Does Stationary Cycling Improve Muscular Strength and Endurance for Pediatric Burned Patients?

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ABSTRACT

Background: *Burn injury is a major problem facing physiotherapists who deal with pediatric burned patients. Management of burned children should be emphasized on quick return to normal function and back to school.* ***Objective:*** *This study was performed to examine the effect of a stationary cycling intervention on muscle strength and endurance in children with lower extremity burns.* ***Intervention:*** *Thirty burned children with 30-40% burn of total body surface area, aged 10-14 years old were randomly assigned to cycling (study) or traditional physical therapy program (control) groups. Thirty-six intervention sessions occurred over 12 weeks. Primary outcomes were peak knee extensor torque using a Biodex System-3 dynamometer and 30 seconds walk test.* ***Results:*** *Significant post-intervention improvementwas found for the peak knee extensor at 150º/second and in the 30 seconds walk test in the studygroup while in the control group significant improvement was recorded in the peak knee extensor at 150º/second only. Also significant difference was recorded post treatment between the two groups in the two evaluation procedures in favor of the study group.* ***Conclusion:*** *It can be concluded that stationary cycling can be used as an effective procedure in improvement of muscle strength and endurance of pediatric burned patient.*
Key words: *Bicycle ergometer, Endurance, Strength, Burned children.*

INTRODUCTION

Severe burn injury results in persistent and extensive skeletal muscle catabolism and weakness, which is confounded by prolonged physical inactivity[9]. Severe burns are physically and psychologically catastrophic. Severely burned children have an elevated resting energy expenditure, whole body catabolism, and muscle weakness, which are worsened by prolonged bed rest and physical inactivity[10]. Current standard treatment includes a rehabilitation program consisting of occupational and physical therapy typically implemented for a 12-weeks period, which can be administered in the hospital setting or at the patient' shome. However, muscle catabolism and weakness persist despite therapy[24]. The physical frailty associated with severe burn injury is often confounded by the presence of cardiac and systemic shock, hypermetabolism, respiratory injury, sepsis, postburn seizures, compromised bone formation, major surgeries, malnourishment, disturbed growth patterns, and psychosocial issues[9]. Additionally, low physical work capacity and muscle strength are major obstacles in allowing the burn victim to return to school and to perform activities of daily living[24]. Because activities of daily living are integrated functions requiring muscle strength and endurance, an effective resistance exercise program may contribute to the rehabilitation of severely burned children by increasing muscular strength and the capacity to do work[23]. Lower-extremity cycling is a rehabilitation tool used by physical therapists to improve strength and cardiorespiratory fitness and appears well-suited as a therapeutic intervention for children with cerebral palsy. Simultaneous strengthening of hip, knee, and ankle musculature may be achieved without the need to perform isolated joint movement out of the basic flexion and extension movement synergies. In contrast to aerobic exercises that require walking or running, cycling is less dependent on balance, coordination, and motor control.Stationary cycling allows precise definition of exercise intensity, duration, and systematic guidelines for exercise progression important factors for research[8]. Exercise has long been proposed as a therapeutic mode in the rehabilitation of burned victims[9]. However, only recently there has been a prospective, controlled, randomized study conducted in burned children that has substantiated the proposed benefits of exercise alone[22]. Despite the extensive amount of literature on the effects of resistance exercise in healthy, no burned children, there is a lack of data on the effects of cycling exercise on muscle strength and endurance and on its benefits on the physical rehabilitation of individuals with burn injury. Therefore, we designed a study to assess whether children with thermal injury would benefit from a stationary bicycle training program by increasing muscle strength, and capacity to do work.

SUBJECTS AND METHODS

Subjects

Thirty children, ages 10–14 years, were enrolled in this study. They were selected from Al-Asher University hospitals with second degree burn. Only patients with 30-40% burn of total body surface area (TBSA) burned, as assessed by the "Lund and Browder Chart" method[16] in the emergency unit, were enrolled in this study. Patients were excluded if they had one or more of the following: leg amputation, anoxic brain injury, psychological disorders, quadriplegia, or severebehavior or cognitive disorders. Informed consent was given by the parent or legal guardian during the first day of treatment. After informed consent was obtained, patients were randomized into two groups of equal number 15 patients each: the study group (cycling intervention) and the control group (no cycling intervention).

