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Effect of a 30-Minute Twice Daily Prolonged Stretch for the Prevention of Joint Contractures in Rats

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Abstract. [Purpose] The purpose of this study was to determine if a 30-minute twice daily prolonged stretch could prevent range of motion limitation in rats. [Subjects and Methods] Twenty-three 8-week-old female Wistar rats were divided into three groups. The right ankle joints of all the rats were fixed in full plantar flexion for a week with plaster casts. The first group was immobilized continuously throughout the experiment (G1). In the second and third groups, the casts were removed daily, and the foot was held in dorsiflexion for 30-minutes once a day (G2) and 30-minutes twice a day (G3), respectively. [Results] The range of motion of G1 and G2 significantly decreased from the first day of the experiment to the last day. However, the range of motion of G3 did not show any significant difference between the first day and the last day. [Conclusion] These results suggest that prolonged stretching for 30-minutes twice daily may be effective for the prevention of joint contractures in rats.
Key words: Joint contracture, Prolonged stretching, Rat

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INTRODUCTION

Joint contracture tends to affect a patient's activities of daily living, such as dressing and walking[1)]. For example, a joint contracture in the lower extremities can cause a patient to fall during stance or gait[2)]. Generally speaking, joint contracture causes a reduction in joint movement after surgery or long bed rest. Treating contractures involves much time and energy[3)]. Reports[4)] have indicated that joint contractures become irreversible when the joint has been immobilized for more than 60 days. Therefore, prevention is very important for joint contractures[5, 6)].

To provide a patient with effective range of motion (ROM) exercises to prevent joint contracture, one must consider the amount of time, frequency and strength of the exercises[7)]. Williams[8)] reported that stretching a joint for over 30-minutes once daily in a rat model could prevent much of the joint motion limitation caused by immobilization. However, Nakata[9)] reported that 30-minutes a day is not enough. The difference in the results may be due to a difference in

experimental methods. Nakata performed his experiment with the hind limb suspended while immobilized, and Williams did not. It is well known that a joint angle can be increased if the amount of pressure placed on the parts when moving the joint is increased[10]. In both of the above experiments, the amount of pressure applied in measuring the ROM and the amount of pressure applied in the prolonged stretching exercise of rats hind limbs seemed to have been subjectively determined. Consequently, the contradictory results may have risen from the different experimental methods of hind limb suspension or may have been due to the differences in the amount of pressure applied during the measuring and stretching of joint angles, and it is difficult to clearly verify the cause of the different results. Jinnouchi et al.[11] repeated the same experiments, but they modified them by using a pressure of 0.3 N for the prolonged stretch and for measuring the ROM. They determined the 30-minute prolonged stretch to be the most effective, although incomplete, in preventing joint contractures. On the other hand, Oki et al.[7] reported that for the prevention of joint contractures, ROM exercise is more effective when done twice a day than just once a day.

The purpose of this experiment was to clarify if a 30-minute twice a day prolonged stretching exercise could adequately prevent joint contractures in rats.

SUBJECTS AND METHODS

Subjects

Twenty-three 8-week-old female Wistar rats weighing 173.2 ± 5.9 g were used. The experiments were conducted in accordance with our university's Guidelines for Animal Experimentation and the U.S. National Institute of Health Guidelines. The animals were housed in a temperature-controlled room at 20 °C with a 12- hour light-dark cycle. The rats were provided free access to standard rat food and water.

Methods

The animals were randomly divided into three groups. The right ankle joint of each rat was fixed in full plantar flexion by a plaster cast (Fig. 1). In this position, the soleus muscle was maintained in a shortened position. The duration of the immobilization was one week.

The first group was immobilized continuously throughout the experiment period (G1, n=7). The casts of the second and third groups were removed daily, and the right foot was held in dorsiflexion by a spring balancer (KYOWA Co, LTS-1KA) set at a force of 0.3 N, for periods of 30-minutes once a day (G2, n=8), and for 30-minutes twice a day (G3, n=8). If the ROM changed as the ankle stretched, the rat was repositioned so that the spring balancer would always apply a force of 0.3 N. After the stretching session was completed, the casts were then reapplied, again with the ankle fixed in full plantar flexion. The rats were anaesthetized by an intraperitoneal injection of Nembutal (0.5 mL/kg) for the application of the immobilization casts, during the stretching procedure, and for the soleus muscle dissection. The immobilized group (G1) was also anesthetized with Nembutal anesthesia (0.5 mL/kg) twice a day. Before the experiment and after one week, the ROM of ankle joint dorsiflexion was measured as follows. First, the rat was positioned on its side, and a force of 0.3 N was applied vertically to the sole of the foot by a tensiometer to measure dorsiflexion. Then, a digital photograph was taken from directly above the hind limb, and the angle of dorsiflexion was measured on a computer (Adobe Photoshop 6.0). The ROM of dorsiflexion was defined as the angle obtained from a line parallel to the longitudinal axis of the fibula and a line parallel to the bottom of the heel, to eliminate forefoot movement from the measurement. When the ROM was measured, the knee joint was flexed. The ROM of dorsiflexion was measured three times, and the mean value was used for analysis. We used SPSS13.0 software for Windows to perform the statistical analyses.

