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Effect of Aerobic and Resistive Exercises on Resting Energy Expenditure and Lean Body Mass during Paediatric Burn Rehabilitation

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Abstract: Purpose: to evaluate the efficacy of aerobic and resistive exercises on resting energy expenditure and lean body mass during paediatric burn rehabilitation. Methods of evaluation: Measurement of the lean body mass (LBM) and the resting energy expenditure (REE). **Methods:-** Thirty children with 40% total body surface area (TBSA) burns and greater, their ages ranged from 7 to 14 years were divided into two groups. Group (A) (Control group) composed of 15 patients received only the evaluation appointments and supplemented with instructions for a home-based physical rehabilitation routine without specific individualization or supervision of the exercise routines performed. Group (B) composed of 15 patients who participated in 12 week exercise programe (Treadmill for aerobic exercise and resistive exercise through dumbbells, theraband and sand bags). **Results and conclusion:-** Results showed that application of 12 week exercise programe (Treadmill for aerobic exercise and resistive exercise through dumbbells, theraband and sand bags) had a valuable effects in increasing the LBM without any significant differences in REE during paediatric burn rehabilitation.
Key words (Aerobic and resistive exercises, Resting energy expenditure, Lean body mass and Paediatric burn rehabilitation).

Introduction:

Severe burn injuries exceeding 40% total body surface area (TBSA) lead to protein breakdown from skeletal muscle stores and the development of a prolonged and profound catabolic state associated with hypermetabolism that is compounded by prolonged bed rest and can lead to major functional impairment and delay in rehabilitation [4,5,21].

Patients with severe burns exhibit elevation of basal metabolism to some of the highest rates observed following any type of trauma. Resting energy expenditure (REE) remains elevated despite healing of skin wounds and may remain so for up to 18 months following injury. During acute admission, this rise in REE may be up to 180% of normal values, declining to 150% by the time of full wound healing at two months post-injury, and steadily decline to 115% of predicted at 12 months. Related clinical features during the rehabilitation phase include impairment of glucose metabolism throughout the first six months post-injury, as well as prolonged derangement of circulating hormones, including cortisol and insulin, together with elevated pro-inflammatory cytokines, found to persist for up to 36 months[1,2,3, 11.]

Burns are one of the most devastating conditions encountered in medicine. The injury represents an assault on all aspects of the patient, from the physical to the psychological. It affects all ages, from babies to elderly people, and is a problem in both the developed and developing world. All of us have experienced the severe pain that even a small burn can bring. However the pain and distress caused by a large burn are not limited to the immediate event. The visible physical and the invisible psychological scars are long lasting and often lead to chronic disability. Burn injuries represent a diverse and varied challenge to medical and paramedical staff. Correct management requires a skilled multidisciplinary approach that addresses all the problems facing a burn patient. This series provides an overview of the most important aspects of burn injuries for hospital and non-hospital healthcare workers[6,7,8,9,12,13.]

The basic pathophysiological consequence of the burn injury is the loss of the capillary integrity, localized increase in the micro vascular permeability, generalized impairment in the cell membrane resulting in cell swelling and increase osmotic pressure of the burned tissues leading to further fluid accumulation and oedema formation, which is a result of the outpouring of the intravascular fluid into the interstitial spaces. This process occurs at all areas of partial skin thickness burns and at the areas which are adjacent to and subjacent to the full skin thickness burns[10,14, 15,29,30.]

The immediate post-burn period is known as the ebb phase, as nutrient flow and oxygen delivery to cells is decreased, leading to a decrease in the basal metabolic rate (B.M.R), then there is a gradual increase in the metabolic rate reaching the normal B.M.R (40 ± 10 % $C/m^2/hr$) and exceeding this normal level up to twice or twice and half the normal value and this is the flow phase. This flow phase is due to the massive catecholamine release from the adrenal medulla and from the nerve endings of the sympathetic division of the autonomic nervous system, leading to systematic vasoconstriction, increased vascular resistance and poor peripheral circulation affecting skin, muscle and nerve, resulting in nerve function alterations[1,17,18, 19,20,27,28.]

