Efficacy Of Combined Isokinetic Training And Aerobic Exercises On Functional Outcomes Postlower Limb Burn

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Abstract:

Background: Burn wounds are one of the most complex and dramatic of all injuries. They initially produce a direct local tissue destruction and damage. In addition, severe burn wounds (second- and third-degree) continue to destroy tissue and muscles, exercise therapy stimulates the early expression of angiogenesis- related growth factors so it results in new vessel in-growth that improves blood supply, increases cell proliferation, accelerates tissue regeneration and healing and regain muscle strength. **Purpose:** The aim of this study was to evaluate the effectiveness of exercise training program (aerobic exercises and resistive exercises) on Muscle power in lower limb burned patients**. Material & methods**: sixty patients with age ranged from 25 to 40 years old with 2nd degree burn (30% to 40% TBSA) who suffered fromlower limb burn participated in this study. The patients were randomly divided into 3 equal groups. **Group A:** This group included 20 patients who received isokinetic exercises for 12 weeks in form of (isokinetic device) in addition to the physical therapy program (splinting, stretching exercise, and range of motion exercise). **Group B:** This group included 20 patients who received aerobic exercises for 12 weeks in form of (stationary bicycle) in addition to the physical therapy program. **Group C:**This group included 20 patients who received both isokinetic exercise and aerobic exercises post healing in form of (stationary bicycle and isokinetic device) in addition to the physical therapy program. **Results:**showed significant increase in muscle strength and endurance in combined isokinetic and aerobic exercises more than group**A (**isokinetic) and **B (**aerobic exercises). **Conclusion:** From the finding of the current study we concluded that that combined isokinetic training and aerobic exercises is an effective, safe, relatively inexpensive, simple and available modality in enhancing muscle power , strength and endurance in lower limb burn.

Key words: Burn,Isokinetic Training ,Aerobic Exercises,dynometery.

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Introduction

Burn injuries have occurred ever since the discovery of fire. They primarily involve a destruction and disruption of the normal anatomical and physiological function of the skin. Burn wounds are one of the most complex and dramatic of all injuries. They initially produce a direct local tissue destruction and damage. In addition, severe burn wounds (second- and third-degree) continue to destroy tissue or progress for up to 48 hours **(1).**The physical rehabilitation of a burned patient consists of the prevention of scar contracture, maintenance of normal range of motion (ROM), maintenance or improvementin muscular strength, and performance of activity of daily living **(2)**.

Strength training can provide significant functional benefits and improvement in overall health and well-being, including increased bone,muscle,tendonandligam entstrengthandtoughness,improved jointfunction,reducedpotentialfor injury, increased bonedensity,increased metabolism, increased fitness, improvedcardiacfunction, and improved lipoprotein lipid profiles, including elevated HDL ("good") cholesterol. Training commonly uses the technique of progressively increasing the force output of the muscle through incremental weightincreases and uses a variety of exercises and types of equipment to target specific muscle groups. Strength training is primarily an anaerobic activity, although some proponents have adapted it to provide the benefits of aerobic exercise through circuit training **(3).**

Exercise is one of the therapies that have been reported to improve functional outcome of burn patients so the purpose of this study was to evaluate the therapeutic effect of isokinetic and aerobic exercises in improving functional outcomes in lower limb burn.

Subject, materials and methods

Sixty patients of both sexes suffered from lower limb burnwere selected from Sheikh ZayedElnahyan hospital, and theywererecruitedin the study if they fulfilled the followingcriteria:(1)Age range between 25-40 years. (2)All patients withsecond degree burn and 30% to 40%.of total burn surface area.(3)Patient with burn in lower limb including quadriceps and hamstring.(4) All patients enrolled to the study had their informed consent.Patients were excluded in case of (1) Cardiac diseases or renal diseases.(2)Deep venous thrombosis.(3)Diabetic patient.(4)Orthostatic hypotension diseases.(5)orthopedic problem (Rematologicalfactors ,arthritis ,……etc).

All patients were given an informed consen and informed about the nature and the effect of the treatment and measurement devices. The patients were also instructed to report any side effects during the treatment sessions.After inclusion the patients were randomly divided into 3 equal groups.

