Research Article

Effect of Isokinetic Strength Training on Lower Leg Muscle Strength: A Comparison of Full Range and Partial Range of Motion Exercises

Junji Matsuba[1†], Hitoshi Maruyama[2]

ABSTRACT

The study aims to compare the effectiveness of muscle strength training at full Range of Motion (ROM) and partial ROM as an aid for developing an effective muscle strength training method.

We included 14 and 11 participants in the full and partial ROM groups, respectively. The participants were instructed to perform knee flexion and extension muscle training using an isokinetic dynamometer. The participants in the full and partial ROM groups performed knee flexion exercises from 130° to 0° and from 90° to 0°, respectively. The exercise protocol in both the groups was 300°/s for three sets, twice per week, over a total exercise period of 8 weeks. Maximum torque (Nm) per 1 kg of body weight was measured before and after the intervention.

Statistical analyses results indicated that both the groups exhibited muscle strengthening after the intervention. No significant between-group difference was observed in the degree of muscle strengthening achieved.

Partial ROM training exerts the same degree of effect as full ROM training.

Keywords: Full range of motion; Partial range of motion; Muscle strength training

Introduction

Skeletal muscle strength is the power source that allows us to accomplish our daily life activities. However, muscle functionality can easily decrease as a result of inactivity or aging. The quadriceps femoris experience a particularly significant amount of atrophy and decline in strength with aging; comparisons between elderly and young individuals have shown that in the elderly, knee extension strength declines by 35%-39% and muscle cross-sectional area decreases by 25%-33% [1,2]. Decline in the muscle strength in the elderly increases the risk of falling and is the secondary cause of various physiological dysfunctions. Muscle strength training is effective for preventing quadriceps strength decline and for strengthening the muscles. Its aim is to increase muscle mass, strength, and power [3-5] as well as to improve bone strength and density and reduce osteoporosis [6-8], improve balance, reduce the risk of injury due to falling [9-11], and improve walking stability and speed [12,13]. Thus, recently, the importance of muscle strength training in the elderly has garnered attention from the perspective of disability prevention and nursing care. In addition, various rehabilitation facilities are now using machines for muscle strength training.

In addition to the increased interest in decreasing the need of nursing care among the elderly, there is a great deal of social interest in preventing lifestyle-related diseases among middle-aged and elderly individuals. Muscle strength training is effective in achieving these goals. Moreover, it is effective in improving hypertension and insulin resistance [14] and has been reported to decrease somatic fat and increase the basal metabolic rate [4,15,16]. Thus, appropriate muscle strength training is likely to make a major contribution to the maintenance and improvement of the health of the general public.

[1]Department of Tokyo Physical Therapy, Teikyo University of Science, Senjusakuragi, Adachi-Ku, Tokyo, Japan
[2]Department of Graduate school, International University of Health and Welfare, Akasaka Minato-ku Tokyo, Japan

†Author for correspondence: Junji Matsuba, Department of Tokyo Physical Therapy, Faculty of Medical Sciences, Teikyo University of Science, 2-2-1 Senjusakuragi, Adachi-Ku, Tokyo, 120-0045, Japan, E-mail: matsuba@ntu.ac.jp

In the field of rehabilitation medicine, there are many occasions when patients are seated in a chair and are performing a knee extension exercise with weights attached to their feet. Normally, the Range of Motion (ROM) used during these exercises varies from 0° (full extension) to 90°. Despite the fact that the knee joint is capable of flexion from 0° to approximately 130°, knee extension exercises in which the patient's knees are completely flexed to ≥ 130° are rarely performed.

Muscle strength training is performed within the range of normal human posture, and it includes the maximum ROM of the joints involved. This is to ensure that muscle strength improves throughout the full ROM.

Conversely, there is a muscle strength training technique that entails repetitive motion over only a part of ROM. Mookerjee et al. [17] reported that, as a result of subjects performing bench presses using partial ROM, specifically from elbow flexion of 90° to full extension, one repetition maximum (RM) increased by 4.8% and 5 RM increased by 4.1%, but there was no significant change in the full ROM for either 1 or 5 RM. Although there are studies reporting that isometric muscle strength increased at both restricted ROM and full ROM [18,19], it remains unclear whether muscle strength training at partial ROM improves muscle strength.

The objective of the present study is to compare the outcomes between partial and full ROM muscle strength training to develop an effective lower-limb muscle strength improvement exercise technique.