Supervised resistance and aerobic exercise programs, in addition to physical and occupational therapy, have been shown to offer considerable benefits during outpatient rehabilitation. These include improvements in passive and active range of joint movement, muscle strength and, lean body mass in addition to a significant reduction in the number of surgical interventions required for burn scar contractures. Despite these benefits however, concerns remained regarding exercise programs potentially exacerbating and further elevating REE following paediatric burn injury[22,23,25,26,30.]

Resting energy expenditure represents the amount of calories required for a 24-hour period by the body during a non-active period. Indirect calorimetry measured indirectly with a metabolic cart by: analysis of respired gases (usually expired) to derive volume of air passing through the lungs, the amount of oxygen extracted from it (i.e., oxygen uptake VO2) and the amount of carbon dioxide, as a by-product of metabolism, expelled to atmosphere (CO2 output VCO2) all computed to represent values corresponding to 1 minute time intervals[7,8,9,11,14,21.]

Lean body mass is a component of body composition, calculated by subtracting body fat weight from total body weight: total body weight is lean plus fat. The Lean body mass (LBM) has been described as an index superior to total body weight for prescribing proper levels of medications and for assessing metabolic disorders, as body fat is less relevant for metabolism. The percentage of total body mass that is lean is usually not quoted- it would typically be 60–90%. Instead, the body fat percentage, which is the complement, is computed, and is typically 10–40%. The Lean body mass (LBM) has been described as an index superior to total body weight for prescribing proper levels of medications and for assessing metabolic disorders, as body fat is less relevant for metabolism[14,15,18,20,21.]

Material and Methods

Subjects:

This study was carried out on thirty children with 40% total body surface area (TBSA) burns and greater, their ages ranged from 7 to 14 years were divided into two groups. Group (A) (Control group) composed of 15 patients received only the evaluation appointments and supplemented with instructions for a home-based physical rehabilitation routine without specific individualization or supervision of the exercise routines performed. Group (B) composed of 15 patients who participated in 12 week exercise programe (Treadmill for aerobic exercise and resistive exercise through dumbbells, theraband and sand bags).

Instrumentation:

In this study the measuring equipment and tools were the Sensor-Medics Vmax 29 metabolic cart (Yorba Linda, CA) (indirect calorimeter) to measure resting energy expenditure (REE) and the body fat analyzer scale for weight, fat percentage measurement (geratherm body fitness) in addition to the length ruler for height measurement for calculating the lean body mass (LBM), while the therapeutic equipment and tools were the Treadmill for aerobic exercise and resistive exercise through dumbbells ,theraband and sand bags) [2,6,7,17,22.]

Procedures

A- Evaluation procedures:

1- Indirect calorimetry to measure resting energy expenditure (REE): Measured indirectly with a metabolic cart by: analysis of respired gases (usually expired) to derive volume of air passing through the lungs, the amount of oxygen extracted from it (i.e., oxygen uptake VO2) and the amount of carbon dioxide, as a by-product of metabolism, expelled to atmosphere (CO2 output VCO2) all computed to represent values corresponding to 1 minute time intervals**.** With these measurements the resting energy expenditure (REE) and respiratory quotient (RQ) can be calculated. The RQ represents the ratio of carbon dioxide exhaled to the amount of oxygen consumed by the individual. RQ is useful in interpreting the results of the REE. The abbreviated Weir equation is used to calculate the 24-hour energy expenditure. These measurements are printed out by the metabolic cart after completion of the indirect calorimetry test[1,7,9,21.]

