The Optimal Duration of Static Stretching Exercises for Improvement of Flexibility post Burn Contracture of Hamstring Muscle

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ABSTRACT

The purpose of this study was to determine the optimal time of static stretching exercises to increase flexibility in post burn contracture of the hamstring muscle, as measured by knee extension range of motion. Twenty male patients ranging in age from 18 to 32 years and who had decreased hamstring muscle flexibility as a result of partial thickness burn were classified into 2 equal groups 10 of each, Group (1): received 60 seconds of stretching exercise and Group (2): received 120 seconds of stretching exercise.. Both groups received stretching exercises 5 days per week for 8 weeks. Measurements of knee extension range of motion were conducted before treatment, post 4 weeks of treatment, and after 8 weeks of treatment. The student' s t test was used to compare knee extension range of motion which revealed that second treatment group (120 seconds stretch) had significant (P< 0.05) gains in knee extension ROM after 8 weeks post stretching exercises. The results of this study suggest that 120 seconds duration is more effective than 60 seconds stretch to improve a hamstring muscle stretching in order to increase ROM.

INTRODUCTION

Post- acute rehabilitation after a burn injury is directed toward minimizing hypertrophic scar formation and contracture; increasing flexibility, strength, and endurance; promoting independence in normal daily activities; and improving the individual's physical skills for returning to work or school[10].

The rehabilitation of patients who suffer burns in the large joints, in particular the knee joint remains a difficult problem facing physical therapist.

Skin scar contractures related to destruction of skin subdermal fat, and fascia are very frequent.Secondary contractures involve muscles and tendons (shortening, serous induction, and scarring of tissues around a joint), after which joint soft tissue contractures develop. Primary artho-osseous contractures result from direct deep burns in a joint, leading to sever and irreversible processes[8].

Stretching is a method used in the post-acute stage after a burn injury. Stretching of scar tissue has been recommended to elongate, soften, and increases the pliability of immature scar[3].

It is surprising that there is little literature concerning how to optimize the stretching time. Although documentation exists that static stretching technique will increase the flexibility of muscle.

Several authors have made suggestions concerning the appropriate time the soft tissue stretching should be maintained in order to be effective, but give no objective data to support their opinion regarding the application of this technique in post-burn contracture.

The effects of hamstring muscle stretching was examined in three groups (stretching for 15, 30 and 60 seconds) as compared with a control group that did not

receive stretching exercises. Subjects in the stretching groups stretched 5 days per week for 6 weeks the results indicated that 30 and 60 seconds of static stretching were more effective at increasing hamstring muscle flexibility than stretching for 15 seconds or without stretching. No difference was found between 30 and 60 seconds of stretching, indicating that 30 seconds of stretching is suitable time of stretching[1].

Another study was done in order to evaluate the effect of time and frequency of static stretching on the flexibility of the hamstring muscles. The results of this study suggested that 30 seconds duration is an effective amount of time to sustain a hamstring muscle stretch in order to increase ROM. No increase in flexibility occurred when the duration of stretching was increased from 30 to 60 seconds or when the frequency of stretching was increased from one to three times per day[2].

On the other hand, the effect of differences in duration of stretching the hamstring muscle group for increasing range of motion was studied in people aged 65 years or older. Longer hold times during stretching of the hamstring muscles resulted in a greater rate of gains in range of motion and a more sustained increase in ROM in elderly subjects. And they stated that these results might differ from those of studies performed with younger population because of the age-related physiologic changes[5].

Studies have produced conflicting results regarding the optimal duration of static stretch necessary to achieve the viscoelastic changes to increase ROM. In the majority of these studies however, the hamstring muscle flexibility was studied in unburned patient, and we believe that the findings can not necessarily be generalized to other types of patients.

In our study, a "long duration" stretch was defined as a stretch greater than 30 seconds duration for one repetition, and a "low intensity" stretch was defined as a stretch based on each subject's perception of the onset of discomfort in the back of the thigh, this definition is similar to the definition of Feland et al., 2001[5].

Clinical ultrasound is used commonly by physical therapists to produce a deep tissue temperature rise within a safe and appropriate therapeutic range. Combining passive stretch with the application of ultrasound facilitates further tissue elongation[9].

The purpose of this study was to determine the optimal time of static stretching exercises to increase flexibility in post burn contracture of the hamstring muscle.

