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Gastrocnemius – Soleus Mechanical Stretch in Relation to Gait in Lower Limb Burn

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Abstract

This study has been conducted to evaluate the effect of the prolonged mechanical passive stretch (PMS) in elongating the gastrocnemius – soleus muscles and the reflection of that on some quantitative gait parameters and the range of motion (ROM) of both knee extension and ankle dorsiflexion. Twenty male patients were participated in this study, who were selected from Cairo University Hospitals with a second degree posterior leg burn and a total body surface area of 15-20%. They were divided randomly into two groups of equal number, group (A), 10 patients who were 20-30 years of age (X=25±3.4), that received the PMS plus the traditional physical therapy program (positioning and exercises) and group (B), 10 patients who were 20-30 years of age (X=24.4±3.75), that received only the same traditional physical therapy program and acted as a control group. Measurements were recorded before treatment and at the end of the first, second and third week of treatment (session for 30 minutes, twice/day, on 5 days / week bases for a total period of 3 weeks). A 16-meter walkway, tape measure and stop watch were used to measure the quantitative gait parameters, while a standard gomiometer was used to measure the knee extension and ankle dorsiflexion ROM. Results of this study revealed that the PMS was effective in elongating, the gastrocnemius – soleus muscles as reflected by the improved gait parameters as well as the ROM of both knee extension and ankle dorsiflexion.

Introduction

Skin is the largest organ in the human body, burn injury causes destruction and disturbance of the normal physiological functions of the skin, [19.20.21].

The ultimate goal of burn rehabilitation always has been to return patient back into society in as near to their normal function capacity as what existed prior to the burn injury, [20.21]. Patients with lower limb burns, often spend significant time and effort attempting to regain their lost walking proficiency, contracted gastrocnemius – soleus muscles result in temporary versus a permanent gait and postural deformities depends on the patient's compliance with an overall rehabilitation program established in consultation with the physical therapist, [23.24].

There are many approaches for lengthening the shorted muscles as gait training, passive and active stretch, in general, stretching exercises are the most important modality in elongating the pathologically shortened soft tissue structures and thereby increasing the range of motion (ROM), [1.6.18].

Material and Methods

Subjects:

Twenty male patients ranging in age from 20-30 years, participated in this study, who were selected from Cairo University Hospitals, with a second degree posterior leg burn and a total body surface area of 15-20%.

Patients were randomly divided into two groups of equal number, the PMS group (study group), that received the prolonged mechanical passive stretch plus the traditional physical therapy program (positioning and exercises), and the control

group, that received only the same traditional physical therapy program.

Instrumentation:

1- The treatment equipment:

The treatment equipment in this study was a posterior foot drop splint (thermoplastic trough splint), with attached foot plate that positioned and immobilized the ankle in the required position, it has a calf trough that extended to include the knee joint. Four measurements were taken to fabricate the splint, the over-all length of the splint was extended from just above knee by 5cm to the toes. Width measurements were taken at calf, heel and the meta-tarsophalangeal joints, widths were half the circumference of the body part,[11.12.19].

2- The measuring equipment:

The measuring equipment in this study were the quantitative gait analysis tools, which were a stop watch to measure the time variables, a tape measure to record the distance variables, a 16-meter walkway, that was fabricated from a plastic material (the 5-meter areas on each end of the walkway were used for warming up and slowing down before and after measurement respectively, while the middle 6-meter area was the measurement area) and two marking pens with washable ink. Plus a standard goniometer to measure ROM of both knee extension and ankle dorsiflexion[14.17].

A) Evaluation:

Before starting the gait parameters and ROM measurements, every patients was asked to take few steps at the side of the walkway to prove that markers were correctly positioned to indicate heel contact, then patient was instructed to walk at his usual walking pattern from one end of the 16-meter walkway to the other end. Stop watch was used to record time taken by the patient to walk, measurements within the middle 6-meter area, were taken for distances from each heel strike (contact) pen mark to the next heel contact pen mark on the same side (stride length), and on the opposite side (step length), while distances of width between successive marks (step width), [8.10.25].