2- Lean Body Mass calculation: via using the Peters formula for children of 13-14 years old or younger. Lean body mass is a component of body composition, calculated by subtracting body fat weight from total body weight: total body weight is lean plus fat. The lean body mass (LBM) has been described as an index superior to total body weight for prescribing proper levels of medications and for assessing metabolic disorders, as body fat is less relevant for metabolism**.** The percentage of total body mass that is lean is usually not quoted- it would typically be 60–90%. Instead, the body fat percentage, which is the complement, is computed, and is typically 10–40%. The Lean body mass (LBM) has been described as an index superior to total body weight for prescribing proper levels of medications and for assessing metabolic disorders, as body fat is less relevant for metabolism, these tools of measurement were used before treatment (First record) and after one month of treatment (second record) to measure improvement in the oral mucositis[7,10,12,13,19.]

B- Treatment procedures:

For group A (Control group): It consisted of evaluation appointments with physical therapists, supplemented with instructions for a home-based physical rehabilitation routine. Patients in the SOC program participated in a 12-week, home-based physical rehabilitation program, although without specific individualization or supervision of the exercise routines performed. The program aims to maintain and enhance range of movement, and minimize scar deformities and contractures. It includes range of motion and strength exercises (not progressive resistance training), positioning and splinting routines, in addition to scar management techniques including (pressure garments, inserts, and physical agent modalities). Therapists assess and confirm that a patient's parent or guardian is able to comply with detailed step-by-step instructions provided for the home program. This program is implemented for all patients (both controlled and EX group patients) starting at discharge up to 6-months. Subsequently, patients in the controlled group then continued in this program at home during the 12 week study period. The control group did not receive an exercise prescription by an exercise physiologist at any time during the study and adherence to exercises were not monitored. This was in contrast to the EX group, where greater than 90% compliance to an exercise prescription was maintained.

For Group B (exercise group): For group B (EX group) (test group):fifteen patients participate in 12 week exercise programe 3 times per day for one hour that included: During the first week of training: EX patients were familiarized with the exercise equipment and instructed in proper weight-lifting techniques. Eight basic resistance exercises were used, incorporating (bench press, leg press, shoulder press, leg extension, biceps curl, leg curl, triceps curl, and toe raises). Initially, each patient lifted a weight or load set at 50–60% of their individual three repetition maximum (3RM). During the second week: Lifting load increased to 70–75% (4–10 repetitions) of individual 3RM. During week 2 up to the end of week 6: Same as second week till end of six week. During weeks 7–12: At this stage, training intensity was increased to 80–85% (8–12 repetitions) of the 3RM. Additionally, each exercise training session also included aerobic conditioning exercises on a treadmill. This aerobic training was carried out three days per week, with each session lasting 30 minutes, with participants exercising at 70–85% of their previously determined individual peak aerobic capacity (VO2 peak). All exercise sessions were preceded by a 5-min warm-up period on a treadmill set to an intensity of 50% of each individuals VO_2 peak. Reevaluation of lean body mass-resting energy expenditure at end of 12 week of rehabilitation [5,10,13,14,0, 18, 19,20,22.]

Data analysis:

Resting energy expenditure (REE) / lean body mass in Kcal/Kg/day and LBM index in Kg/m2, were measured and calculated pre-treatment as a first record and after 12 week exercise programe as a second final record in both groups. Collected data were fed into computer for the statistical analysis; descriptive statistics as mean, standard deviation, minimum and maximum were calculated for each group. The t-test was done to compare the mean difference of the two groups before and after application and within each group. Alpha point of 0.05 was used as a level of significance[16,24.]

Results

As shown in table (1) and figure (1), the mean value of the REE/LBM in Kcal/Kg/day before treatment was (55.1 ± 22.4) Kcal/Kg/day in the study group (Ex group), while after treatment was (52.9 ± 19.8) Kcal/Kg/day. These results revealed non-significant difference in REE/LBM (P > 0.05). Also in the control group, the mean value of the REE/LBM before treatment was (54.8 ± 20.7) Kcal/Kg/day, while after treatment was (54.76 ± 20.5) Kcal/Kg/day. Also these results revealed non-significant difference in the REE/LBM (P > 0.05).

