The effect of action observation training on knee joint function and gait ability in total knee replacement patients

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The purpose of this study is to investigate that effect of action observation training (AOT) on knee joint function and balance in total knee replacement (TKR) patients. The subjects consisted of eighteen post-TKR patients. All participants underwent conventional physical therapy. In addition, patients in the AOT group (n = 9) were asked to observe video clips showing daily actions and to imitate them afterward. Patients in the control group (n = 9) were asked to execute the same actions as patients in the AOT group. Outcome measures Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) included pain, stiffness, function and Timed Up and Go (TUG) test. After intervention, pa-

tients in the AOT group score better than patients in the control group. After TUG test, patients in the AOT group and control group were no significant difference between two groups. In addition to conventional physical therapy, AOT is effective in the rehabilitation of post-TKR patients. Action observation training is considered conducive to improving knee functions and ameliorating pain and stiffness, of patients who underwent TKR.

Keywords: Action observation training, Total knee replacement, Universities Osteoarthritis Index

INTRODUCTION

The knee joints are weight-bearing joints; therefore, osteoarthritis of the joints rapidly leads to severe degenerative changes or flexion and valus and varus deformity, affecting gait. When there is no effect of conservative therapy, osteoarthritis is treated by total knee arthroplasty.

Those who received total knee arthroplasty, accompanied by the weakening of muscle strength and endurance resulting from muscular atrophy, may perform continuous passive motion exercises and muscle strengthening exercises for stability and normal function of the post-operative knee joints. Patients may learn and practice the exercises on their own or perform passive flexion exercises with the help of a physical therapist at a hospital (Dawson et al., 1998).

Recently, attempts to apply action observation training (AOT)

as a treatment method have been made. AOT was devised to help an observer's learning activities or revise his or her undesirable motions using visual and auditory effects on activities of another's motions or the motions of a model in a video. This method is based on the mirror neuron system (Small et al., 2012). Mirror neurons are activated during certain movements or when the performance of other individual is observed (Rizzolatti et al., 1996). Recent prior research attempted to apply action observation training clinically to patients with a musculoskeletal system disorder (Bellelli et al., 2010). Bellelli et al. (2010) experimented with total knee arthroplasty patients and noted that action observation training created significant differences in rehabilitation. AOT based on mirror neurons, a neuro-physiological treatment method, resulted in more rapid recovery than existing treatment methods for such neuro-physiological problems (Dobkin, 2005).

However, previous studies have mostly concerned activities of

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daily living, balance, and improvement in stroke patients' upper extremities. Therefore, this study intends to examine repetitive observation of rehabilitation exercise videos by patients with ordinary musculoskeletal system disorders and without brain damage, and its effect on their gait ability, pain, and activities of daily living.

MATERIALS AND METHODS

Experimental subjects

The subjects of this study were 18 patients who underwent total knee arthroplasty, received hospital treatment at a hospital located in J City, understood the purpose of this study, and consented to participate in this experiment. This study was approved by Hospital, and all the participants provided their written informed consent. The average age of the AOT group and the physical training group was 72.67 and 70.56, respectively ($P = 0.47$), and their ages were not significantly different. The average height of the AOT group and the physical training (PT) group was 158.44 cm and 157.89 cm, respectively, and their height was not significantly different ($P = 0.78$). Their average weight also did not significantly differ with the AOT group at 61.44 kg and the PT group at 61.89 kg ($P = 0.82$) (Table 1).

The criteria for selection as subjects were those who were diagnosed with degenerative gonarthritis and underwent total knee arthroplasty, and those who received physical therapy every day due to post-operative inflammation and continuous passive motion treatment as rehabilitation training. The subjects were randomly allocated to the action observation training group (n = 9) and the PT group (n = 9) through coin flipping.

