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Isokinetic training enhanced by Kinesio tape for quadriceps muscle weakness post lower limb healed burn

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Abstract---Objective: To investigate the effect of isokinetic training enhanced by Kinesio tape (KT) on weak quadriceps muscle following healed lower limb burn. Design: A double-blinded, randomized, controlled trial. Setting: Outpatient, Kasr El Aini Hospital, and Orabi Hospital. Participants: Sixty patients with weak quadriceps of dominant lower limb following healed partial thickness burn. Thirty to forty percent of their total body surface area (TBSA) was affected by burn including the anterior thigh. They were distributed randomly into two groups; the isokinetic training and Kinesio tape group, and the isokinetic training group. Intervention: group (A); 30 patients who received isokinetic training (concentric and eccentric contraction exercises) of the quadriceps muscle (dominant side) at an angular velocity of 90°/s, three times per week, and Kinesio tape was applied twice per week, group (B): 30 patients who received isokinetic training in the form of (concentric and eccentric contraction exercises) of the

quadriceps muscle (dominant side) at an angular velocity of 90°/s, three times per week. All groups were evaluated pre-treatment and after 8 weeks from the beginning of the treatment. Outcome measures: All patients were realized isokinetic evaluation for dominant Quadriceps muscle functions (concentric and eccentric peak torque, work, and power) that had been evaluated by using an Isokinetic dynamometer. Results: By comparing the results of both groups post-treatment, there were statistically significant increases in peak torque and average power of group A compared with that of group B post-treatment ($p < 0.05$). However, there was no statistically significant difference in total work between groups ($p > 0.05$). Conclusion: isokinetic training enhanced by Kinesio tape (KT) has beneficial effects on peak torque, work, and average power of weak quadriceps muscle following healed lower limb burn patients and consequently can be added to the treatment protocols for these debilitating conditions.

Keywords--isokinetic training, kinesio tape, quadriceps muscle, burn.

Introduction

There is growing evidence that pathophysiologic responses that occur immediately or early after a burn will affect the long-term outcome of severely burned patients [1]. Changes in gait patterns may occur as a consequence of joint tissue derangement, knee joint swelling, weakness of the quadriceps muscle, or muscle inhibition due to pain [2]. Recovery of knee extensor strength is essential for functional rehabilitation. Previous reports have shown that the functional outcome is positively correlated with extensor strength, thus indicating that muscle strengthening is a precondition for functional recovery [3]. Training using eccentric contractions is more effective for muscle recovery because it promotes greater changes in neural activation and muscle hypertrophy [4].

Since eccentric modality provides strong mechanical stress at a lower metabolic cost, it appears particularly suitable for training individuals with medical conditions associated with muscle wasting and reduction in muscle strength, mobility, and aerobic capacity [5]. Isokinetic contractions provide muscle training throughout the range of motion (ROM) of a joint at a pre-set constant speed of contractions. When a specific speed is reached, the device will automatically accommodate to give resistance to each point of the ROM, allowing the specific speed to be maintained. When the subject applies force, the device provides resistance. If the force stops, the resistance stops automatically. Force changes caused by muscle length/tension relationship, skeletal leverage, pain, or fatigue are then easily accommodated [6]. One advantage of isokinetic testing is that it provides numerous objective parameters that can be used to evaluate and analyze a patient's or athlete's performance it frequently used to analyze muscular performance include peak torque, time rate of torque development, total work, and mean power [7]. Isokinetic dynamometry provides objective measures of concentric dynamic strength. It provides optimal and efficient loading of muscles and joints through the range, thereby minimizing the potential risk for injury [8].

Kinesio tape (KT) is a commonly used adhesive elastic tape. The hypothesized effects of KT include reduced pain, facilitated or inhibited muscle strength, and increased range of motion [9]. One of the proposed mechanisms is that the recoiling force of KT may be transmitted to the fascia [10]. This force may then assist in muscle contractions if the contraction and the KT have the same direction of pull [11]. Studies reported the effects of KT on strength improvements [12]. The most common design of KT studies is grounded on immediate or acute applications, for example, work and time to reach the peak torque of the quadriceps muscles [13]. Studies addressed the use of KT during functional tasks and sports performance several techniques of kinesiology taping exist and the application of kinesiology tape for certain pain, injury prevention, performance enhancement, and joint stabilization can differ significantly depending on each technique. [14]. The need for this study arises from the instant and continuous queries to find out advanced physical therapy modalities suitable for those after healing of lower limb burn to enhance their functional abilities and physical performance. The aim of the present study was to find out the effect of isokinetic training enhanced by Kinesio tape on peak torque, work, and power of quadriceps muscle among those with healed lower limb burn within the dominant side.