Table (1): Comparison of the mean values of the REE/LBM in Kcal/Kg/day before and after treatment in the study and control groups

	Before treatment		After treatment		Mean difference	T-value	P.value	Level of significance
	Mean	SD	Mean	SD				
Study Group	55.1	22.4	52.9	19.8	2.20000	0.29	0.778	Non-significant
Control Group	54.8	20.7	54.6	20.5	0.20000	0.03	0.979	Non-significant

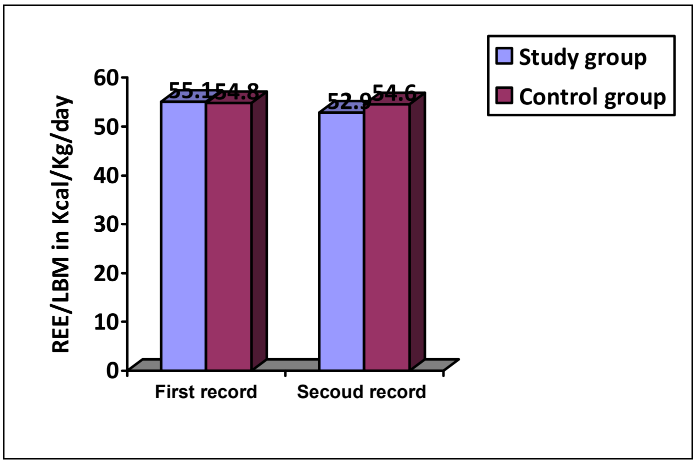

Fig (1): Mean values of the REE/LBM before and after treatment in both groups.

As shown in table (2) and figure (2), the mean value of the LBM index in Kg/m2 before treatment was (14.7 ± 4.2) Kg/m2 in the study group, while after treatment was (19.6 ± 6.1) Kg/m2. These results revealed a significant increase in LBM index ($P < 0.01$), while in the control group, the mean value of the LBM index before treatment was (14.8 ± 4.1) Kg/m2, while after treatment was (14.9 ± 4.4) Kg/m2, but these results revealed non-significant difference in the LBM index in Kg/m2 ($P > 0.05$).

Table (2): Comparison of the mean values of the LBM index in Kg/m2 before and after treatment in the study and control groups

	Before treatment		After treatment		Mean difference	T-value	P.value	Level of significance
	Mean	SD	Mean	SD				
Study Group	14.7	4.2	19.6	6.1	- 4.90000	- 2.56	0.017	Significant increase
Control group	14.8	4.1	14.9	4.4	- 0.10000	-0.06	0.949	Non-significant

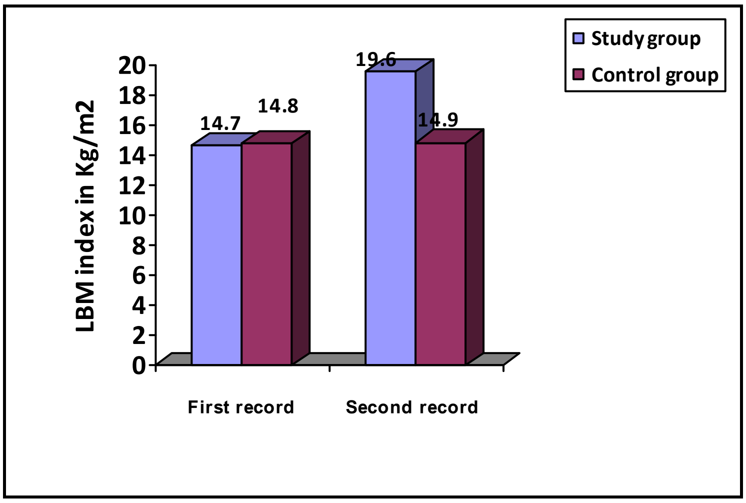

Fig (2): Mean values of LBM index in Kg/m2 of the 2 records in both groups.

