The Effect of Dexterity and Perturbation Exercise on Knee Osteoarthritis through Functional Balance and Power Improvement of Quadriceps and Hamstring

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Abstract

Backgrounds and Objective: Osteoarthritis (OA) is a set of joint disorders caused by different factors but has the same pathological changes. OA of the knee joint occurs mainly due to the tibiofemoral and patelofemoral joints as a continuous body weight support throughout human life both static and dynamic, thus gradually causing changes in the structure of the knee joint tissue. This study aimed to know the function and strengthening of muscle strength of quadriceps and hamstring in patient with knee osteoarthritis.

Method: Twenty-two patients with knee OA (average age of 51.7 years; range 40 to 65 years) were randomly grouped into intervention group (agility and perturbation exercises plus strengthening exercise of quadriceps and hamstring muscles) and the control group (strengthening exercise of quadriceps and hamstring muscles). Both group participated in a four-week exercise. Balance function, quadriceps and hamstring muscles strength (BBS, TUG, EN-Tree 1 RM) were assessed before and after intervention.

Result: The intervention and control group improved 1 RM quadriceps muscle ($p = 0.0001$) and 1 RM hamstring muscle ($p = 0.0001$) but there was no statistically significant difference between groups, score of BBS in intervention group improved significantly ($p = 0.0001$) and statistically increased significant between groups ($p = 0.0001$), score of TUG in intervention group improved significantly ($p = 0.002$) but there was no statistically significant difference between groups ($p = 0.324$).

Conclusion: Supplementation of agility and perturbation exercises on strengthening exercise of quadriceps and hamstring to balance function provided additional benefit with respect to the BBS score after four-week intervention of patients with knee osteoarthritis.

Keyword: *knee osteoarthritis, perturbation, muscle strength, Berg Balance Scale, Time up and go test.*

Background

Osteoarthritis is a joint disorder caused by different factors but has the same pathological changes. Osteoarthritis (OA) of the knee joint occurs mainly due to the tibiofemoral and patelofemoral joints as a continuous body weight support throughout human life both static and dynamic, thus gradually causing changes in the structure of the knee joint tissue [1]. If the changes do not handle properly and appropriately it will develop into a chronic pathological process that causes damage to the entire structure of knee tissue[2].

Rehabilitation outpatient unit of Dr. Soetomo General Hospital Surabaya reported that the number of knee OA cases between October 2011 until April 2012 was 127 new cases and 3211 old cases. The high number of old cases was due to care phase and recurrence due to undiscipline in doing knee joint conservation program on damaged knee joints of their anatomical structure and function. Based on this report it was noted that knee OA

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is the second highest case after low back pain.

Some aspects of the human body such as vestibular system, vision, proprioceptive, muscle strength and cognition, have a relationship to the control of human balance thus it is an essential ability for everyday life. In knee OA there is a pathological change in the tissue structure within the joint space, ligaments, tendons, and periarticular tissues including muscles. This condition is followed by malfunction of the knee joint receptor mechanisms resulting a decreased proprioceptive function [3]. On histological examination it was reported that the number of sensory receptors in the knee joint ligaments with OA decreased. Eldery with physiologically impaired proprioseptic function suffers from knee OA will further aggravate its proprioceptive function, thus it is estimated that this condition may cause an increase in the incidence of falling while walking or standing [4].

A study in 2002 found that the addition of dexterity and perturbation exercise in women aged 73 years with instability complaints on both knees due to OA during 12 sessions indicated that instability incidence did not continue and the patient could return to recreational activities such as walking, playing tennis and golf [5]. The difference outcomes of both studies led researchers to examine the effects of adding dexterity and perturbation exercises on quadriceps and hamstring strengthening exercises to the improvement of proprioceptive function that controled the balance thus it could improve the performance of the stability dynamics component of knee OA patients.

Method

This research was pre- and post-test control group design. This research was conducted in January 2013 until finished in Medical Rehabilitation Installation Unit of Dr. Soetomo Surabaya. The samples were new knee OA patients based on clinical symptoms and radiological examinations that met inclusion criteria and did not meet exclusion criteria [6]. The sampling technique of this research was consecutive sampling method and then done a simple random sampling through lottery. Ethical appeals were submitted to the Ethics Commission for basic science/clinical research at Dr. Soetomo Surabaya[7].