SUBJECT, MATERIAL AND METHODS

Subjects

Patients treated from burn injuries at El-Hussien teaching hospital were randomly selected for participation in this study. This study eligibility required that patients be more than 18 years of age; 3 to 8 months after the occurrence of the burn injury; had unilateral scars across the posterior aspect of the knee (popliteal fossa); the percentage of burn did not exceed 20%, and had no history of other lower extremity pathology.

Inclusion assessment to participate in the study, subjects must have exhibited unilateral tight hamstring muscles. Operationally defined as having greater than 30 degrees loss of knee extension as measured with the femur held at 90 degrees of hip flexion. In addition, subjects who were not involved in any exercise activity at the start of the study had to agree to avoid lower extremity exercises and activities other than those prescribed by the research protocol.

During the 8 weeks of training 20 male subjects, with age range from 18 to 32 years, met the established criteria and completed the study.

Group assignment

To ensure equal distribution of hamstring muscle contracture, the patients were stratified into two groups based on their degree of hamstring muscle contracture. Patients assigned to group 1 (n=10 patients, age=23.80 years, and range=60.2) served as treatment group 1 and received 60 seconds stretch. Patients assigned to group 2 (n=10 patients, age=24.30 years, and range=60.2) served as treatment group 2 and received 120 seconds stretch.

Instrumentation

A double-arm (30.5 cm) clear plastic goniometer was used to measure knee extension ROM. Prior to data collection; we performed a pilot study to establish intra-tester reliability of measurements of knee extension ROM. A test-retest design was used on 10 subjects of similar hamstring contracture, with measurements taken week a part. Reliability was determined using an intraclass correlation coefficient. An ICC of 0.96 was considered appropriate for continuing the study.

A sonopulse 434 ultrasound unit was used to administer the deep heat as warming up prior to stretching to avoid tendon rupture.

Experimental procedure

Measurement protocol

Measurement of knee extension ROM was made with the subject lying supine with the opposite lower extremity extended and the lower extremity being measured positioned at 90 degrees of hip flexion. The greater trochanter and lateral epicondyle of the femur and the lateral malleolus were palpated and served as landmarks during measurement. We attempted to maintain hip flexion at 90 degrees while the tibia was moved into the terminal position of knee extension, which was defined as the point at which the subject reported feeling of discomfort. Zero degree was considered to be 90 degrees of knee flexion. The goniometric value was recorded. The measurement of knee extension ROM was considered to be an indirect measure of hamstring muscle flexibility, with hamstring muscle tightness being the purported cause of a lack of knee extension ROM. All subjects were measured on the same day and at the same time each month, before they had stretching for that day. Measurements were taken before treatment, post 4 weeks of treatment and post 8 weeks of treatment.

Treatment protocol

1- Warming procedure

Prior to stretching technique warming up of hamstring muscle was achieved in both groups by ultrasound application. The generator operated at a frequency of 1MHz ± 0.2. The transducer head was 6.2 cm in diameter, and the beam non-uniformity ratio of the crystal was a maximum of 5. The effective radiating area of the sound head was 5.0 cm^2 ± 20%. Calibration and an electrical safety inspection were performed prior to testing. Ultrasound treatment was administered to the hamstring muscle at the site of contracture[8].

2- Stretching procedure

I. Stretching of the hamstring muscles was performed by 2 researchers (Lecturers in the Physical Therapy department for Surgery).

II. Contractures of the knee can be stretched by placing the patient prone on firm surface with a pad under the knee and with the leg extending unsupported beyond the end of

the table. A low force was applied by researcher hands at the level of the ankle for 60 seconds in group 1 and 120 seconds in group 2 while the other hand of the researcher stabilize just above the knee joint. Both groups received 4 stretches per day with 10 seconds a rest interval between each stretch. The stretch session always performed at the morning after awaking (to eliminate morning stiffness and energize oneself). The stretching technique was repeated 5 days per week for 8 weeks (the total time of the experiment). Instructions included the use of same verbal cues to minimize variation in administration. An attendance sheet was used to document adherence. If a subject was not able to receive the session on a particular day, the subject would receive the session at the vacation day. Any subject missing more than 4 days of stretching was dropped from the study.

III. All subjects were retested after 8 weeks using the same procedures described for the pretest. Two days of rest separated the last day of stretching and the post-test.

