)]
 - 32) Buyomi A, Nossier AA, Ali I: The effect of exercise program intervention for children with acute lymphoblastic leukemia. Unpublished thesis submitted to physical therapy department for surgery, in partial fulfilment of the requirement for master degree in physical therapy, faculty of physical therapy, Cairo University, 2008.
 - 33) Landolt MA, Buehlmann C, Maag T, et al.: Brief report: quality of life is impaired in pediatric burn survivors with posttraumatic stress disorder. *J Pediatr Psychol*, 2009, 34: 14–21. [[Medline](#)] [[CrossRef](#)]
 - 34) Juel C, Klarskov C, Nielsen JJ, et al.: Effect of high-intensity intermittent training on lactate and H⁺ release from human skeletal muscle. *Am J Physiol Endocrinol Metab*, 2004, 286: E245–E251. [[Medline](#)] [[CrossRef](#)]
 - 35) Grisbrook TL, Wallman KE, Elliott CM, et al.: The effect of exercise training on pulmonary function and aerobic capacity in adults with burn. *Burns*, 2012, 38: 607–613. [[Medline](#)] [[CrossRef](#)]
 - 36) Conradsson M, Lundin-Olsson L, Lindelöf N, et al.: Berg balance scale: intrarater test-retest reliability among older people dependent in activities of daily living and living in residential care facilities. *Phys Ther*, 2007, 87: 1155–1163. [[Medline](#)] [[CrossRef](#)]