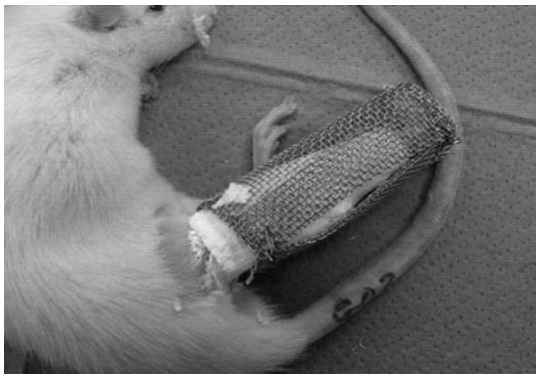

Fig. 1. Ankle fixation method. The right ankles were fixed in full plantar flexion by plaster casts.

Table 1. ROM in dorsiflexion (degrees)

group	pre experiment (means ± SD)	post experiment (means ± SD)
G1: immobilization (n=7)	37.1 ± 4.9	68.6 ± 8.6[a]
G2: 30 min once daily (n=8)	36.2 ± 5.6	48.7 ± 6.0[a]
G3: 30 min twice daily (n=8)	37.5 ± 7.2	38.6 ± 4.0

[a]: significant difference between pre and post experiment ($p<0.05$).

Analysis of variance was used to compare the ROM of dorsiflexion before the experiments among all the groups. A paired t-test was used to compare the ROM of dorsiflexion changes before and after the experiments in each group. A P value less than 0.05 was considered significant.

RESULTS

Table 1 shows the data for the ROM of dorsiflexion of groups G1, G2 and G3 before and after the experiments. The means and SD values for the ROM of dorsiflexion before the experiments were: G1, 37.1 ± 4.9°; G2, 36.2 ± 5.6°; and G3, 37.5 ± 7.2°. The ROM measurements of dorsiflexion before the experiments were not significantly different among the groups. The means and SD values for the ROM of dorsiflexion after the experiments were: G1, 68.6 ± 8.6°; G2, 48.7 ± 6.0°; and G3, 38.6 ± 4.0°. The differences in the ROM of dorsiflexion measured before and after the immobilization were statistically significant for all the rats in G1 and G2. However, the ROM of dorsiflexion for all the rats in G3 showed no significant differences in the measurements obtained before and after the experiments.

DISCUSSION

ROM exercise is the most frequently used manual technique in physical therapy. However, it has not been clarified yet under what conditions ROM is effective at preventing joint contractures[12]. We investigated whether a 30-minute twice daily prolonged stretch can prevent joint contractures.

Previous studies[8, 9, 11] did not reach any definite consensus on the effectiveness of the 30-minute daily procedure. Our study showed that ROM exercises for dorsiflexion performed once daily for 30-minutes could not prevent joint limitation in rats. Our study supports the results of Jinnouchi et al.[11] and Nakata et al.[9] that indicated that the 30-minute once daily exercise is effective to some extent at preventing joint contractures, but it does not work effectively enough to prevent them completely.

In general, the more frequently a stretch exercise is performed, the more effective it is at preventing contractures[5]. However, previous researchers[8, 9, 11] did not examine the effectiveness of the 30-minute twice daily prolonged stretch exercise. We found that performing the exercise twice daily is necessary to prevent joint contractures. In other words, the more frequent joint motion exercise is performed, the more effective it is for the prevention of joint contractures.

Ono et al.[13] reported that in the treatment of bone fracture, in the acute stage, joint fixation could be removed for exercise only and reapplied. This procedure resembles our experimental design. Although our experiment was performed on rats, our results suggest that prolonged stretching may prevent joint contractures in humans as well.

In future studies, we intend to evaluate the effectiveness of prolonged stretching at preventing contractures after fixation for one week in a cast, and we intend to perform a histological analysis of the muscles of the experimental rats.

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