Data analysis

The equivalence of both stretching groups regarding the amount of knee flexion contractures prior to the study was checked by conducting independent t-test on knee range of motion.

Dependent t-test was calculated on the pre-test to post-test change for each group (a total of 3 t tests were performed).

Finally to assess whether any difference existed in the post-test scores an independent t test was calculated on the post-test change for both groups (a total of 3 tests were performed in-between group 1 and group 2).

For all statistical tests and all follow-up tests, the 0.05 level of probability was used.

RESULTS

The descriptive characteristics of the subjects in both groups are shown in table(1) and figure(1). There was no statistical difference between the two groups regarding the age, depth of burn, percentage of burn and the duration post burn.

Table (1): Descriptive characteristics in both groups.

comparison	Age in years		Depth of burn in millimeters		Duration post burn in months		% of burn	
Groups	G 1	G 2	G 1	G 2	G 1	G 2	G 1	G 2
Mean	23.80	24.80	2.30	2.10	5.40	5.40	16.80	17.00
SD	4.47	4.88	0.48	0.31	1.57	1.64	2.15	1.88
t value	0.24		1.10		0.00		0.22	
P value	0.81		0.29		1.0		0.83	
Significance	NS		NS		NS		NS	

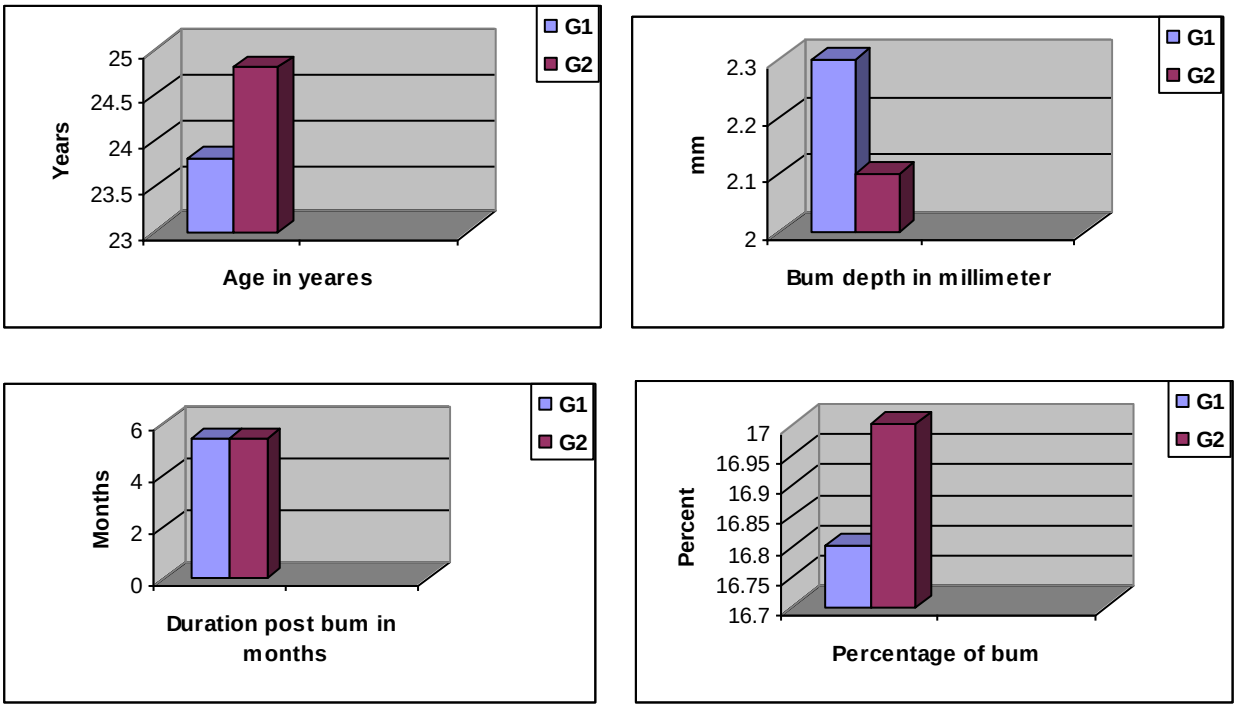

Fig. (1): Age, depth of burn, duration post burn, percentage of burn in both groups.