Strength measurements

Strength assessments were conducted at the beginning the study and at the end of treatment (after 3 months). Before strength testing, the patient was familiarized with the exercise equipment. The patient was asked to sit quietly for 15 minutes before measurement was recorded. After this time period vertical height and body weight was measured.Strength testing was conducted using a Biodex System-3 dynamometer (Shirley, NY). The isokinetic test was performed on both leg extensors and tested at an angular velocity of 150°/s. This speed was chosen because it is well tolerated (compared with lower or higher angular speeds) by the children across all of the ages and all of the groups[19]. The children were seated and their position stabilized with a restraining strap over the midthigh, pelvis, and trunk in accordance to the Biodex System-3 Operator's Manual. All of the children were familiarized with the Biodex test in a similar manner. First, the administrator of the test demonstrated the procedure. Second, the test procedure was explained to the child. Third, children were allowed to practice the actual movement during 3 submaximal repetitions without load as warm-up. More repetitions were not allowed to prevent the possible onset of fatigue. The anatomic axis of the knee joint wasaligned with the mechanical axis of the dynamometer before the test. After the 3 submaximal 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 were given to minimize the effects of fatigue, and the test wasrepeated. Values of peak torque were calculated by the Biodex software system. The highest peak torque measurement between the 2 trials was selected and recorded.

The thirty-seconds walk test

For the 30sWT, children were asked to walk at their preferred speed. The distance completed in 30 seconds was recorded. This test was conducted twice; before the start of the study and after its end[8].

Cycling intervention

The stationary bicycle used for this study was designed for rehabilitation. The time of cycling was 15 minutes for each child in the study group as detected by a pilot study done before beginning of the treatment protocol. Features included a semi recumbent design with a wide padded seat, trunk support, foot straps, and a unique "cyclocentric" lower-limb–loading feature to provide resistance[19]. The cycling intervention was performed 3 times per week, for a total of 36 sessions, within a 12 successive weeks. A generalized stretching program was performed prior to cycling. If the participant could not cycle independently, manual assistance was provided until independence was achieved. If limb movement was not maintained in the sagittal plane, corrections were made using physical guidance by the therapist, verbal cueing, or adaptations, such as modification of the foot position on the pedal. No strength training activities were permitted outside the supervised training session; however, both groups were allowed to pursue their normal daily activities. Physical therapy treatment for the two groups included:

1- Range of motion exercises for all joints of lower limbs.

2-Stretching exercises for hip flexors, hip adductors, knee flexors, and plantar flexors.

3- Transcutaneous nerve stimulation is used for one hour before the session as pain killer modality[27].

RESULTS

The collected data from this study represent the statistical analysis of peak torque (Newton meters Nm) for knee extensors and the 30 seconds walk test (meters/minute) measured pre and post three months of treatment for the two groups. The raw data of the measured variables for the two groups were statistically treated to determine the mean and standard deviation. Paired t-test was then applied to examine the significance of the treatment conducted for each group pre and post treatment. Independent t-test was used to measure the level of significance between both groups of the study at the end of treatment.

There were no significant differences between the study and control groups in age, percentage of total body surface area (TBSA), height and weight as shown in table (1).

Table (1): Demographic characteristics of burned children.

	Age(years)		%of burn		Height(cm)		Weight(kg)	
	S	C	S	C	S	C	S	C
Mean	12.80	12.47	37.27	36.87	151.60	151.20	44.13	44.60
±SD	1.47	1.46	1.87	1.92	12.33	12.42	10.26	10.27
t-value	0.623		0.578		0.089		-0.124	
P-value	0.538		0.568		0.930		0.902	
Level of significance	Not sig.		Not sig.		Not sig.		Not sig.	

S= study group, C= control group, SD= standard deviation sig. = Significant.

The obtained results in this study revealed no significant when comparing the pretreatment mean values of the two groups. Significant improvement was observed in the measurement of peak torque value for knee extensors in the two groups when comparing their pre and post treatment mean values as shown in table (2).

Table (2): Pre and post treatment mean values of the torque values (Nm) of knee extensors for the study and control groups.

	Study group				Control group			
	Right LL.		Left LL.		Right LL.		Left LL.	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	21.47	29.87	20.20	28.67	20.53	24.87	19.73	24.20
±SD	1.88	2.53	1.74	2.41	1.68	1.88	1.58	1.52
t-value	-39.287		-35.819		-15.083		-23.276	
P-value	0.000		0.000		0.000		0.000	
Level of significance	Sig.		Sig.		Sig.		Sig.	

LL= lower limb.

A significant increases observed in the mean values of the 30 seconds walk pre and post treatment for the study group, while no significant difference (P<0.05) was observed in the same test pre and post treatment for the control group as shown in table (3).

Table (3): Pre and post mean values of the 30 seconds walk test (meter/minute) for the study and control groups.

	Study group		Control group	
	Pre	Post	Pre	Post
Mean	63.00	65.00	63.00	63.20
±SD	2.27	1.98	2.04	2.08
t-value	-9.933		-1.871	
p-value	0.000		0.082	
Level of significance	Sig.		Not sig.	

