

Original Article

# Effects of proprioceptive circuit exercise on knee joint pain and muscle function in patients with knee osteoarthritis

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**Abstract.** [Purpose] This study applied proprioceptive circuit exercise to patients with degenerative knee osteoarthritis and examined its effects on knee joint muscle function and the level of pain. [Subjects] In this study, 14 patients with knee osteoarthritis in two groups, a proprioceptive circuit exercise group (n = 7) and control group (n = 7), were examined. [Methods] IsoMed 2000 (D&R Ferstl GmbH, Hemau, Germany) was used to assess knee joint muscle function, and a Visual Analog Scale was used to measure pain level. [Results] In the proprioceptive circuit exercise group, knee joint muscle function and pain levels improved significantly, whereas in the control group, no significant improvement was observed. [Conclusion] A proprioceptive circuit exercise may be an effective way to strengthen knee joint muscle function and reduce pain in patients with knee osteoarthritis.

**Key words:** Proprioceptive circuit exercise, Muscle function, Pain

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## INTRODUCTION

Osteoarthritis (OA), also known as degenerative arthritis, is most common in the knee joint and steadily advances the degradation of the joint cartilage. It is a chronic illness common to the joints of the low back, hip, and knee that mostly affects middle-aged people and the elderly<sup>1)</sup>. For patients with knee osteoarthritis, exercise is the most common and effective therapy for enhancing knee function and reducing pain; it is also more cost-effective than other types of medical interventions. However, its mechanism is not fully understood<sup>2-5)</sup>. A proprioceptive exercise is based on the notion that when a patient performs balance-keeping exercises on unstable surfaces, proprioception responses occur first among those generated by the somatic senses. These responses allow compensatory adjustments in the lengths of various muscles, their tension levels, and the position of the joints to facilitate joint movements<sup>6)</sup>. Proprioceptive training improves knee functions in osteoarthritis patients, and quadriceps muscle strengthening is known to mitigate the symptoms of knee osteoarthritis and improve knee function<sup>7)</sup>. Proprioceptive neuromuscular facilitation of the

afflicted area is closely related to deteriorated mobility and pain, and restoring proprioceptive neuromuscular function is essential during the final stage of a rehabilitation program<sup>8)</sup>. A circuit exercise applies the concept of circuit training to resistance exercise. The advantages of a circuit exercise are reduced muscle fatigue, which is generally observed during resistance exercise, and improved exercise efficiency by minimization of the recovery time between exercise sets<sup>9)</sup>. Against this background, this study designed and applied a proprioceptive circuit exercise to patients with knee osteoarthritis to analyze the impact of the exercise program on knee muscle function and the associated pain.

## SUBJECTS AND METHODS

This study included 14 female patients,  $\geq 60$  years old, who demonstrated both clinical and radiological evidence of knee osteoarthritis, as described by the American Rheumatism Association<sup>10)</sup>. The patients in the proprioceptive circuit exercise group (PCEG) were  $65.7 \pm 3.5$  years old and had an average height of  $152.4 \pm 5.1$  cm and an average weight of  $64.7 \pm 2.3$  kg. In the control group (CONG: not the intervention group), the average age was  $65.1 \pm 2.9$  years, with an average height and weight of  $153.1 \pm 4.5$  cm and  $60.6 \pm 7.69$  kg, respectively. There was no statistically significant difference in physical characteristics between the two groups ( $p < 0.05$ ). The proprioceptive circuit exercise program (20 min/session) lasted for eight weeks. The subjects participated in the exercise program three times a week. Three sets (10 times/set) of the proprioceptive circuit

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**Table 1.** Comparison of knee joint peak torque in each group

Group	Muscle strength	Before (mean ± SD) Nm	After (mean ± SD) Nm
PCEG	RKF*	24.3 ± 8.6	37.7 ± 13.2
	RKE*	57.1 ± 23.6	68.3 ± 26.0
	LKF*	21.9 ± 9.7	30.3 ± 8.8
	LKE*	63.3 ± 19.5	71.0 ± 24.0
CG	RKF	28.0 ± 8.0	37.6 ± 12.4
	RKE	51.1 ± 10.4	40.9 ± 18.4
	LKF	23.7 ± 7.6	29.4 ± 10.7
	LKE	44.7 ± 11.0	44.4 ± 17.0