Action observation training

Eight kinds of tasks were presented in the video on action observation training. The tasks were raising legs in a supine position, flexing and extending the ankles, sitting without flexing the knees, sitting and standing without flexing the waist, walking with a walker, going upstairs and downstairs, flexing and extending the knees, and standing on one leg with the hands against the

wall. For all motions, imaging photographed in front and from the sides was provided so that the subjects were able to observe themselves three-dimensionally. The tasks of the action observation training group were divided according to the week. During the first week, the group observed imaging in action observation; they then carried out the first four tasks three times during the second week and the remaining four tasks three times during the third week. It took about two to three minutes to show each task. Those who underwent surgery on the left knee observed imaging of the tasks conducted using the left side, and those who had surgery on the right knee observed imaging of the tasks conducted using the right side. PT was carried out for the control group and the experimental group.

Physical training

PT program was made up 30 min of gait exercise and treadmill. Gait exercise was carried out for low impact-step, grapevine step, lunge, knee-up, low front kick, side kick, mambo step. The action observation training group performed action observation for 10 min and received physical training for 30 min, and the PT group received physical training for 30 min. The subjects conducted exercises once per day, three times per week, for three weeks, in a therapy room where patients receive interventions. After the three-week intervention, the result was measured using the same test that was used prior to the intervention.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The WOMAC is widely used as a measurement tool for patients who have undergone a surgical operation or for inpatients, due to its instrumental validity and sensitivity to changes; it has been reported to have high reliability and validity (Dougados, 2004). This tool includes pain, stiffness, and one activity of daily living. Whether the subject can perform activities of daily living is judged by each activity, with a total score of 85 points. Pain and stiffness are evaluated by the patient's subjective judgment, with 35 points as the standard and a total score of 120 points. As for functional scores, the lowest is given when the subjects cannot perform motions within two minutes, and one point is provided for each item.

Visual analogue scale (VAS)

VAS is used in measuring in order to grasp the criterion of pain. It is an index showing patient's subjective pain, and it is commonly used in measuring the strength of pain in study. By draw-

Table 1. General characteristics of subjects

	AOT+PT group	PT group	P
Age (years)	72.67 (12.25)	70.56 (10.98)	0.47
Height (cm)	158.44 (5.26)	157.89 (7.21)	0.78
Weight (kg)	61.44 (4.23)	61.89 (6.88)	0.82

Mean + SD. AOT, action observation training; PT, physical training.

ing the 10 cm line, left side would be the area of zero where pain does not exist, and right side would be the area where the strength of pain gets stronger. Grade is measured from zero to ten, and it was applied by measuring the marking point of patients into distance (Scott and Huskisson, 1979).

Time up and go test (TUG)

The TUG test measures functional mobility and movement ability. The time during which subjects who are seated on a chair stand according to a starting signal, pass the halfway point at three meters in front of the chair, and come back and sit down on the chair again is measured. The inter-rater reliability ($r = 0.98$) and intra-rater reliability ($r = 0.99$) of this test were high (Ries et al., 2009).

Data analysis

All data for each subject were encoded and recorded. An independent t-test was used in order to examine differences in knee joint functions and balance ability between the action observation training group and the PT group. A paired t-test was used in order to look at differences in each group between prior to the intervention and after the intervention. A statistical program (SPSS version 18.0) was employed for all analysis of the collected data, and the significance level for verifying statistical significance was set at $\alpha = 0.05$.

RESULTS

Table 2 shows the changes in the TUG test results of the two groups after the exercises. The average time of the action observation training group decreased significantly to 18.11 ± 3.06 sec after the exercises from 42.27 ± 11.03 prior to the exercises ($P =$

Table 2. The within-group and between-group comparisons for the outcome measures

	AOT+PT group		PT group	
	Pre-test	Post-test	Pre-test	Post-test
TUG	42.23 (11.03)[a]	18.11 (3.06)*	38.01 (9.45)	18.31 (4.48)*
Pain (VAS)	7.56 (1.74)	3.22 (1.09)*,†	6.89 (1.36)	4.44 (0.73)*
WOMAC				
Stiffness	7.56 (1.74)	3.22 (1.09)*,†	6.89 (1.36)	4.44 (0.73)*
Function	76.11 (6.33)	21.67 (2.83)*,†	70.56 (7.27)	29.44 (5.83) *