2.1. Treatment

Sixty patients of both sexes were randomly distributed into three equal groups.**Group A:** This group included 20 patients who received isokinetic exercises for 12 weeks in form of isokinetic device**(Quadriceps Exercise Table, BTE Primus RS w/PRO package and chairs)**.During the 12 weeks intervention period, an isokinetic exercise program were applied by quadriceps isokinetic chair program including a 20 repetition session three times a week (60 times/week) under the supervision of physiotherapist. Patient sit on chair then exercising of the opposite leg wasdone by the lifting of the torque unit from its bracket and placing it on the other end of the table.By changing angle between the two arms, and by changing directions of weight in order to work on hamstring and quadriceps muscles maximum or minimum resistance can be given at any point in the range.**Group B:** This group included 20 patients who received aerobic exercises for 12 weeks in form of Stationary bike (**Hangzhou Fu Tai Fitness equipment Co., Ltd. 2.3uF 400V**). During the 12 week intervention period, an aerobic training (AT) program including a 60 minute session was applied three times a week (180 min/week) under the supervision of an exercise physiologist.**Group C:**This group included 20 patients who received both isokinetic exercise and aerobic exercises for 12 weeks in form of stationary bicycle and isokinetic device.

All patients in this study received physical therapy program in the form of (splinting, stretching exercise, and range of motion exercise)for 12 weeks.**Splinting:**Splints were tailored to help to maintain the functional or anti-contracture position of the injured body parts **(7).**The intervals for monitoring vary from once every hour to once every 4–6 hours, depending on types of splints and skin conditions. It was described as 10 hours on and two hours off. When the splint is taken off, active and/or passive ROM should be carried out **(8).ROM exercises** for bothquadriceps and hamstring muscles were performed. Dependent on the severity of the burn, active and very gentle passive range of motion exercises for lower limb were begun from day one of healing after injury.**Stretching**exerciseis a form of physical exercise in which hamstring and quadriceps is deliberately flexed or stretched in order to improve the muscle's felt elasticity and achieve comfortable muscle and to increase muscle control, flexibility, and ROM ,for hamstring stretch the therapist stand in a solid stance then patient was ask to keep the limb completely relaxed to help the joints to warm up and then creeping was applied by taking limb passively in about 80 degree full leg raising while for quadriceps the patient was asked to lie sideline and bend affected limb and then his leg was taken in full extensionwith hold for 30 second then the patient was asked to contract his

muscle with about 20% to50% of his strength for 8 to 15 second then relax and repeat.Physical therapy programshould be applied 3 times weekly for 12 weeks, patients were asked to frequently perform active exercises in between sessions.

Muscle strength assessment for both quadriceps and hamstring were done by usinghand held dynamometry (HHD) **(Two Micro FET 2, Hoggan Health Industries, Inc., Draper, UT). (4)**Subjects were randomly assigned to one of two plinths along with a corresponding HHD. Subjects were then marked with a permanent felt-tip marker to ensure, consistent dynamometer placement between each time in different days). The strength of right lower extremity movements was then challenge isometrically by each of the measurements in turn.Black paper gait analysis was used it to measure the step length and its phases time.The feet were dusted with chalk and the patient walked along the length of the sheet of paper. Gait parameters were recorded from the chalk footprints **(5)**. paper strip (e.g. 0.6 meter wide × 10 meters long); the resultant set of foot prints is analyzed for average step length pressure. All assessment methods were done pre-treatment and after the treatment program (after 12 weeks).

2.2Statistical procedures:

In this study, the mean, the standard deviation and the standard error were calculated for each group in the study. The mean, the standard deviation were used as a primary source of connecting facts about each parameter to measure central tendency. Paired t-test was used to compare within each group and to detect level of significance in each group. Anova to compare the variable between groups was used to detect significance level between two groups (comparison).the statically package for social science (SPSS) was utilized for data analysis and the level of significance was set at the 0.05 level **(14).**

Results

All the patients involved in the study have been continued the study until the end of it. None refused or withdrawn

3.1 patient's demographic data:

The mean values of age in Group A, B,C were 33.95 ± 5.8, 34.35 ± 5.98 and 34.9 ± 6.58 respectively. There was no significant difference between groups in the mean age, ($p > 0.05$).