Material and Methods

Study design

The study was designed as a randomized, single-blinded, controlled clinical trial to be conducted between April and December 2021.

Participants

Sixty patients (35 males and 25 females) who assumed weak quadriceps of dominant lower limb following partial thickness burn and a TBSA of (30 to 40%) included the anterior thigh and they were stable for a minimum of 12 months. They were selected randomly from the outpatient clinic of Kasr El Aini Hospital and Orabi Hospital, Cairo, Egypt. Patients confirmed their participation in the study by signing a consent form after clarifying the nature, and benefits of the treatment and their right to drop out from the study at any time. Ethical approval was gained from the institutional review board at Faculty of Physical Therapy, Cairo University before initiating the study [No :P. T.REC/012/002969].

Inclusion criteria

To be included in the study; patients should have weak quadriceps muscle of dominant side following healed burn. All patients had burn with TBSA of 30% to 40%. Their ages ranged from 25 to 40 years, and they were stable for a minimum of 12 months.

Exclusion Criteria

Patients were excluded from the study if they had specific disorders (such as Musculoskeletal injuries, Cardiac disease, Equilibrium disorders, Treatment-

resistant heart rhythm disturbances, Acute medical problems at study onset, Whole length exposed hand or foot tendons as they were at risk of tendon rupture, Allergy to Kinesio tape, and Lower limb amputation.

Sample size

Sample size calculation was performed using G*POWTER statistical software (version 3.1.9.2) based on data of peak torque from a pilot study conducted on 5 patients in each group and revealed that the required sample size for this study was 30 patients per group. Calculations were made using $\alpha=0.05$, power 80%, the effect size of 0.74, and allocation ratio $N_2/N_1 = 1$. The number of patients increased to 33 for possible dropout.

Randomization and blinding

Outcome measures were collected by an assessor who was not blind to the patients' treatment. The patients were kept in the dark about their therapy assignment and were not told what intervention the other group would receive. After the baseline test, the patients were randomly assigned to two groups; (group A), Isokinetic training plus Kinesio tape, group (B) Isokinetic training by a blinded and an independent research assistant who opened stamped envelopes that had a randomization card generated by a computer-based randomization program. (Figure 1).

Interventions

Patients were assigned randomly into two groups.

- **(Group A);** Isokinetic training and Kinesio tape, consisted of 30 patients (19 males and 11 females) who received isokinetic exercises (concentric - eccentric program) of dominant quadriceps, three times per week and application of Kinesio tape was twice per week for eight consecutive weeks.
- **Group (B):** Consisted of 30 patients (22 males and 8 females) who received isokinetic exercises for dominant quadriceps, three times per week for eight consecutive weeks.

All patients in the two groups were assessed at the beginning of the treatment by a well-trained physiotherapist as a baseline and at the end of the eight weeks.