Comparison between pre and post treatment within the same group

Results of the first treatment group (Group 1, 60 seconds stretching)

In the first treatment group, the mean values for knee extension were 60.2 degrees (SD = ± 1.75), for the pre-test measurement, 64.80 degrees (SD = ± 1.31), for the post 1 test measurement i.e.: after 4 weeks of stretching, and 69.60 degrees (SD = ± 1.57) for the post 2 test measurement i.e: after 8 weeks of stretching. The paired t test demonstrated a statistically significant difference between pre test and post 1 test knee extension range of motion (t=11.5, P=0.00), similarly there was a statistically significant difference between pre test and post 2 test knee extension range of motion score and between post 1 test and post 2 test stretching score respectively (t=16.73, P=0.00 and t=12.35, P=0.00) table (2) and figure (2-a and b).

Table (2): Comparison between Group 1 mean results measured at deferent stages of treatment program.

mean	pre	Post1	pre	Post2	Post1	Post2
	60.2	64.80	60.2	69.60	64.80	69.60
SD	1.75	1.31	1.75	1.57	1.31	1.57
T	11.5		16.73		12.35	
P	0.00		0.00		0.00	
Sig	S		S		S	

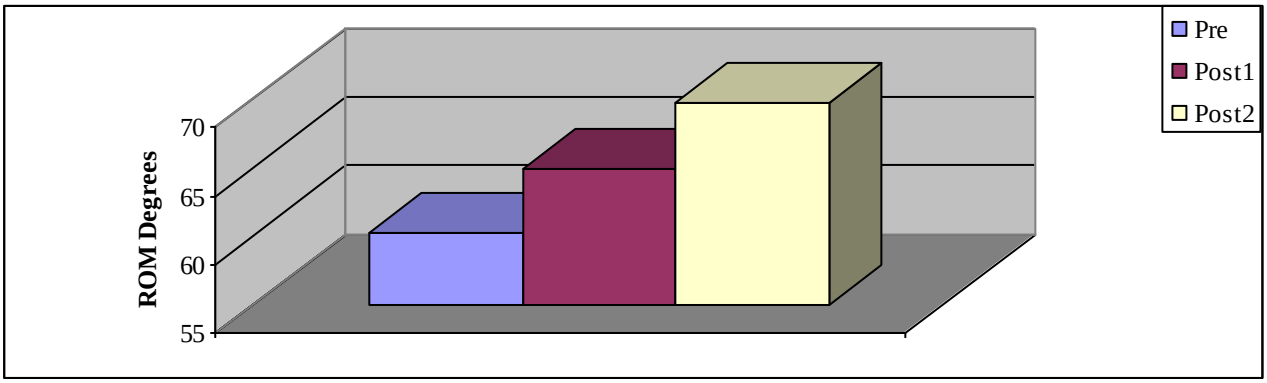

Fig. (2): Comparison between Group 1 mean results measured at deferent stages of treatment program.

Results of the second treatment group (Group 2, 120 seconds stretching)

In the second treatment group, the mean values for knee extension were 60.2 degrees (SD = ± 1.75), for the pre-test measurement, 66.50 degrees (SD = ± 1.31), for the post 1 test measurement i.e: after 4 weeks of stretching, and 75.70 degrees (SD = ± 1.41) for the post 2 test measurement i.e: after 8 weeks of stretching. The paired t test demonstrated a statistically significant difference between pre test and post 1 test knee extension range of motion (t=9.21, P=0.00), similarly there was a statistically significant difference between pre test and post 2 test knee extension range of motion score and between post 1 test and post 2 test stretching score respectively (t=23.7, P=0.00 and t=19.71, P=0.00) table (3) and figure (3).

Table (3): Comparison between Group 2 mean results measured at deferent stages of treatment program.

mean	Pre	Post1	pre	Post2	Post1	Post2
	60.2	66.80	60.2	75.70	66.80	75.70
SD	1.75	1.31	1.75	1.41	1.31	1.41
T	9.21		23.70		19.71	
P	0.00		0.00		0.00	
Sig	S		S		S	