3.2. Within group comparison:

Comparing pre and post- treatment mean values of quadriceps strength within each group of the three groups (A, B and C):

The mean values of quadriceps strength pre-treatment in groups (A), (B) and (C) were 2 ± 0.33, 2.06 ± 0.37 and 2.03 ± 0.32 respectively. There was no statistical significant difference before treatment application when compared between three groups($p=0.877$). The mean values of quadriceps strength post-treatment in groups A, B and C were 2.35 ± 0.34, 2.64 ± 0.39 and 2.93 ± 0.29

respectively.There was statistical significant increase when compared with the corresponding mean values (pre-treatment) in groups (A), (B) and (C) (p=0.000, p=0.000 and p=0.000) respectively and % of improvement were 17.5 %, 28.15 % and 44.33 %.as shown in table (1).

Comparing pre and post- treatment mean values of hamstring strength within each group of the three groups (A, B and C):

The mean values of hamstring strength pre-treatment in groups (A), (B) and (C) were 1.96± 0.33, 1.94± 0.27 and 2.07 ± 0.27respectively.There was no statistical significant difference before treatment application when compared between three groups (p=0.342).Themean values of hamstring strength post-treatment in groups A, B and C were 2.34 ± 0.36, 2.6 ± 0.28 and 3.2 ± 0.26.There was statistical significant increase when compared with the corresponding mean values (pre-treatment) in groups (A), (B) and (C) (p=0.000, p=0.000 and p=0.000) respectivelyand % of improvement were22.48 %, 34.02 % and 54.58 %respectively.as shown in table (1).

Comparing pre and post- treatment mean values of step length within each group of the three groups (A, B and C):

The mean values of step length pre-treatment in groups (A), (B) and (C) were 50.9 ± 5.58, 52.65 ± 3.72 and 50.45 ± 5.15 respectively.There was no statistical significant difference before treatment application when compared between three groups(p=0.329).Themean values of step length post-treatment in groups A, B and C were61.2 ± 5.28, 67.45 ± 4.98 and 73.35 ± 4.42 respectively.There was statistical significant increase in step length when compared with the corresponding mean values (pre-treatment) in groups (A), (B) and (C) (p=0.000, p=0.000 and p=0.000) respectively and % of improvement were 20.23 %, 28.11 % and 45.39 % as shown in table (1).

Table (1):Comparison between pre and post- treatment mean values of quadriceps strength (Ibs), hamstring strength (Ibs) and step length within the different groups (A, B and C).

Item	Quadriceps strength (Ibs)						Hamstring strength (Ibs)						Step length (cm)					
	Group A		Group B		Group C		Group A		Group B		Group C		Group A		Group B		Group C	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	2	2.35	2.06	2.64	2.03	2.93	1.96	2.34	1.94	2.6	2.07	3.2	50.9	61.2	52.65	67.45	50.45	73.35
± SD	± 0.33	± 0.34	± 0.37	± 0.39	± 0.32	± 0.29	± 0.33	± 0.36	± 0.27	± 0.28	± 0.27	± 0.26	± 5.58	± 5.28	± 3.72	± 4.98	± 5.15	± 4.42
MD	0.35		0.58		0.9		0.38		0.66		1.13		Ss		14.8		22.9	
% of Improvement	17.5 %		28.15 %		44.33 %		22.48 %		34.02 %		54.58 %		20.23 %		28.11 %		45.39 %	

T-value	16.34	21.68	21.22	5.17	16.39	27.61	18.47	21.2	23.15
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Level of Significance	S	S	S	S	S	S	S	S	S

Pre: Before treatment. Post: After twelve weeks of treatment. SD: Standard Deviation. MD: Mean Difference. % of improvement: Percentage of improvement.T-value: Paired and Un-paired t- test value. P-value: Probability value. S.: Significant.

3.3 Comparison between groups:

Comparing post - treatment mean values quadriceps strength between (A and B), (A and C) and (B and C) groups:

The mean values after twelve weeks of treatment application when comparing between groups (A and B) were 2.35 ± 0.34 and 2.64 ± 0.39 respectively, while comparing between groups (A and C) were 2.35 ± 0.34 and 2.93 ± 0.29 respectively and when comparing between groups (B and C) were 2.64 ± 0.39 and 2.93 ± 0.29 respectively. There was significant difference between groups (A and B), (A and C) and (B and C) (p=0.016, p=0.000 and p=0.011 respectively) and % of improvement were 12.34 %, 34 % and 24.68 % respectively as shown in **table (2)**

Table (2): Comparison of post- treatment mean values of quadriceps strength (Ibs) between (A and B), (A and C) and (B and C) groups.