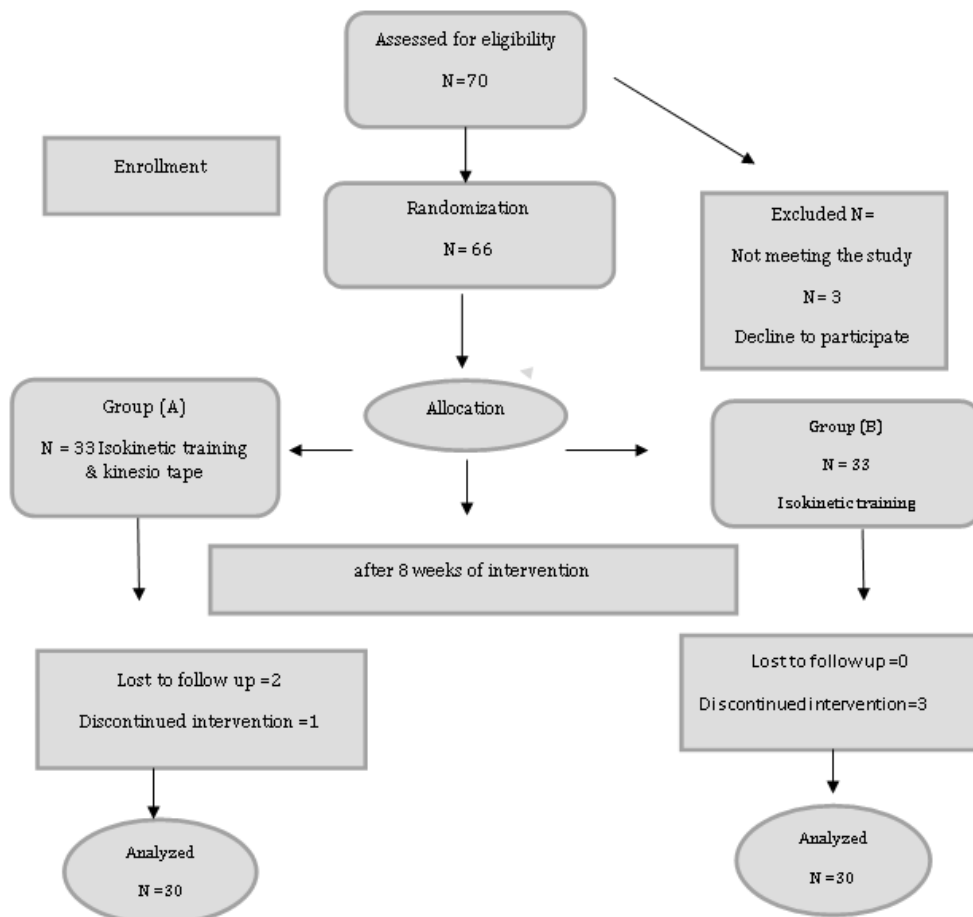


Figure 1. Flow diagram showing the number of patients after 8 weeks of treatment

Isokinetic training exercises

Humac Norma Isokinetic equipment was used for Isokinetic torque assessment as well as for training. After warming up and free active stretching of the dominant lower extremity, three 30 s repetitions with a 30 s interval for 5 minutes. patients were positioned on the Isokinetic training chair with the hip joint at 85° of flexion and was attached to the isokinetic chair by velcro straps during maximal contractions. Training consisted of 10 knee extension/flexion repetitions at an angular velocity of 90°/s with a submaximal effort level. patients performed concentric and eccentric contraction of dominant quadriceps. The exercise program began with 60% average peak torque. It was increased from one set to five sets during the first five sessions and remained at six sets for the remaining 6th to 15th sessions. Finally, a dose of ten sets was applied for the 16th to 24th session. The patients would be taught to stop the exercise and to notify if they felt any dizziness.



Figure 1. Isokinetic training with KT

Application of Kinesio tape

Kinesio tape was used to be applied on weak dominant quadriceps muscle. The skin was cleaned and dried, Sitting with the knee bent at 90°, kinesiology tape was stretched about 25% of its length, without stretching either end (approximately 2–3 cm), It was applied to 3 of 4 muscles constituting the quadriceps; the rectus femoris, vastus medialis, and vastus lateralis, from the origin to the insertion, the tape was applied from the anterior superior iliac spine to the superior border of the patella, from inward of the intertrochanteric line to the medial superior aspect of the patella and from the greater trochanter to the lateral superior region of the patella [14]. It was changed twice per week when it appeared to be ineffective.



Figure 2. Application of three KT (I shape straps)

Outcome measures

- The initial evaluation of knee extensor muscles of the dominant burned limb was performed with HUMAC NORM isokinetic dynamometer.

- After a warm-up, consisting of 3 trial of knee extension/flexion repetitions at an angular velocity of 90°/s with a submaximal effort level, patients performed 5 maximal voluntary muscle contractions consecutively without rest in between. Three minutes of rest was given to decrease the effects of fatigue, and the test was repeated.
- Five maximal contractions were recorded at each repetition, with a one min rest period between each set, three sets per day. A maximum peak torque was calculated of the best five contractions [15].
- The average torque, work, and power of the quadriceps would be measured, for patients (using an isokinetic dynamometer assessment machine) at angular velocity of 90°/s.