Significant improvement was also observed when comparing the post treatment values of peak torque for knee extensors and 30 seconds walk test of the two groups in favor of the study group (P<0.05) as shown in figure (1,2).

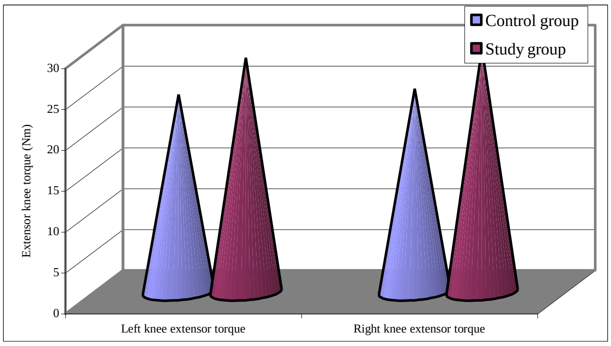

Fig. (1): The mean value of knee extensors torque between the two groups post treatment.

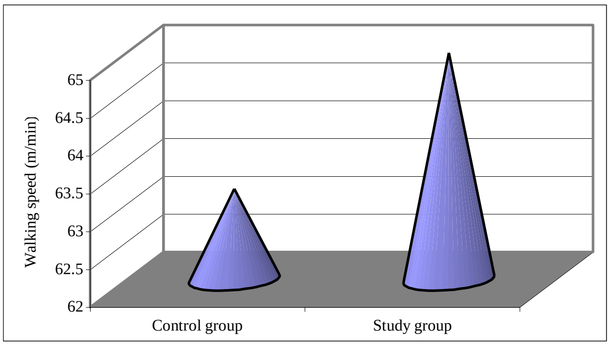

Fig. (2): The mean value of 30 second walk test between the two groups after end of treatment.

DISCUSSION

Physical fitness is affected in people with extensive burns, and exercise training programs can bring on relevant improvements in all components.

Pediatric burned patients should be provided with exercise protocols that maximize health, promote functional improvement and minimize secondary conditions.Significant strength gains are possible in all populations, including children, women, and elderly when exposed to an adequate strength-training program. Strength gains occur from enhanced neuromuscular activation over the initial 8 weeks and from increased fiber density and hypertrophy during subsequent weeks[21].

Although exercise programs after burns are considered standard of care, there is limited evidence for efficacy in pediatric patients. Inspite Paratz et al.,[17] had concluded that a high-intensity cardiovascular or resisted exercise program included a supervised high intensity combined aerobic or resisted exercise program for six weeks for adult patients, resulted in significant improvements in functional, physical, and psychological measures and should be mandatory for all burned patients. The results of our study is confirmed by Suman et al.,[25] who found that participation of severely burned children in a resistance exercise program resulted in a significant improvement in muscle strength (assessed leg muscles strength before and after 12 weeks rehabilitation program at isokinetic speed of 150 °/seconds, power, and lean body mass relative to standard rehabilitation program without exercise).

Similarly, a study was done to compare the efficacy and effects of exercise programming versus traditional output therapy in burned children, and concluded that exercise programming may be safely included in rehabilitation programs for severely burned children and can be effective in increasing muscular strength and functional outcome[3]. Also, in the study of Suman and Herndon[26] to determine the effects of cessation of a structured and supervised exercise conditioning program on lean body mass and muscle strength in severely burned children, it was concluded that participation in an exercise program (assessed by leg isokinetic muscle strength at a speed of 150°/seconds) resulted in a greater improvement in lean body mass and muscle strength in the exercise group than in the non-exercise group. In addition, Al-Mousawi et al.,[1] confirmed that exercise training in rehabilitation of burned pediatric patients significantly enhanced lean mass and strength without observed exacerbation of post-burn hypermetabolism concluding that the use of exercise conditioning as a safe and effective component of pediatric rehabilitation is advocated.

The present study differed from previous resistance training studies on burned patients through evaluating the effects of stationary bicycle training on the development of muscular strength and endurance. To our knowledge no other study has used the stationary bicycle to induce muscular strength and endurance in burned children.

Selection of age group (10-14 years) as it was reported that exercise for strength and muscle endurance will be emphasized more for older children than for younger children. Older children can develop strength and muscular endurance using formal weight training. However, other activities are generally better suited to the needs of most children[21].

The outcome measures in this study were isokinetic strength for knee extensors and muscular endurance.

Previous reports indicate that children can increase their muscular strength above and beyond normal growth and maturation by participating in a progressive resistance training program[6,7,14,20].