Item	**Quadriceps strength (Ibs) (post- treatment)**					
	Group A	**Group B**	**Group A**	**Group C**	**Group B**	**Group C**
Mean	2.35	2.64	2.35	2.93	2.64	2.93
± SD	± 0.34	± 0.39	± 0.34	± 0.29	± 0.39	± 0.29
MD	0.29		0.58		0.29	
% of Improvement	12.34 %		24.68 %		10.98 %	
T-value	2.52		5.85		2.69	
P-value	0.016		0.000		0.011	
Level of Significance	S		S		S	

Pre: Before treatment. Post: After twelve weeks of treatment. SD: Standard Deviation. MD: Mean Difference. % of improvement: Percentage of improvement.T-value: Paired and Un-paired t- test value. P-value: Probability value. S.: Significant.

Comparing post - treatment mean values of hamstring strength between (A and B), (A and C) and (B and C) groups:

The mean values after twelve weeks of treatment application when comparing between groups (A and B) were 2.34 ± 0.36 and 2.6 ± 0.28 respectively, while comparing between groups (A and C) were 2.34 ± 0.36 and 3.2 ± 0.26 respectively and when comparing between groups (B and C) were 2.6 ± 0.28 and 3.2 ± 0.26 respectively. There was significant difference between groups (A and B), (A and C)

and (B and C) (p=0.016, p=0.000 and p=0.011 respectively) and % of improvement were 11.11 %, 36.75 % and 23.07 % respectivelyas shown in **table (3)**.

Table (3): Comparison of post- treatment mean values of hamstring strength (Ibs) between (A and B), (A and C) and (B and C) groups.

Item	Hamstring strength (Ibs) (post- treatment)					
	Group A	Group B	Group A	Group C	Group B	Group C
Mean	2.34	2.6	2.34	3.2	2.6	3.2
± SD	± 0.36	± 0.28	± 0.36	± 0.26	± 0.28	± 0.26
MD	0.26		0.86		0.6	
% of Improvement	11.11 %		36.75 %		23.07 %	
T-value	2.47		8.58		7.09	
P-value	0.019		0.000		0.000	
Level of Significance	S		S		S	

Post: After twelve weeks of treatment. SD: Standard Deviation.
MD: Mean Difference. % of improvement: Percentage of improvement.
T-value: Paired and Un-paired t- test value. P-value: Probability value.
S: Significant.

Comparing post - treatment mean values of step length between (A and B), (A and C) and (B and C) groups:

The mean values after twelve weeks of treatment application when comparing between groups (A and B) were 61.2 ± 5.28 and 67.45 ± 4.98 respectively, while comparing between groups (A and C) were 61.2 ± 5.28 and 73.35 ± 4.42 respectively and when comparing between groups (B and C) were 67.45 ± 4.98 and 73.35 ± 4.42 respectively. There was significant difference between groups (A and B), (A and C) and (B and C) (p=0.000, p=0.000 and p=0.000 respectively) and % of improvement were 10.21 %, 19.85 % and 8.74 % respectively as shown in**Table (4)**

Table (4): Comparison of post- treatment mean values of step length (cm) between (A and B), (A and C) and (B and C) groups.

Item	Step length (cm) (post- treatment)					
	Group A	Group B	Group A	Group C	Group B	Group C
Mean	61.2	67.45	61.2	73.35	67.45	73.35
± SD	± 5.28	± 4.98	± 5.28	± 4.42	± 4.98	± 4.42
MD	6.25		12.15		5.9	
% of Improvement	10.21 %		19.85 %		8.74 %	
T-value	3.85		7.9		3.96	
P-value	0.000		0.000		0.011	
Level of Significance	S		S		S	

Post: After twelve weeks of treatment. SD: Standard Deviation. MD: Mean Difference. % of improvement: Percentage of improvement.T-value: Paired and Un-paired t- test value. **P-value: Probability value. S: Significant**

Discussion

Burn injuries are one of the major health problems of the industrial world. Mortality from burn injuries rises with age, extent and depth of burn. Severe or dangerous burn involving more than 30% of the total body surface area (TBSA) may be life threatening (9).Burn wounds are one of the most complex and dramatic of all injuries. They initially produce a direct local tissue destruction and damage. In addition, severe burn wounds (second- and third-degree) continue to destroy tissue or progress for up to 48 hours (10).