Statistical methods

Unpaired t-test was conducted for comparison of age, BMI, and TBSA between groups. The normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity was conducted to test the homogeneity between groups. Unpaired t-test was conducted for comparison of peak torque, total work, and average power between groups while paired t-test was conducted for comparison between pre- and post-treatment in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Patient characteristics

Table 1 Showed the subject characteristics of groups A and B. There was no statistically significant difference between groups in the mean age, BMI, TBSA, elapsed time since burn (at least 12 month) and sex distribution ($p > 0.05$).

Table 1
Comparison of subject characteristics between groups A and B

	Mean \pm SD		MD	t- value	p-value
	Group A	Group B			
Age (years)	32.63 \pm 3.56	33.2 \pm 4.3	-0.57	-0.55	0.58
BMI (kg/m ²)	26.66 \pm 1.01	26.88 \pm 1.52	-0.22	-0.67	0.5
TBSA (%)	34.93 \pm 3.75	35.3 \pm 3.44	-0.37	0.39	0.69
Females/Males	11/19	9/21		($\chi^2 = 0.3$)	0.58

SD: Standard deviation; MD: Mean difference; χ^2 : Chi-squared value; p-value: Probability value

Effect of treatment on peak torque, total work, and average power Within-group comparison

There was a statistically significant increase in peak torque, total work, and average power of groups A and B post-treatment compared with that of pre-treatment ($p > 0.001$). The percent of change of peak torque, total work, and

average power of group A was 938.31, 20.27, and 54.39% respectively and that of group B was 22.42, 20.16, and 35.26% respectively (Table 2).

Between groups comparison

There was no statistically significant difference between groups pre-treatment ($p > 0.05$). There was a significant increase in peak torque and average power of group A compared with that of group B post-treatment ($p < 0.05$). However, there was no statistically significant difference in total work between groups ($p > 0.05$) (Table 2).

Table 2
Mean peak torque, total work, and average power pre- and post-treatment of groups A and B

	Group A Mean \pm SD	Group B Mean \pm SD	MD (95% CI)	t- value	P value
Peak torque (Nm)					
Pre-treatment	41.4 \pm 7.6	41.3 \pm 6.85	0.1 (-3.64: 3.84)	0.05	0.95
Post-treatment	57.26 \pm 12.03	50.56 \pm 8.41	6.7 (1.33: 12.06)	2.5	0.01
MD (95% CI)	-15.86 (-18.42: -13.3)	-9.26 (-10.99: -7.54)			
% of change	38.31	22.42			
t-value	-12.66	-10.99			
	$p = 0.001$	$p = 0.001$			
Total work (Joule)					
Pre-treatment	62.3 \pm 11.55	61.36 \pm 10.56	0.94 (-4.78: 6.65)	0.32	0.74
Post-treatment	74.93 \pm 11.79	73.73 \pm 11.52	1.2 (-4.82: 7.22)	0.39	0.69
MD (95% CI)	-12.63 (-14.03: -11.22)	-12.37 (-14.08: -10.64)			
% of change	20.27	20.16			
t-value	-18.38	-14.68			
	$p = 0.001$	$p = 0.001$			
Average power (Watt)					
Pre-treatment	32.6 \pm 6.31	33.86 \pm 6.04	-1.26 (-4.46: 1.92)	-0.79	0.43
Post-treatment	50.33 \pm 7.72	45.8 \pm 8.89	4.53 (0.22: 8.83)	2.1	0.03
MD (95% CI)	-17.73 (-19.64: -15.81)	-11.94 (-14.33: -9.53)			
% of change	54.39	35.26			
t-value	-18.95	-10.16			
	$p = 0.001$	$p = 0.001$			

SD: Standard deviation; MD: Mean difference; CI: Confidence interval; p-value: Level of significance

Discussion

The aim of this study was to investigate whether isokinetic training enhanced with kinesio tape is effective on isokinetic parameters (peak torque, total work and average power) of quadriceps muscle in patients with healed lower limb burn.

Severe burn injury results in a hypermetabolic/catabolic state that is intimately associated with both a systemic inflammatory response and a stress response [14]. Muscle wasting is the most widely known effect of severe burn injury and it is widely attributed to hypermetabolism [15]. Skeletal muscle plays a central role in locomotion, as well as in the homeostasis of whole body protein, lipid, and glucose metabolism. Body protein is in a constant process of synthesis and breakdown [16].