Participants and Methods

We enrolled 25 males with no history of orthopedic surgery in their lower limbs and who did not exercise habitually. In accordance with the Declaration of Helsinki, prior to performing measurements, all participants were provided oral and written descriptions of the study details, and their consent was obtained before the start of the study. "Exercise habit" was defined as exercise performed at least twice per week for at least 30 min per session continually for at least 1 year, in accordance with the definition used in the National Health and Nutrition Survey (Ministry of Health, Labor and Welfare). The participants were randomly allocated to either the full ROM training group (full ROM group, n=14) or the partial ROM training group (partial ROM group, n=11). The full ROM group performed muscle strength training with knee flexion and extension movements ranging from 0° to 130°. The partial ROM group performed muscle strength training with knee flexion and extension movements ranging from 0° to 90°. Data (mean ± standard deviation) for age, height, and weight in both the groups are presented in **Table 1**.

Results

A scatterplot of knee extension muscle strength is shown in **Figure 1**, and the analytical results are shown in **Table 2**.

The results indicated the following:

- **The partial ROM group:** Postintervention muscle strength (Nm/Kg)=138.56+0.12 preintervention muscle strength (Nm/Kg)
- **The full ROM group:** Postintervention muscle strength (Nm/Kg)=138.56+0.12 preintervention muscle strength (Nm/Kg)-67.79+0.55 preintervention muscle strength (Nm/Kg)=70.77+0.67 preintervention muscle strength (Nm/Kg)

Statistical significance was not observed in the interaction between preintervention muscle strength and the groups. We could not rule out parallelism in the slope of the regression lines for the two groups. Thus, it cannot be said that the muscle strengthening effect in the partial and full ROM groups was different.

The scatterplot for knee flexion muscle strength is shown in **Figure 2**, and the analytical results are shown in **Table 3**. The results indicated the following:

- The partial ROM group: Postintervention muscle strength (Nm/Kg)=14.89+0.78 preintervention muscle strength (Nm/Kg)

Table 1: Characteristics of the study participants.

Group	Age (years)	Height (cm)	Weight (kg)
Full range of motion group (n=14)	20.3 ± 2.2	170.4 ± 5.0	62.9 ± 7.9
Partial range of motion group (n=11)	20.0 ± 1.3	168.8 ± 5.2	63.0 ± 5.3
Mean ± standard deviation			

Table 2: Estimated parameters of knee extension.

	Coefficient	Std. Error	p-value
Intercept	138.56	32.59	<0.001**
Pre	0.12	0.25	0.63
Group	−67.7943	37.51	0.09
Pre × group	0.55	0.28	0.07

Analysis of covariance (ANCOVA, corrected for pre intervention muscle strength); pre: pre intervention muscle strength; **p<0.01

Table 3: Estimated parameters of knee flexion.

	Coefficient	Std. Error	p-value
Intercept	14.89	23.78	0.54
Pre	0.78	0.45	0.10
Group	13.56	26.93	0.62
Pre × group	−0.1341	0.50	0.79

Analysis of covariance (ANCOVA, corrected for pre intervention muscle strength); pre: pre intervention muscle strength

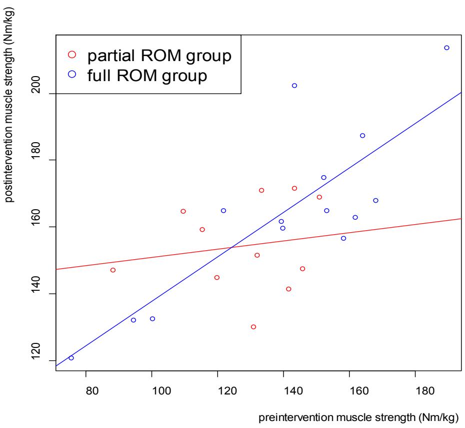

Figure 1: Knee extension muscle strength.

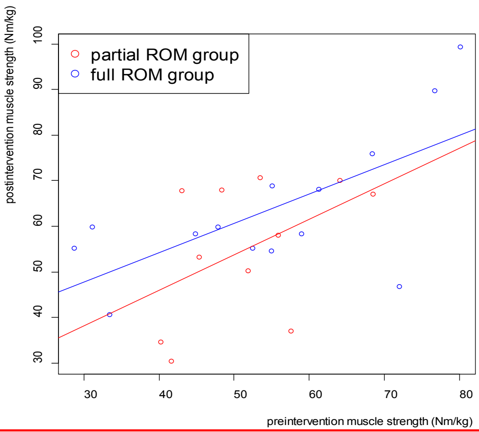

Figure 2: Knee flexion muscle strength.

- The full ROM group: Postintervention muscle strength (Nm/Kg)=14.89+0.78 preintervention muscle strength (Nm/Kg)+13.56-0.13 preintervention muscle strength (Nm/Kg)=28.45+0.65 preintervention muscle strength (Nm/Kg)

As was the case with knee extension muscle strength, we were unable to detect any statistical significance in the interaction between preintervention muscle strength and the groups for knee flexion. Thus, in this case also, we could not rule out parallelism in the slopes of the regression lines for the two groups. This indicated that the muscle strengthening effect in the partial and full ROM groups cannot be said to be different.