Stride length was calculated in centimeters by measuring distance from right heel contact mark to right heel contact mark (by the same foot), and the same for the left foot, [3.5.7].

Step length was calculated by measuring line of progression from the left contact pen mark to the right contact pen mark, and vice-versa on the left side. Step width was the perpendicular distance to the line of progression from left contact mark to right, as well as from right to left, [4.9.13]. Step time was an average step time in seconds, as well as the stride time was an average stride time in seconds, [2.15.16].

B) Treatment:

The prolonged mechanical passive stretch was done one week post burn, with the patient in the supinelying position and his foot free from bed, [11.18.20].

Therapist was beside the patient at the ankle joint level, one hand grasped the patient's heel, other hand over the anterior aspect to stabilize it[5.11.20].

The stretch force was gentle, slow and in sustained manner, at first, ankle joint was tracted and the patient's foot was manually moved at a force and velocity that allowed the soft tissue structures to accommodate to the change in range of motion without resulting excessive resistance, pain or possibility of injury till the point of tightness, after that ankle joint moved beyond it. Then the position was maintained by using the posterior foot drop splint, [14.17.20].

C) Data analysis:

One session for 30 minutes, twice / day, 5 days / week for a total period of 3 weeks, was done via the PMS technique. Gait parameters and ROM were measured and recorded before treatment and at the end of the first, second and third week of treatment. Collected records were fed into computer for the statistical analysis, descriptive statistics as mean, standard deviation, minimum and maximum, that were calculated for each group. The t-test

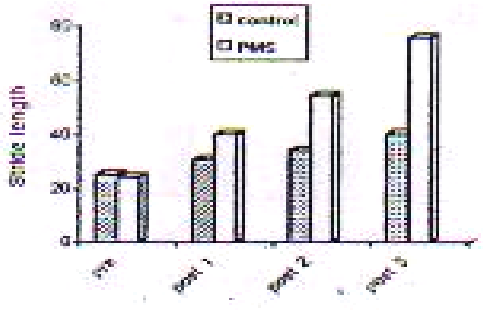
was done to compare between the mean differences of the two groups and within each group. Alpha point of 0.05 was used as a level of significance.

Results

As shown in table (1) and demonstrated in figure (1): there was a non-significant difference in the mean values of the stride length (cm), between PMS study and control groups, in the pre-treatment records (P>0.05). On the other hand there was a significant difference in the mean values of the stride length (cm) between the PMS study and the control (after one, two and three weeks of treatment (P<0.001).

Table (1): Comparison of stride length between the two study groups pre, post one, post two and post three week of treatment

Stride length	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	25±4.0	24.1±3.69	0.879
Post one week	30.5±3.7	40.3±3.2	<0.001
Post two week	34.2±3.4	54.6±4.12	<0.001
Post three week	40.4±3.4	76.2±5.8	<0.001



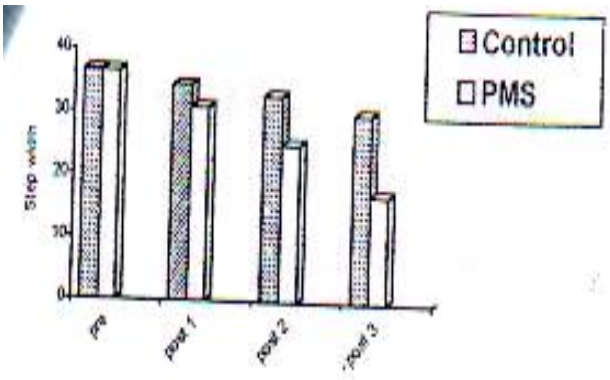
Time of evaluation

Fig. (1): Comparison of stride length values before treatment (pre), after first week (post 1), after second week (post 2), and after third week (post 3) between the two study groups.

As observed in table (2) and demonstrated in figure (2): also there was a non-significant difference in the mean values of the step length (cm), between the PMS study and control groups in the pre-treatment records (P>0.05) while there was a significant increase in the mean values of the step length (cm) between the PMS study and control groups (after one, two and three weeks of treatment) (P<0.001).