Burn injury leads to persistent and extensive skeletal muscle catabolism and weakness, confounded by prolonged physical inactivity. Muscle wasting is a characteristic hyper metabolic response in patients with burn injury. Increased protein degradation following burn injury has been postulated to be a major contributor to muscle wasting(11).People with burns of 30% total body surface area (TBSA) or larger showed significantly less torque, work, and power in the quadriceps than control subjects. This was the primary cause of selecting burned subjects with 30–40% TBSA. It can be said that cause of loss of muscle mass mainly by catabolic effect of burn injury in addition to other co-factors, such as pain and physical inactivity (12).

The physical rehabilitation of a burned patient consists of the prevention of scar contracture, maintenance of normal range of motion (ROM), maintenance or improvement in muscular strength, and performance of activity of daily living (13).Standard physical therapy targets improvement in overt physical changes associated with burn injury, such as uncomfortable scarring, range of motion (ROM) limitation, and contractures (14).

Aerobic exercise is an exercise having adequate oxygen supply to the working groups of muscles without exhaustion. Wide variety of physical activities count as exercise including yard work and many recreational activities (Dancing, tennis, basketball, golfing). Also the traditional recognized aerobic exercises (E.g., walking, running, bicycling and swimming) in addition to aerobic physical activity, stretching and resistance training to improve flexibility and muscle strength (15).

Aerobic exercise consisted mainly of walking or running on a treadmill, cycling, and calisthenics involving upper and lower limbs (16).Isokinetic training is beneficial in the restoration of muscle strength of normal and burned groups, the percentage improvement of subjects with burn injury was higher than the improvement of healthy subjects for all modes of contraction and speeds; except for during concentric contraction at an angular velocity of 90o/s (14).

The result of the current study revealed a significant increase in muscle power strength and step length in all groupsconfirming the fundamental effects of rehabilitation exercises for burned patients. However, combination between aerobic and isokinetic exercise has more significant effect on muscle power than other groups. Our results with respect to isokinetic exercise agreed withEbid et al.,2012(17) who

worked on Burned adult patients, with 35-55% total body surface area (TBSA) burned, burned patient were assessed in this study at 6 months after burn in respect to leg muscle strength at 150° s(-1), using isokinetic dynamometry. Non-burned adults were assessed similarly, and served as controls. The burned adults participated in the resistance training programme 3 times weekly. The isokinetic exercise programme was begun with 60% of the average peak torque. Intensity of isokinetic exercise was increased from one set to five sets during the first through fifth sessions and remained at six sets for the remaining 6th to 24th sessions and found that that adults with severe burns, relative to non-burned adults, had significantly lower peak torque as well as total work performance using the extensors and flexors muscles of the thigh. Participation in isokinetic training resulted in a greater improvement in extensor and flexor muscle strength in adults with held thermal burn compared to base line values.

Also,Ahmed and Abel-Aziem., 2011(14) found that there was a significant increase in the quadriceps peak torque for both groups at both angular velocities after isokinetic training. During eccentric contraction at angular velocities of 30°/s and 90°/s the percentage improvement in the burned group was higher than in the healthy group (p = 0.003 and p = 0.0008, respectively). During concentric contraction at an angular velocity of 30°/s the percentage improvement in the burned group was higher than the healthy group (p = 0.020). However, during concentric contraction at an angular velocity of 90°/s there was no significant difference between the groups (p = 0.742),and concluded that The isokinetic training program was effective in increasing the concentric and eccentric peak torque of the quadriceps muscle for healthy subjects and patients with burn injuries

Our results concerning aerobic exercisesare supported by **De Lateur et al., 2007(19)**who applied A 12-week, 36-session, aerobic treadmill exercise program where work to quota participants intensified their exercise according to preset quotas and work to tolerance 0070zarticipants continued to their tolerance and showed that significant improvements in aerobic capacity from baseline to 12 weeks (t=−3.60, P≤.01; t=−3.17, P≤.01, respectively). participants demonstrated significantly greater improvements in aerobic capacity in comparison to the other patient who didn't ma de exercise (F=4.6, P≤.05).