Discussion

The maximum torque in the partial and full ROM groups increased, showing that the muscles were strengthened. However, no significant between-group difference was observed in terms of increase in muscle strength, with the same findings observed for both knee flexion and extension.

Mookerjee et al. [17] reported that partial ROM, i.e, bench presses performed from 90°elbow flexion to full extension, resulted in increases of 4.8% for 1 RM and 4.1% for 5 RM of the target ROM. However, no significant difference was observed between pre- and postintervention values for 1 or 5 RM at full ROM. The bench press is an exercise with a muscle strength curve that indicates an ascending type of exercise in which the muscle exertion increases in the first half of the ROM. Thus, the weight to be lifted is determined by the minimum muscle strength in the first half of the ROM. Therefore, it is likely that in the study by Mookerjee et al. [17], the muscle strengthening effect in the first half of the ROM, which is the nontraining range, was low and that is why no significant increases in 1 or 5 RM were observed at full ROM. Conversely, in the present study, the amount of exertion required by the knee flexion and extension exercises gradually increased during the first half of the ROM and reached a peak in the middle of ROM, after which it gradually declined, resulting in a bell-shaped curve. The maximum torque output angle is reported to be at a knee flexion angle of approximately 60° during extension exercise and at approximately 40° during flexion exercise [20]. These angles were included in the training ranges of both the groups. Therefore, the results of the present study are consistent with the findings reported by Mookerjee et al. [17].

Isokinetic contraction is a method of muscle contraction in which the angular velocity of the joint is maintained constant. There is no determined load, but the speed of the movement is controlled. The exercise protocol used in the present study is based on the "safe and effective isokinetic application method" recommended by Sakai Medical Co., Ltd., in which the angular velocity is 300°/s. Fast isokinetic training is more effective in improving performance in various exercises compared with slow isokinetic training [21]. Furthermore, the former is more effective in increasing the overall muscle strength [22]. However, a study on mean power improvement at various velocities reported that a moderate velocity (179°/s) is the most effective [23]. Thus, there is no consensus regarding the optimum angular velocity.

Unlike normal muscle strength training that is performed using barbells and similar devices, the isokinetic training performed in the present study involved only concentric contractions. Isotonic training that incorporates concentric and eccentric contractions results in a much larger increase in concentric and eccentric muscle strengths than muscle training that uses concentric contractions alone at the same number of repetitions [24]. This suggests that the same would be true for isokinetic training. However, one reported benefit of isokinetic training using concentric muscle contractions alone is the fact that it keeps muscle pain to a minimum [25]. Although eccentric contraction exercise is effective in muscle strengthening, if it leads to muscle pain onset, this may have a negative effect on training motivation. In addition, because isokinetic training using afferent muscle contractions alone does not require lifting of either free weight or weight stacks, there is little risk of injury and assistance is not normally required.

Nevertheless, if there is no system that provides accurate feedback on the amount of exertion and work done during exercise in the machine being used, it is difficult for the person performing the training to determine how much effort he or she is putting. In addition, because there are no visible weights or weight stacks when using an isokinetic dynamometer, the issue of motivation may become a problem for some users. Although there are models of this type of machine that have a monitor displaying the force being exerted with each repetition, these models are currently not widely available at exercise facilities, such as sports clubs.

Despite the fact that a large number of studies on the effect of isokinetic training using only concentric contractions, as in the present study, have been performed, very few of them consider the issue of the optimum number of sets and reps. Nevertheless, when engaged in muscle strength training over short term, the number of reps has nearly no effect on improving the maximum torque.

In the present study, the participants performed an "open kinetic chain" exercise in which their lower-limb extremities were allowed to remain free. The fact that it was easy to discontinue the exercise depending on the status of the target joint made this method safer than the "closed kinetic chain" type. However, caution is required when performing an open kinetic chain exercise because it increases the shearing force, increasing the stress on the joint [26].

Conclusion

According to a study on joint angle specificity in isometric training, increase in the muscle strength occurs only within a narrow target joint angular range, and it does not occur throughout the entire ROM for the target joint. As a general rule, exercises performed for muscle strength training include the entire ROM within the range of normal everyday postures. This is done to ensure that there is muscle strength improvement throughout the entire ROM. However, in both sporting and normal daily life activities, there are few cases in which individuals exert force over the entire ROM of a joint. Exceptions to this general rule include ski jump athletes who jump from a position in which their knees are at nearly maximum flexion and weightlifters who engage in the same type of motion. This type of movement is not present in other types of sports. Thus, it is practical to perform muscle strength training at partial ROM that includes the joint angle at which maximum output occurs.

Conflict of Interest

None

References

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