[a]Mean+SD. *Significant difference within groups ($P < 0.05$). †Significant difference between groups ($P < 0.05$). AOT, action observation training; PT, physical training; TUG, timed up and go; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

0.00). The average time of the PT group also decreased significantly to 18.31 ± 4.48 sec after the exercises from 38.01 ± 9.45 prior to the exercises ($P = 0.01$). Differences in the TUG result between the two groups were compared: there were no significant differences ($P = 0.91$). Table 1 display the two groups' changes in the WOMAC after the exercises. The WOMAC has three scales: pain, stiffness, and function. In the action observation training group, the average value of pain decreased significantly from 20.44 ± 3.16 to 6.11 ± 1.45 after the exercises ($P = 0.00$), the average value of stiffness decreased significantly from 7.56 ± 1.74 to 3.22 ± 1.09 after the exercises ($P = 0.00$), and the average value of function decreased significantly from 76.11 ± 6.33 to 21.67 ± 2.83 after the exercises ($P = 0.00$). In the PT group, the average value of pain decreased significantly from 20.011 ± 4.24 to 10.00 ± 2.06 after the exercises ($P = 0.00$), the average value of stiffness decreased significantly from 6.89 ± 1.36 to 4.44 ± 0.73 after the exercises ($P = 0.00$), and the average value of function decreased significantly from 70.56 ± 7.27 to 29.44 ± 5.83 after the exercises ($P = 0.00$). The WOMAC was compared between the two groups, and there were significant differences ($P = 0.00$) (Table 2).

DISCUSSION

Action observation training examined through the WOMAC in this study was effective in decreasing pain and contracture of patients who received total knee arthroplasty and in improving their function. However, gait ability examined with the TUG test did not significantly differ between the action observation training group and the PT group after the experiment. This result was slightly different from the study result of Bellelli et al. (2010), who found that action observation training was effective in motor recovery of orthopedic disease patients.

This study examined action observation training with a neuro-physiological approach, and in previous studies that have looked at stroke patients with this approach, action observation training was similar to a rehabilitation method called mirror therapy (Dohle et al., 2009; Altschuler et al., 1999). Mirror therapy was devised by Ramachandran et al. (1995). A mirror was placed on the midsagittal plane of a patient, and the non-paretic side was reflected in the mirror, making movements of the non-paretic side look like movements of the paretic side. The method was effective in reducing phantom pain of patients whose hand had been amputated and in recovering upper extremity function of stroke patients. Although action observation training and mirror therapy are different methods, they have in common that they use visual

and proprioceptive feedback; they are both neuro-physiological treatment methods that use mirror neurons. In a study using functional magnetic resonance imaging, Ertelt et al. (2007) observed that there was functional reconstruction of motor functions in a small number of subjects (n = 8) among those to whom action observation training was applied, and such reconstruction was noticeable in mirror neurons.

As the present study shows, rehabilitation treatment is mostly dependent on previously performed research and observation, and basic treatment was effective in recovering motor damage of patients' lower extremities (Celnik et al., 2006). Overall, past studies of stroke patients in the clinical field have demonstrated that action observation is effective in reconstructing motor memory (Celnik et al., 2008). In theoretical terms, prior studies focused only on secondary brain damage, not on motor recovery in relation to action observation. According to the present study's results, pain, stiffness, and function improved in patients with musculoskeletal system disease who had undergone total knee arthroplasty. Thus, future research needs to examine whether action observation training is effective on a long-term basis in the balance ability of patients who undergo total knee arthroplasty.

This study has some limitations. The experimental period was short, and the exercise program was not composed of exercises related to gait only. Therefore, future research should involve a program for patients who received total knee arthroplasty. In conclusion, AOT is considered conducive to improving knee functions and ameliorating pain and stiffness, of patients who underwent total knee arthroplasty.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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