\*p < 0.05. PCEG: proprioceptive circuit exercise group; CG: control group; RKF: right knee flexion; RKE: right knee extension; LKF: left knee flexion; LKE: left knee extension

exercise per session were performed. The detailed exercise program consisted of repetition of walking in place and four different types of proprioceptive circuit exercise, including half squat, straight lunge, side lunge, and one-legged balance exercise, on a Jumper (TOGU, Germany) and Aero-step (TOGU, Germany). For those participants who were unable to perform exercise properly due to loss of balance on the equipment, an exercise instructor held the participants' hands until the end of each exercise. IseMed 2000 (D&R Ferstl GmbH, Hemau, Germany) was used to measure knee joint isokinetic strength. A Visual Analog Scale (VAS) was used to measure the extent of pain. The data was analyzed by using IBM SPSS Statistics for Windows, Version 20.0 (IBM SPSS., Armonk, NY, USA), and the results from both groups were compared before and after the program. The comparisons were made using paired t-tests ( $p < 0.05$ ). All the subjects understood the purpose of this study and provided their written informed consent prior to participation in the study in accordance with the ethical standards of the Declaration of Helsinki.

## RESULTS

In the PCEG, knee joint muscle function showed significant improvement in all examined areas ( $p < 0.05$ ), whereas in the CONG, no significant improvement was observed (Table 1). As for changes in the level of pain, significant improvements were observed in the PCEG ( $p < 0.05$ ) but not in the CONG (Table 2).

## DISCUSSION

Patients with degenerative knee osteoarthritis show reduced quadriceps strength and a decline in proprioception and balance<sup>2, 3</sup>). Reduced proprioception in patients with osteoarthritis weakens their thigh muscle strength and could limit their walking ability and dynamic balance<sup>11</sup>). Also, joint pain may have harmful effects on muscle function (muscle strength and activation) and senses (proprioception and balance)<sup>5</sup>). Therefore, an exercise program was designed to strengthen the thigh muscles, enhance proprioception, and reduce pain in patients with degenerative osteoarthritis.

**Table 2.** Visual Analog Scale pain measurement in each group

Group	Before (mean ± SD)	After (mean ± SD)
PCEG*	6.6 ± 1.6	3.1 ± 1.1
CONG	6.9 ± 1.6	7.1 ± 1.4

\*p < 0.05. PCEG: proprioceptive circuit exercise group

This study showed increased knee joint muscle function and decreased pain in the group that underwent proprioceptive circuit exercise training ( $p < 0.05$ ). A combined application of proprioceptive circuit muscle strengthening exercise and proprioceptive exercise is more effective than a single muscle strengthening training program in terms of improving joint stability<sup>11</sup>). The 8-week proprioceptive circuit exercise improved postural sway and isokinetic strength, leading to improved ankle joint stability<sup>12</sup>). Also, combining resistance and proprioceptive training resulted in greater muscle hypertrophy, supporting an improved knee joint muscle function outcome<sup>13</sup>). Diminished knee joint proprioception is highly correlated with the level of pain<sup>14</sup>), and the interaction between proprioception and muscle strength is closely related to functional body movements<sup>15</sup>). Also, exercise on an unstable surface might be helpful for improving the muscle strength and alignment of lower extremities as well as for improving physical function related to the knee joint<sup>16</sup>). This indicates that application of proprioceptive circuit exercise improves proprioception and knee joint muscle function, thereby reducing patient pain. Additionally, pain causes reflex arthrogenous muscle inhibition, reduces activation of the thigh quadriceps, and weakens the quadriceps<sup>5</sup>). Therefore, strengthening knee joint muscle function likely helps reduce pain. This study showed that proprioceptive circuit exercise in patients with degenerative knee osteoarthritis can be an effective way of strengthening knee joint muscle function and reducing pain. The results are expected to provide a useful basis for future efforts to enhance knee joint functions and improve pain control in patients with knee osteoarthritis.

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