Table (2): Comparison of step length between the two study groups pre, post one, post two, post three weeks of treatment.

Step length	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	12.5±2	12.05±1.84	0.879
Post one week	15.25±1.82	20.15±1.59	<0.001
Post two week	17.1±1.69	27.3±2.05	<0.001
Post three week	20.1±1.76	38.1±2.9	<0.001



Time of evaluation

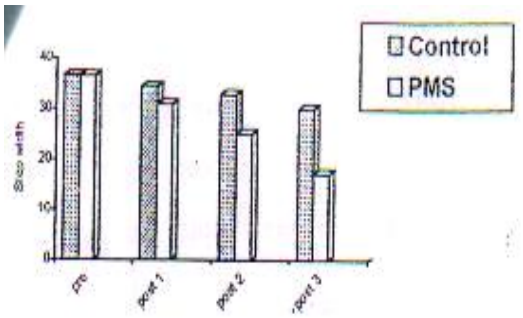
Fig (2): Comparison of step length values before treatment (pre), after first week (post 1), after second week (post 2), and after third week (post 3) between the two study groups.

As revealed from table (3) and demonstrated in figure (3): there was a non-significant difference in the mean values of the step width (cm), between the PMS

study and control groups in the pre-treatment and after the first week treatment (P>0.05). But there was a significant decrease in the mean values of the step width (cm) between the PMS experimental and control groups (after the second and third week of treatment (P<0.001).

Table (3): Comparison of step width between the two study groups pre, post one, post two, post three weeks of treatment.

Step width	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	36.65±4.3	36.57±3.96	0.999
Post one week	34.41±4.11	30.98±4.04	0.177
Post two week	32.96±4.07	25.17±2.808	<0.001
Post three week	30.17±3.85	17.21±1.408	<0.001



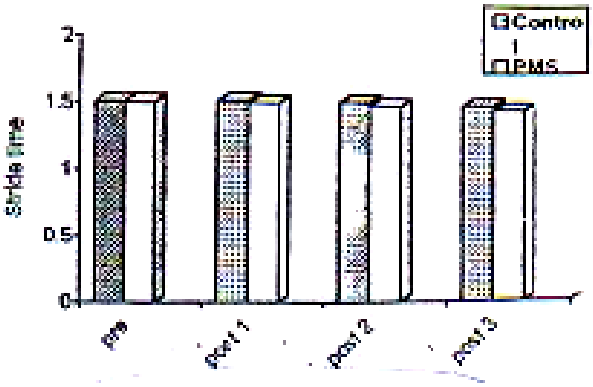
Time of evaluation

Fig. (3): Comparison of step width values before treatment (pre), after first week, (post 1), after second week (post 2), and after third week (post 3) between the two study groups.

As shown in table (4) and demonstrated in figure (4): There was a non-significant difference in the mean values of the stride time (second), between the PMS study and control groups in the 4 records (pre-treatment, after the first, second and third week of treatment) (P>0.001).

Table (4): Comparison of stride time between the two-study groups, pre, post one, post two, post three weeks of treatment.

Stride time	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	1.512±0.09	1.5058±0.08	0.987
Post one week	1.5078±0.09	1.493±0.08	0.928
Post two week	1.5054±0.09	1.4812±0.08	0.820
Post three week	1.49±0.09	1.4566±0.08	0.539



Time of evaluation

Fig. (4): Comparison of stride time values before treatment (pre), after the first week (post 1), after the second week (post 2), and after the third week (post 3) between the two study groups.

As observed in table (5) and figure (5): There was a non-significant deference in the mean values of the step time (second), between the PMS study and control groups in the 4 records (pre-treatment, after the first, second and third week of treatment) (P>0.05).

Table (5): Comparison of step time between the two study groups pre, post one, post two, post three weeks of treatment.