Isokinetics uses a preset fixed velocity while allowing for accommodating resistance through the ROM. The fixed velocity ranges from $1^\circ/\text{s}$ to approximately $1000^\circ/\text{s}$. The accommodating resistance exactly matches the active muscle force produced by the patient throughout the ROM, thereby providing the only way to dynamically load a muscle to its maximum capability at every point through the ROM [17], [18]. Kinesio taping is considered one of the most common and recent used techniques, where it is used as a therapeutic technique for pain relief [19]. In addition to this type of taping has a lot of positive effects, where due to its elasticity, skin can be folded and allow more space under the skin that allows good circulation to the injured area and improve performance and strengthening muscles and joints [20]

By the end of this study, the analysis of data revealed that

In study group, the peak torque increased by 938.31% after 8 weeks from the beginning of the treatment, while the total work increased by 20.27 % and the average power increased by 54.39%. In control group the peak torque increased by 22.42 % after 8 weeks from the beginning of the treatment, while the total work increased by 20.16 % and the average power increased by 35.26%. Therefore, there was more efficacy of isokinetic training while applying kinesio tape than isokinetic training without taping on strength of weak quadriceps. Based on the method, participants were divided into two groups composed of 30 patients for each; that is group A had isokinetic training with kinesio tape and group B had isokinetic training without tapping. It was concluded that, isokinetic training with KT had favorable outcome in persons with post burned weak quadriceps by significant increasing in peak torque and total work when compared with isokinetic training without tapping [21].

Vithoulka et al. suggested that KT application in 20 healthy women on the anterior surface of the thigh might increase isokinetic eccentric peak torque. [22]. Furthermore, Aytar et al. reported that improved quadriceps strength at $60^\circ/\text{s}$ and $180^\circ/\text{s}$ and static and dynamic balance scores before and at 45 min after KT application [23]. This can be explained as the mechanical effects of KT on fascia or its sensory tactile effects on the skin [24]. The postulated mechanism by which KT could have increased the quadriceps torque, improved the performances could be due to a central nervous system neuromodulation [25]. The isokinetic dynamometer measures the peak torque produced by the muscle under a fixed angular velocity, so the muscle must resist the dynamometer at different angles [26]. Thus, Pamuk et al. confirmed that KT can not only change the passive tension of connective tissues but can also alter the length of muscles, and so KT can assist muscle contraction at different angles [27],[28].

In contrast Wong et al who found no significant differences in the EMG activity of the vastus lateralis or the concentric and eccentric knee peak torque at 60° /s. [29]. Similarly, Janwantanakul and Gaogasigam who found no effects of KT on the quadriceps peak torque or total work in 14 healthy men [30]. that could be explained as the lack of alterations in the muscle performance after KT application [31]. Vercelli et al concluded that KT did not significantly improve muscle peak torque, power, or work in healthy nonathletic males [32]. In addition, Wageck et al. did not find a significant difference in the flexor or extensor peak torque at 60°/sec between the KT-treated and sham-taping group after four days of taping in knee osteoarthritis (OA) patients [33],[34]. The present study had a remarkable effect of isokinetic training enhanced by kinesiotaping application on isokinetic muscle strength improvement for patients with weak burned quadriceps. The findings of increased isokinetic muscle strength are particularly valuable as muscle strength is very important for knee stability [35].

The study supports that the KT as an enhancing effective tool for physical therapists in treating weak quadriceps following burn. This study was limited by the small sample size of patients and shortage of patients that accept to share in the study. In addition, there was no follow-up to investigate the long-term effect of the treatment, and there were no different age groups included in this trial, which are both significant limitations for future research. It was recommended that the increment of sample size and to do more studies to use various methods of assessment of quadriceps muscle weakness are valuable. Furthermore, other cooperative studies with various physical therapy modalities used in muscle strengthening can be studied in the future.

Conclusion

It could be concluded that isokinetic training enhanced by Kinesio tape are effective methods in improving weak quadriceps muscle peak torque, work, and average power after healed lower limb burn.

Conflict of Interest

There are no conflicts of interest declared by the authors.

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