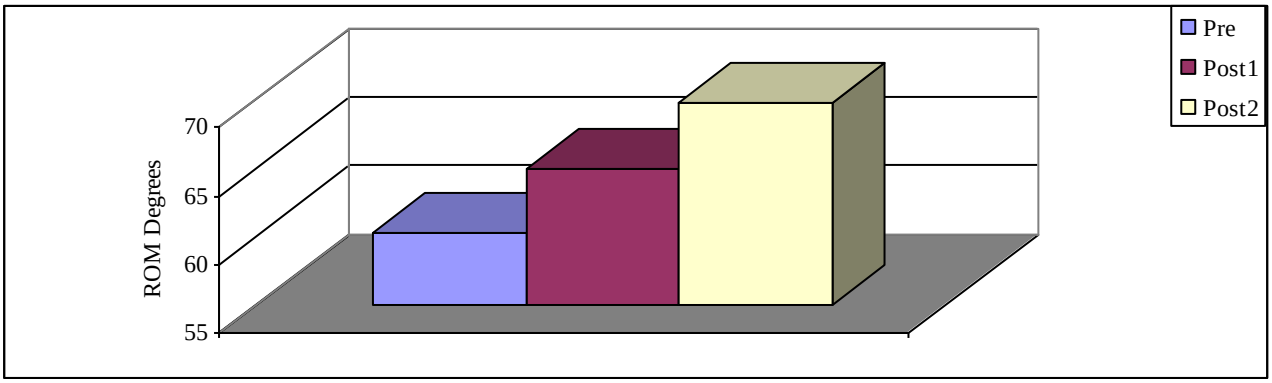

Fig. (3): Comparison between Group 2 mean results measured at deferent stages of treatment program.

Results of the un-paired t test for group differences showed no significant difference between both groups regarding the knee extension range of motion prior to the stretching program (t=0.00, P=1.0).

Results of the un-paired t test for group differences showed a significant increase in the knee extension range of motion post 4 weeks to stretching program (t=2.61, P=0.018).

Results of the un-paired t test for group differences showed a significant increase in the knee extension range of motion post 8 weeks to stretching program (t=9.09, P=0.00) table (4) and figure (4).

Table (4): Comparison between mean results of the 2 groups measured at deferent stages of treatment program.

comparison	Pre		Post 1 (4 weeks)		Post 2 (8 weeks)	
Groups	G 1	G 2	G 1	G 2	G 1	G 2
mean	60.2	60.2	64.80	66.50	69.60	75.70
SD	1.75	1.75	1.31	1.58	1.57	1.41
t-value	0.00		2.61		9.09	
P value	1.0		0.018		0.000	
Significance	NS		S		S	

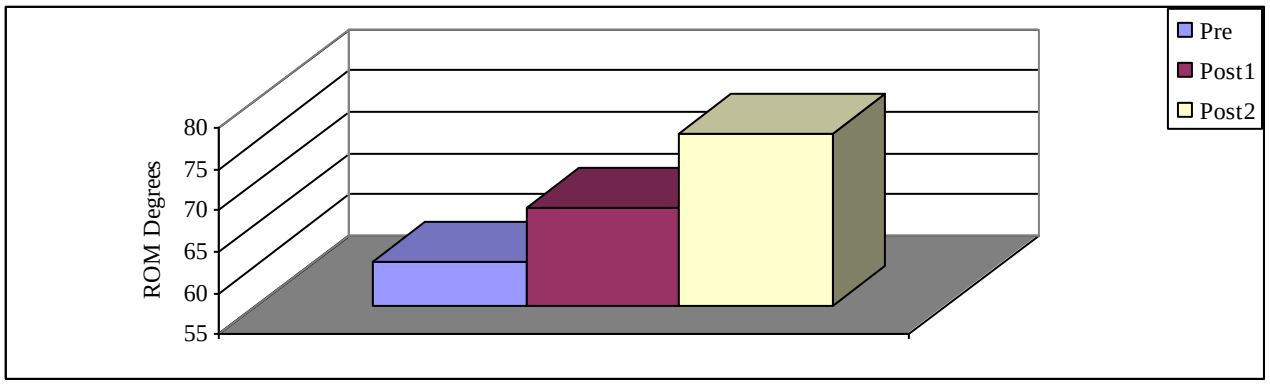

Fig. (4): Comparison between mean results of the 2 groups measured at deferent stages of treatment program.