Step time	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	0.756±0.04	0.7529±0.04	0.987
Post one week	0.754±0.04	0.7465±0.04	0.928
Post two week	0.7527±0.04	0.7406±0.04	0.819
Post three week	0.7499±0.05	0.7283±0.04	0.539

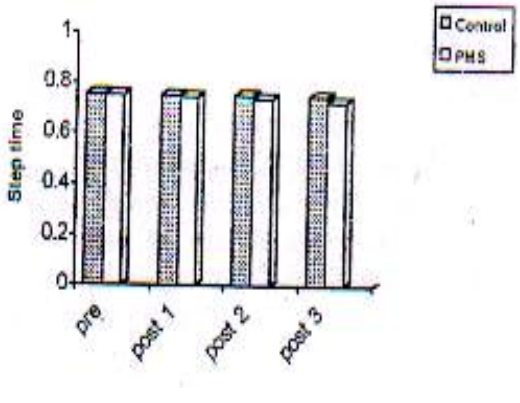


Fig. (5): Comparison of step time values before treatment (pre), after first week (post 1), after second week (post 2), and after third week (post 3) between the two study groups.

As shown in table (6) and figure (6): there was a non-significant difference in the mean values of the knee extension (ROM), between the two groups in the pre-treatment records (P>0.005). While there was a significant difference in the mean values of the knee extension (ROM), between the two groups (after the first, second and third week of treatment) (P<0.001).

Table (6) Comparison of knee extension ROM between two study groups pre, post one, post two, post three weeks of treatment.

Knee Extension	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	-25.66±2.51	-25.99±2.13	0.947
Post one week	-22.9±2.38	-18.23±1.64	<0.001
Post two week	-21±2.30	-11.8±1.52	<0.001
Post three week	-17.96±2.36	-1.8±1.59	<0.001

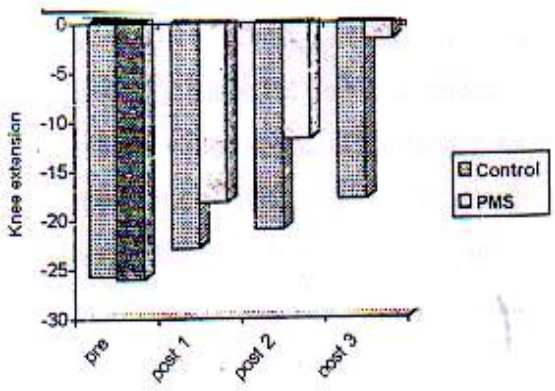


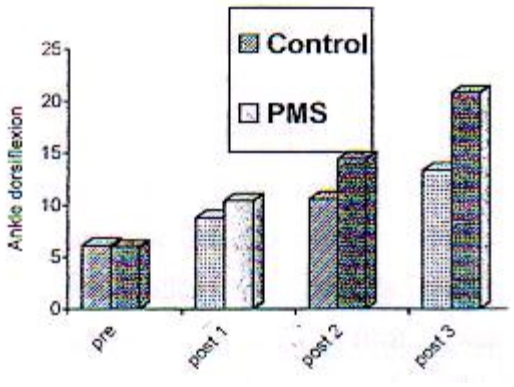
Fig (6): Comparison of knee extension values before treatment (pre), after first week (post 1), after second week (post 2), and after third week (post 3) between the two groups.

As revealed from table (7) and demonstrated in figure (7): there was a non-significant difference in the mean values of the ankle dorsiflexion (ROM), between the two groups in the pre-treatment records (P>0.05).

On the other hand there was a significant difference in the mean values of the ankle dorsiflexion (ROM), between the two groups (after the first, second and third week of treatment) (P<0.001).

Table (7): Comparison of dorsiflexion ROM between the two groups pre, post one, post two, post three weeks of treatment.

Ankle Dorsiflexion	Control X±S.D	PMS X±S.D	P. Value
Pre treatment	6.14±1.72	5.93±1.46	0.953
Post one week	8.81±1.37	10.43±1.08	0.012
Post two week	10.56±1.16	14.43±1.07	<0.001
Post three week	13.43±1.08	20.9±1.25	<0.001



Time of evaluation

Fig (7): Comparison of ankle dorsiflexion values before treatment (pre), after first week (post 1), after second week (post 2), and after third week (post 3) between the two study groups.