Discussion

Burns may be classified into 3 groups according to the percentage of TBSA, minor burns involve less than 10% of the TBSA, major burns involve more than 10% of the TBSA, and dangerous burns involve more than 30 % of the TBSA the estimation of the TBSA percentage is implemented by the application of the rule of nines, which is the most common clinical method, in which the body is divided into areas, each one representing approximately 9% or 18 % of the TBSA, as follows: head and neck represent 9 %, each upper limb represents 9 %, each lower limb represents 18 %, anterior trunk represents 18 %, posterior trunk represents 18 % and the perineum represents only 1% [4, 12,26.]

Burns can leave skin vulnerable to bacterial infection and increase risk of sepsis, a life-threatening infection that travels through the bloodstream and affects the whole body. Sepsis is a rapidly progressing, life-threatening condition that can cause shock and organ failure. A number of complications may occur, with infections being the most common. In order of frequency, potential complications include: pneumonia, cellulitis, urinary tract infections and respiratory failure. Risk factors for infection include: burns of more than 30% TBSA, full-thickness burns, extremes of age (young or old), or burns involving the legs or perineum[12, 20, 23.]

In large burns (over 30% of the total body surface area), there is a significant inflammatory response. This results in increased leakage of fluid from the capillaries, and subsequent tissue edema. This causes overall blood volume loss, with the remaining blood suffering significant plasma loss, making the blood more concentrated. Poor blood flow to organs such as the kidneys and gastrointestinal tract may result in renal failure and stomach ulcers[1, 3, 7,17,19.]

Increased levels of catecholamines and cortisol may result in a hyper metabolic state which can last for years. This is associated with increased cardiac output, metabolism, a fast heart rate, and poor immune function. Electrical burns may lead to compartmental syndrome. Blood clotting in the veins of the legs is estimated to occur in 6 to 25% of burn patients. The hypermetabolic state that may persist for years after a major burn can result in a decrease in bone density and a loss of muscle mass[1, 6,8,18, 19, 29.]

Exercise training is a non-pharmacological treatment that attenuates muscle catabolism associated with aging and chronic disease. Rehabilitative exercise, initiated 6 months post-burn (typically 2-3 months after discharge), results in significant improvements to LBM, muscular strength and Cardiorespiratory fitness in severely burned children. However, the determination of fractional synthetic rate in these patients is needed in order to determine the impact of rehabilitative exercise on skeletal muscle protein metabolism [14,17, 18,26,28.]

The findings of the present study showed non-significant differences in the pre-treatment records of both resting energy expenditure (REE) / lean body mass in Kcal/Kg/day and LBM index in Kg/m2 between the mean values of the study and the control groups.

Results of the study group revealed a significant increase in the mean values of LBM index in Kg/m2, after application of 12 week exercise programe (Treadmill for aerobic exercise and resistive exercise through dumbbells ,theraband and sand bags), when compared against the pre-application results. While results of the control group revealed non-significant difference in the mean values of LBM index in Kg/m2, when compared against the pre-application results.

Results of the study group revealed non-significant difference in the mean values of resting energy expenditure (REE) / lean body mass in Kcal/Kg/day, after application of 12 week exercise programe (Treadmill for aerobic exercise and resistive exercise through dumbbells ,theraband and sand bags), when compared against the pre-application results. Also results of the control group revealed non-significant difference in the mean values of resting energy expenditure (REE) / lean body mass in Kcal/Kg/day, when compared against the pre-application results. Significant differences showed in the study and control groups were consistent with those observed and recorded by[1,2,4,6,7,11,14,17,19,20,21,22,23,25,26,27,29,28,30].

Results of this study support the expectation that application of 12 week exercise programe (Treadmill for aerobic exercise and resistive exercise through dumbbells, theraband and sand bags) had a valuable effects in increasing the LBM index in Kg/m2 without any significant differences in resting energy expenditure (REE) / lean body mass in Kcal/Kg/day during paediatric burn rehabilitation.

Conclusion

Application of 12 week exercise programme (Treadmill for aerobic exercise and resistive exercise through dumbbells, theraband and sand bags) had a valuable effects in increasing the LBM index in Kg/m2 without any significant differences in resting energy expenditure (REE) / lean body mass in Kcal/Kg/day during paediatric burn rehabilitation.

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