DISCUSSION

Stretching is used as part of rehabilitation programs because it is thought to positively influence performance and prevent further injury. Numerous studies have been conducted to investigate the effectiveness of stretching exercises. Shortening and contractures of the hamstring muscle may cause limitations in ROM that restrict the normal action of the muscle. This potentially harmful condition may be managed with a stretching program, which may positively influence an individual's functional activities of daily living and decrease risk of further injury[6].

The results indicated that a 120 seconds stretch was more effective in increasing knee extension ROM than a 60 seconds stretch after 3 to 8 months post burn contracture. These results contradict those of Bandy and Irion[1], who claimed that increasing the time of static stretching of hamstring muscle will not increase the knee extension range of motion.

In our study, all stretches were repeated 4 times with a 10 seconds rest between stretches. We used repeated stretches because it was suggested that maximal muscle-tendon unit elongation occurs after approximately 4 stretches, and additional stretches (i.e: up to 10 stretches) resulted in little further improvement.

We believe that this cyclic stretching technique may be even more beneficial for burn patient due to physiological changes of increased muscle stiffness and collagen deposition that occur with burn as reported by Taylor et al[11].

The scientific basis of the traditional rehabilitation technique of stretching with the goal of improving range of motion may actually be found in the cellular and molecular adaptive mechanisms of a muscle fiber which stated that passive stretch is transmitted via connective tissue (perimysium and endomysium) to the muscle fiber, which inconsequence leads to increased sarcomeres in series (myofibrillogenesis), thus creating a longer muscle[4].

We presumed that the effects obtained in this study were due to the direct result of connective tissue lengthening. Mobility of the musculoskeletal system is dependent on the formation of loose or areolar in connective tissue in all loci where motion between organs and tissues should occur.

Although the major components of connective tissue are extracellular fibers, these fibers are not unreactive to the conditions of their environment. Connective tissue shows the property of progressive shortening when not opposed by a stretching force and of plastic elongation when subjected to constant tension[7].

Limitations of the study

Our study was limited to the effects of stretching the hamstring muscles on knee flexion ROM, as 120 seconds bout of stretching the hamstring muscles was more effective than 60 seconds of stretching but similar studies are needed to evaluate the effects of various duration of stretching on other muscles such as the gastrocnemius, soleus and quadriceps.

We only examined stretching of up to 120 seconds in duration. Additional researches are needed to evaluate whether duration of 180 to 240 seconds or longer will provide more flexibility.

One potential threat to the validity of the study was the use of non-blinded measurer. The researcher was aware of both the experimental condition. We do not consider this to be a major problem as the measurement

procedure used was relatively impervious to observer bias.

Finally, the sample under study was relatively young, with a mean age of 24 years. Conclusions from this study should only be applied to similar burn population with different age groups.

Conclusion

We concluded that stretching for 120 seconds 4 times per day for 5 days per week for 8 weeks can yield a greater rate of improvement in knee extension ROM than similar regimens of 60 seconds stretches in post burn patients. The results from this study will be more beneficial for those clinicians who incorporate static stretching exercises as a part of their rehabilitation program for burn patients.

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الملخص العربى

المدة المثلى لتمرينات الإطالة الساكنة لتحسين مرونة عضلة الفخذ الخلفية المنكمشة بعد الحرق

الهدف من هذه الدراسة هو تحديد المدة المثلى لتمرينات الإطالة الساكنة لزيادة مرونة عضلة الفخذ الخلفية المنكمشة بعد الحرق وقياسها بمعدل حركة الفرد في الركبة. عشرون مريضا من الرجال يتراوح أعمارهم من 18 إلى 32 سنة من الذين يعانون من نقص في مرونة العضلة الخلفية للفخذ نتيجة حرق جزئي قسموا إلى مجموعتين متساويتين . المجموعة الأولى : تتكون من عشرة مرضى يتلقون 60 ثانية من تمرينات الإطالة والمجموعة الثانية : تتكون من عشرة مرضى يتلقون 120 ثانية من تمرينات الإطالة. كلا المجموعتين يتلقون تمرينات الإطالة خمسة أيام في الأسبوع لمدة ثمانية أسابيع. وقد أظهرت نتائج هذا البحث وجود فروق ذات دلالة إحصائية في زيادة معدل حركة الفرد في الركبة بالنسبة للمجموعة الثانية التي تلقت 120 ثانية من تمرينات الإطالة مقارنة بالمجموعة الأولى التي تلقت 60 ثانية من تمرينات الإطالة.