Also,**Suman et al.,2001(20)** worked on explore the effects of a structured supplemental exercise program for children with severe burns under the age of 7-years and supported the findings from the burn literature that rehabilitation programs supplemented with an organized and structured exercise regimen improves outcomes for children with severe burns and showed that patients in the supplemental group significantly improved in all passive and active ROM , children in the 12-week program were able to actively reinforce and practice gross motor skills that were carried out during their occupational and physical therapy sessions and showed also repetition of gross motor movements during play and engagement in continuous active movement for the duration of each group sessions were the primary methods used to enhance strength, endurance, and ROM, The group format not only allowed for social interaction but also enhanced motivation for children to complete the various motor tasks presented.

Concerning combination of isokinetic and aerobic exercise,our results are supported by**Grisbrook et al., 2012(22),**who evaluated the effects of exercise training on aerobic capacity 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 for12 weeks. Exercise training result were improvements in aerobic capacity and clinically relevant achievement towards occupational performance goals, which is in agreement with the results of the current study.

Also,**Allojou and colleagues**(11) has shown that severely burned children (>50% TBSA burned) participating in progressive resistive exercise for 12 weeks beginning at 6 months post injury show improved upper and lower limb muscle strength relative to age-matched controls receiving medical treatment alone . Furthermore, a 12-week program incorporating resistance exercise (8 exercises focusing on compound movements involving the upper and lower limbs performed at 50–80% of 3 repetition maximum) as well as aerobic conditioning (20–40 min at 70–85% of VO_2 peak 3 times weekly) has been shown to have significant benefits for the convalescing burn victim . In this study, resistive exercise increased total lean body mass (trunk, leg, and arm) in children with large burns (>50% TBSA), while lean body mass was unchanged in a similar group of patients receiving medical care only over the same time frame. Further, isokinetic (150°/sec) peak torque and work capacity as well as VO_2 peak increased in the Resistive exercise group, with no changes being observed in the medical group. Thus, resistive exercise group had clear benefits on lean body mass and muscle function in children recovering from massive burns. Interestingly, while exercise likely resulted in transiently increased energy expenditure, resistive exercise group did not worsen hypermetabolism in this patient cohort. Indeed, they have more recently reproduced this finding in similarly injured children, showing that resistive exercise, as compared to medical care only, improves muscle mass and strength without worsening hypermetabolism This underscores the safety and efficacy of resistive exercise in severely burned children. Similar effects of exercise on skeletal muscle strength have also been seen in adults.

In a cohort of 40 severely burned adults (>40% TBSA burned) studied approximately 6 months post injury, muscle peak torque of the leg extensors and flexors was 28% and 24% lower than that seen in a cohort of 23 unburned controls, respectively burned patients were subsequently randomized to one of two treatments: home-based exercise program focusing on range of motion exercises (n=20) or supervised isokinetic leg exercise 3 times per week for a total of 12 weeks (n=20). In the group receiving supervised isokinetic exercise, leg extensor and flexor peak torque significantly increased to values that were similar in magnitude to those of unburned controls, whereas no significant improvements were detected in the group randomized to home-based exercise. Therefore, it would seem that supervised exercise interventions are significantly more efficacious in restoring skeletal muscle strength than home-based programs. This underscores the importance of including individualized supervised RET as part of outpatient care, particularly when isokinetic exercise programme can be performed in a

hospital/clinic setting (**Allojou et al., 2008)(11).**

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Reference

1- Porter, C., Hardee, J., Herndon, D. N., &Suman, O. E. (2015).The role of exercise in the rehabilitation of patients with severe burns. Exercise and sport sciences reviews, 43-40(1):

2- Hart, S. R., Staudigel, H., Koppers, A. A., Blusztajn, J., Baker, E. T., Workman, R., Fornari, D., et al. (2000). Vailulu'u undersea volcano: The new Samoa. Geochemistry, Geophysics, Geosystems, 1(12).doi:10.1029 2000GC000108.

3- Shaw, I., & Shaw, B. S. (2014). Resistance Training and the Prevention of Sports Injuries. In: Hopkins, G. (Ed.). Sports Injuries: Prevention, Management and Risk Factors. Nova Science Publishers, Hauppauge, NY. USA. ISBN 978-1-63463-305-5.