Discussion

The quantitative gait analysis method became a useful tool in documenting the effectiveness of the treatment procedures. It improved the accuracy and sensitivity of patient diagnosis and provided an effective and reliable quantification of the dynamic movement dysfunction that still difficult to be observed visually, [15.26].

Kinematic quantitative gait analysis can be used to obtain information on time, distance, gait variables and motion patterns, these objective data provides the therapist with database that enables him to assess and document the patient improvement, [14.17].

Goniometric measurement of the joint ROM, remain the most versatile and widely used method. It is objective, reliable and valid method for measuring ROM, for the most application to extremities, the universal goniometer is still the preferable instrument for measuring ROM, [10.11.26].

The results of this study pointed out that, there were a significant differences between the pre treatment application and after the first, second and third week of application, in both the selected gait parameters and range of motion for both knee extension and ankle dorsiflexion.

A considerable improvements were observed in the control group, that can be attributed to the traditional physical therapy program, while the greater improvements were observed in the PMS study group, that can be attributed to the combined effects of both PMS and the traditional physical therapy program.

These results were hand in hand with the researches and studies introduced by Hepburn, 1987; Bohannon, 1984; Bohannon and Larkin, 1985; Lyons, 1989; Moseley, 1997; Silverstein et al., 1997 and Richard et al, 1995.

These significant improvements in walking characteristics and goniometric data were attributed to the immobilization of muscles in a lengthened, position (that was associated with the increased number of sarcomers in series, and the increased muscles length) and due to the optimal plastic deformation of the tissue from the prolonged low force mechanical stretch, indicating that there was a direct correlation between the stretch duration and the resulted proportion of the plastic permanent elongation, [8.18.22].

Conclusion

According to the results of this study supported by the review of literature passive mechanical stretch was found to be fruitful and effective modality in improving patient's walking efficiency and goniometeric variables of knee and ankle

joints, enhancing rehabilitation of the burned lower limb.

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علاقة الاستطالة الميكانيكية لعضلتى الساق "التوأمية والأخمصية" بطريقة المشى فى حروق الطرف السفلى

ذكريا موافى امام زكريا ، عادل عبد الحميد نصر ،
صلاح عبد الغنى ، أمال عبد الباقى
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هدفت هذه الدراسة إلى تحديد تأثير الإستطالة الميكانيكية لعضلتى الساق التوأمية والأخمصية بإستخدام جبيرة مصنوعة من البلاستيك الحرارى على المقاييس المسافية والزمنية لطريقة المشى وكذلك على المدى الحركى لمفصلى الركبة والكاحل فى حالات حروق الطرف السفلى. ولقد شارك هذا البحث عشرون مريضا من الذكور ، ممن كان لديهم حروق فى الجزء الخلفى من الساق وكانت درجة الحرق من الدرجة الثانية بنسبة تتراوح مابين 15% الى 20% وكانت أعمارهم تتراوح مابين 20-30 سنة. ولقد تم تقسيمهم عشوائيا إلى مجموعتين متساويتين العدد، حيث تلقوا الإستطالة الميكانيكية والعلاج الطبيعى التقليدى لمرضى المجموعة الأولى، والعلاج الطبيعى التقليدى فقط لمرضى المجموعة الثانية. ولقد تم العلاج بواقع جلستين يوميا (مدة الجلسة ثلاثون دقيقة)، فى نفس الأوقات لمدة 5 أيام فى الاسبوع طوال فترة 3 أسابيع. وتم قياس النتائج باستخدام مقياس الزوايا لقياس مدى البسط فى مفصل الركبة ومدى الثنى فى مفصل الكاحل، وطريق طوله 16 متر مصنوع من البلاستيك، وساعة وقتية وشريط متر بلاستيك وكذلك قلم مثبت خلف القدم ذو حبر يمكن إزالته بسهولة لقياس المتغيرات المسافية والزمنية لطريقة المشى. ولقد تم عمل الجداول الإحصائية لإجراء المقارنة بين المجموعتين قبل العلاج وبعد أول وثانى وثالث اسبوع من العلاج. ولقد اظهر البحث ان طريقة الاستطالة الميكانيكية أدت إلى نتائج أفضل من التى نجمت عن المجموعة الثانية.