Simultaneous strengthening of hip, knee, and ankle musculature may be achieved without the need to perform isolated joint movement out of the basic flexion and extension movement synergies. In contrast to aerobic exercises that require walking or running, cyclingis less dependent on balance, coordination, and motor control. Cycling may induce positive speed related changes in neuromotor control and muscle physiology by promoting higher speeds of movement than are possible during daily activities of most children with CP[8]. We decided to examine the effect of cycling in pediatric burn patients.

Pedaling is a dynamic, bilateral task, which is safer and can be performed when a patient is in various stages of motor recovery. It is a simple, constrained motion, thus its biomechanics are much easier to measure and analyze than those of walking[2]. One of the types of bicycle ergometer is mechanical friction devices in which a belt encompassing a flywheel is tightened or loosened to adjust the resistance against which the subject pedal. The subject's power output depends on the pedal rate. The faster the pedal the greater the power output[29].

Muscle activation patterns during over-ground walking have been compared individually to walking on a treadmill[13], but not to stationary cycling, and not together in one study using the same participants in all conditions. Stationary cycling has been investigated in rehabilitation programs[24,28] as a low-impact activity that requires similar reciprocal leg movement to walking while the majority of the patient's body weight is supported by the seat[18].

The individual cycling position may be recumbent or upright which affect muscle activation, whereas in this study was upright, that explain the need for earlier quadriceps activity to drive the pedal away from the body from the point where the pedal is closest to the body[12] Johnston et al.,[11] reported a greater duration of hamstring muscle activity during recumbent stationary cycling.

There is no literature concerning post burn exercise tolerance among pediatric patients. In an effort to quantify the endurance capabilities of pediatric burn victims, stress testing of 59 patients was carried out with a modified Bruce protocol. No differences in exercise tolerance were found among these children irrespective of the presence of inhalation injury, method of excision, or burn size. If these trends continue as more data are accumulated, the long-term prognosis for the child with severe burns will be encouraging[15].

Fatigue is a major barrier for burned individuals. Studies indicated that a slow return to normal or near-normal muscle strength is the natural course of recovery. With no special interventions, other than the usual care tailored to the needs of the individual, post-burn patients will make gradual improvement in strength and aerobic capacity[5]. The results of the present study is consistent with deLateur et al.,[4] who investigated the efficacy of 12-weeks exercise program in producing greater improvement in aerobic capacity in adult burn survivors, after 36 sessions of aerobic treadmill exercise program proved that.

Walking tests are field tests providing a valid and easily accessible method of measuring function-limited exercise tolerance in patients with respiratory or cardiac chronic diseases. These walking tests are non-threatening, inexpensive, easy to perform and to understand for children. Walking tests performed in daily practice are the following: "time-based" tests (2-, 6- or 12-min walking test), 3-min step test (on a step) and the shuttle walking test. It may be a useful measure to assess therapeutic intervention and provide information on the prognosis. They are simple and safe methods to evaluate quality of life in these patients[28].

Improvement detected in walking speed in the study group has been consistent finding following stationary bicycle training.

In conclusion, stationary bicycle training can be incorporated into the treatment program for pediatric burned patients as an effective modality aiming to improve strength and endurance.

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الملخص العربي

هل العجلة الثابتة تحسن القوة العضلية وقوة الاحتمال عند الأطفال المصابين بالحروق ؟

أجريت هذه الدراسة لبيان تأثير استخدام العجلة الثابتة علي القوة العضلية وقوة الاحتمال عند الأطفال المصابين بحروق الأطراف السفلية . اشترك في الدراسة ثلاثون طفلاً تتراوح نسبه الحروق بين 30-40% من إجمالي سطح الجسم وتتراوح أعمارهم بين 10-14 عام . وتم تقسيمهم إلى مجموعتين : مجموعه الدراسة التي تضمنت تدريب العجلة الثابتة والمجموعة الحاكمة التي تضمنت برنامج علاج تقليدي لمثل هؤلاء الحالات . وكانت مدة العلاج 12 أسبوع تم عمل 36 جلسة علاج لكلتا المجموعتين . أشتمل التقييم علي قياس العزم لعضل ة الفرد لمفصل الركبة باستخدام جهاز بيودكس وبالإضافةإلى اختبار المشي لمدة 30 ثانية . أظهرت النتائج فروق ذات دلالة إحصائية بين مجموعة الدراسة والمجموعة الحاكمة لصالح مجموعة الدراسة بينما بالنسبة لاختبار المشي لا يوجد تحسن في المجموعة الحاكمة . بناء علي النتائج نستنتج أن العجلة الثابتة تؤثر علي القو ة العضلية وقوة الاحتمال عند الأطفال المصابين بالحروق أفضل من البرنامج التقليدي المستخدم لهؤلاء الحالات فقط .