4- Kelln, B. M., McKeon, P. O., Gontkof, L. M., &Hertel, J. (2008). Hand-held dynamometry: reliability of lower extremity muscle testing in healthy, physically active, young adults. Journal of sport rehabilitation, 17(2), 160-170.

5- 5-Sutherland, D. H. (2002). The evolution of clinical gait analysis: Part II Kinematics. Gait & posture, 16(2): 159-179.

6- 6-Diego, A. M., Serghiou, M., Padmanabha, A., Porro, L. J., Herndon, D. N., &Suman, O. E. (2013). Exercise training after burn injury: a survey of practice. Journal of Burn Care & Research, 34(6): 311-317.

7- Kwan, M. W., &Kennis, W. H. (2002). Splinting programme for patients with burnt hand. Hand Surgery, 7(2): 231-241.

8- Cen, Y., Chai, J., Chen, H., Chen, J., Guo, G., Han, C., Li-Tsang, et al. (2015).Guidelines for burn rehabilitation in China. Burns & trauma, 3(1): 20.

9- Eggers, C. H., Kimmel, B. J., Bono, J. L., Elias, A. F., Rosa, P., & Samuels, D. S. (2001). Transduction by φBB-1, a Bacteriophage of Borreliaburgdorferi. Journal of bacteriology, 183(16): 4771-4778.

10- Edelman, L. S. (2007). Social and economic factors associated with the risk of burn injury. Burns, 33(8), 958-965.

11- Alloju, S. M., Herndon, D. N., McEntire, S. J., &Suman, O. E. (2008). Assessment of muscle function in severely burned children. Burns, 34(4): 452-459.

12- St-Pierre, D. M., Choinière, M., Forget, R., &Garrel, D. R. (1998). Muscle strength in individuals with healed burns. Archives of physical medicine and rehabilitation, 79(2): 155-161.

13- Stampfer, M. J., Hu, F. B., Manson, J. E., Rimm, E. B., & Willett, W. C. (2000). Primary prevention of coronary heart disease in women through diet and lifestyle. New England Journal of Medicine, 343(1): 16-22.

14- Ahmed, E. T., & Abel-Aziem, A. A. (2011).Effect of isokinetic training on quadriceps peak torque in healthy subjects and patients with burn injury. Journal of rehabilitation medicine, 43(10): 930-934.

15- Phillips, J. D., Parker, T. L., Schubert, H. L., Whitby, F. G., Hill, C. P., & Kushner, J. P. (2001). Functional consequences of naturally occurring mutations in human uroporphyrinogen decarboxylase. Blood, 98(12): 3179-3185.

16- Porter, C., Hardee, J., Herndon, D. N., &Suman, O. E. (2015).The role of exercise in the rehabilitation of patients with severe burns. Exercise and sport sciences reviews, 43(1): 34 – 40.

17- Ebid, A. A., Omar, M. T., & El Baky, A. M. (2012). Effect of 12-week isokinetic training on muscle strength in adult with healed thermal burn. Burns, 38(1): 61-68.

18- Paratz, J. D., Stockton, K., Plaza, A., Muller, M., & Boots, R. J. (2012). Intensive exercise after thermal injury improves physical, functional, and psychological outcomes. Journal of Trauma and Acute Care Surgery, 73(1): 186-194.

19- De Lateur, B. J., Magyar-Russell, G., Bresnick, M. G., Bernier, F. A., Ober, M. S., Krabak, B. J., Fauerbach, J. A., et al. (2007). Augmented exercise in the treatment of deconditioning from major burn injury. Archives of physical medicine and rehabilitation, 88(12): 18-23.

20- Suman, O. E., Spies, R. J., Celis, M. M., Mlcak, R. P., & Herndon, D. N. (2001). Effects of a 12-wk resistance exercise program on skeletal muscle strength in children

with burn injuries. Journal of applied physiology, 91(3): 1168-1175.

21- Silverberg, R., Lombardo, G., Gorga, D., Nagler, W., Himel, H., & Yurt, R. (2000).Gait variables of patients after lower extremity burn injuries. The Journal of burn care & rehabilitation, 21(3): 259-267.

22- Grisbrook, T. L., Wallman, K. E., Elliott, C. M., Wood, F. M., Edgar, D. W., & Reid, S. L. (2012). The effect of exercise training on pulmonary function and aerobic capacity in adults with burn. Burns, 38(4): 607-613.