The Effect of ROM Exercise on Rats with Denervation and Joint Contracture

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Abstract. [Purpose] The purpose of this study was to investigate whether there is an effect of ROM exercise on rats with denervation and joint contracture. [Methods] Fifteen female 8-week old Wistar rats were used. For seven out of the fifteen rats, the left hind limbs were used as control limbs (group 1), and the right hind limbs (group 2) were fixed continuously with white tape in full plantar flexion for one week. The remaining eight rats received bilateral sciatic neurectomies. The left hind limbs (group 3) were fixed continuously with white tape in full plantar flexion for one week. The right hind limbs (group 4) were fixed in full plantar flexion with white tape that was removed daily from the second through the seventh experimental days. After the tape was removed the foot was held in dorsiflexion by a spring balancer for 30 minutes. After the ROM exercise session was completed, the white tape was reapplied, again with the ankle fixed in full plantar flexion. [Results] Before the experiment, there were no significant differences among the groups. After the experiment: compared to group 1, ROM in group 2 and group 3 was significantly increased; compared to group 2, ROM in group 3 and group 4 was significantly decreased; and compared to group 3, ROM in group 4 was significantly decreased. [Conclusion] ROM exercise was effective for preventing ROM limitation. These results suggest that ROM exercise is effective for preventing joint limitation in rats with denervation and joint contracture.

Key words: Joint contracture, ROM exercise, Denervation

INTRODUCTION

Restriction of joint range of motion (ROM) is one of the symptoms of disuse syndrome1). The causes of joint ROM restriction are myogenic and arthrogenic2). Skeletal muscles immobilized in a shortened position show a decrease in sarcomere number and a shortened muscle length3). Joint ROM exercise is effective for reducing the restriction of joint ROM caused by disuse syndrome, because joint ROM exercise is accompanied by skeletal muscle stretching that prevents a decrease in the number of sarcomeres4). Moreover, denervated skeletal muscles immobilized in a shortened position result in severe muscle contracture5). Does ROM exercise reduce muscle contracture caused by denervation with immobilization? Denervated muscle immobilized in a lengthened position showed an increase in sarcomeres in a series6,7). Therefore, we hypothesized that ROM exercise with the muscle held in the lengthened position might be effective...
for reducing muscle contractures caused by
denervation and immobilization.

The purpose of this study was to investigate the
effect of ROM exercise on rats with denervation
and joint contracture.

SUBJECTS AND METHODS

Fifteen female 8-week old Wistar rats with an
initial body weight of 176 ± 5 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 23 °C with a 12
hour light-dark cycle. The rats were provided free
access to standard rat food and water.

The duration of the experiment was one week8). The assignment of groups is shown in Table 1. Out of the 15 rats, eight rats received a sciatic neurectomy
and seven did not. The seven non-sciatic neurectomy
rats were anesthetized with sodium pentobarbital (40
mg/kg). The left hind limbs were used as the control
limbs (group 1), and the right hind limbs were fixed
continuously with white tape in full plantar flexion
for one week. The right hind limbs (group 4) were
fixed in full plantar flexion with white tape that was
removed daily from the second through the seventh
experimental days. After the tape was removed the
foot was held in dorsiflexion by a spring balancer set
at a force of 0.3 N8), for a period of 30 minutes (Fig. 2).
If the ROM changed as the ankle was stretched, the rat was repositioned so that the spring balancer
would always apply a force of 0.3 N. After the ROM
exercise session was completed, the white tape was
reapplied, again with the ankle fixed in full plantar
flexion. In addition, all of rats were anesthetized with
sodium pentobarbital (40mg/kg) every day in order
to maintain the same physical conditions.

Before the experiment and after one week, all the
rats were anesthetized with sodium pentobarbital
(40mg/kg). The ROM of ankle joint dorsiflexion
was measured as follows. First, the rat was
positioned on its side, to measure dorsiflexion. A
force of 0.3 N was applied perpendicularly to the
sole of the foot by a tension meter (Kyowa Co.,
LTS-1KA) (Fig. 3). Then, a digital photograph was
taken from directly above the hind limb, and the
angle of dorsiflexion was measured with computer
software (Scion image beta 4.03). 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 Kruskal-Wallis test was used to compare the
ROM of dorsiflexion changes from before and after
the experiment in each group. Scheffe’s post hoc
test was used to identify significant comparisons.
The accepted alpha level of all of the statistical
processing was at the 0.05 level.

RESULTS

The average and standard deviation of the
changes in ROM of dorsiflexion are shown in Table
2. Before the experiment, there were no significant
differences among the groups. After the experiment:
compared to group 1, ROM in group 2
and group 3 was significantly increased; compared
to group 2, ROM in group 3 and group 4 was
significantly decreased; and compared to group 3,
ROM in group 4 was significantly decreased.
DISCUSSION

In group 2, the ankles were fixed continuously in full plantar flexion for one week without a sciatic neurectomy, so the joint contractures that developed were due to disuse. Anatomically, joint contractures are caused by myogenic restrictions and arthrogenic restrictions\(^2\). In group 2 and group 3, the duration of immobilization of the ankle joints was the same, one week. Therefore, group 2 and group 3 had the same degree of disuse, but group 3 received a sciatic neurectomy. We focused on the influence of the denervation on joint ROM. Our results indicate that group 3 had less joint ROM limitation than group 2. This result is the same as that obtained by Hayat\(^9\). It seems that the speed for adapting the length of the muscle is diminished in the denervated muscle\(^9\). The process of joint ROM limitation development may be different for disuse with no denervation and disuse with denervation\(^7\). Goldspink et al. reported that denervated muscles immobilized in a shortened position for four weeks showed a marked reduction in muscle flexibility\(^6\) and increased joint ROM limitation\(^5\). According to our results, the flexibility of denervated muscles immobilized in a shortened position decreased slowly during the first week. If we consider the results of Goldspink et al., where there was a marked reduction over a period of four weeks, the marked decrease may occur during the remaining three weeks.

Our study investigated the effect of ROM exercise once a day on rats with denervation and joint contracture. Our results indicate that joint ROM exercise prevents the development of joint contracture caused by disuse and denervation. Two factors, increases in sarcomere numbers and muscle length, may have influenced the effects of joint ROM exercise in group 4, because there are reports that, even if muscles are denervated, an increase in

Fig. 1. Method of ankle fixation. Under anesthesia, the ankle was fixed in full plantar flexion by using white tape. We used a wire netting cover, because the rats bit the white tape.

Fig. 2. Method of ROM exercise. Under anesthesia, the foot was held in dorsiflexion by a spring balancer set at a force of 0.3 N for periods of 30 minutes / day. a: PET bottle filled with water for stabilizing the rat’s body, b: Spring balancer.

Fig. 3. Ankle ROM measurement using a tension meter. The angle of dorsiflexion was defined as angle a-b-c. The tip of the black stick indicates the head of the fibula. a-b: parallel line from the head of the fibula to the bottom of the heel, b-c: parallel line along the bottom of the heel, d: black stick, e: tension meter.
the number of sarcomeres could occur when the muscle was immobilized in a lengthened position\(^6,7\). It seems that joint ROM exercise may help maintain flexibility of myogenic and arthrogenic restrictions. Further investigation is necessary to clarify whether joint ROM exercise has an effect on myogenic and arthrogenic restrictions.

REFERENCES