The inclusion criteria were women aged 40 - 65 years; new knee OA sufferers who met the American College of Rheumatology clinical criteria of knee pain, less than 30 minutes of morning stiffness, crepitation when the knee was moved, tenderness on joint palate, swelling of the knee joint but not warm at palpation, new knee OA sufferers who met clinical criteria according to Kellgren-Lawrence radiology degree II and III, Berg Balance Scale (BBS) examination 41-56 = low risk fall, and 21-40 = moderate risk fall, examination of Time up and go test (TUG test) ≤20 = walking without aids, willing to participate in the research by signing the approval sheet after getting an explanation [8].

The exclusion criteria were patients with aids for ambulation, having fall history resulting in musculoskeletal disorders, patients with severe visual impairment, the patient had undergone total knee arthroplasty, patients with uncontrolled hypertension, patients with cardiovascular disease history, patients with nerve disorders resulting body weakness, and decreased sensibility and knee pain with VAS >3 with or without knee inflammation marks. Drop out criteria was arising knee pain during exercise with VAS >3 [9].

The samples were randomly divided into two groups. Group 1 received strengthen training of quadriceps and hamstring muscles with EN-Tree tools plus dexterity and perturbation exercise twice/week every Tuesday and Thursday for 4 weeks, while group 2 received quadriceps and hamstring strengthening exercises with EN-Tree tools twice/week every Monday and Wednesday for 4 weeks. Pre- and post-exercise evaluation of balance function was done using BBS tool, TUG test and quadriceps muscle strength and hamstring 1 RM with EN-Tree. Data were anaysed and compared their improvement of balance function and increased quadriceps and hamstring muscle strength before and after treatment [10].

The data were arranged in sheet and tabulated, then processed statistically using SPSS 21.0 (SPSS. Inc. Chicago IL). Normality test using one sample Kolmogorov-Smirnov test was done before comparing data between groups, homogeneity test was done using Levene test. Since the data were normally distributed and homogeneous, t 2 free samples were used to compare the data between groups, whereas paired t test was used to compare the data before and after the treatment [11].

Result

Table.1 Subject's characteristic of respondent

Characteristic	**Treatment group (n=11)**	**Control group (n=11)**	**p***
Age (year)	51.7 ± 7.7	51.7 ± 4.8	1.0Φ
Weight (kg)	64.8 ± 13.4	67.2 ± 15.2	0.7Φ
Height (cm)	157.3 ± 7.2	159.8 ± 5.9	0.4Φ
BMI (kg/cm²)	26.1 ± 4.7	26.2 ± 5.5	1.0Φ
Sex			
Female	9	6	0.4€
Male	2	5	
Grade OA			1.0€
Grade 2	7	6	
Grade 3	4	5	

Significan if $p<0.05$

Φ t 2 free samples test

€ Chi-Square test

It could be seen from demographic characteristics in table above that treatment group that the youngest was 40 years and oldest was 65 years old with average of 51.73 ± 7.7 years, while in control group th yougest was 45 years and the oldest was 59 years with average of 51.73 ± 4.8 years. In the treatment group, the average weight was 64.82 ± 13.4 kilograms, while in control group was 67.18 ± 15.2 kilograms. In the treatment group, average height was 157.27 ± 7.2 cm while in control group was 159.82 ± 5.9 cm. In the treatment group, the average body mass index (BMI) was 26.1379 ± 4.7 while in control group was 26.22 ± 5.4.From the test result in table 1, it could be concluded that the research subject data according to age, body weight, body height, body mass index (IMT) was normally distributed.

Table.2 Comparison between control and treatment group on 1RM, BBS, and TUG to muscle

	Treatment group (n = 11)		**p**	**Control group (n = 11)**		**p**
	Before	**After**		**Before**	**After**	
The association of average 1RM quadriceps	2.0 ± 0.3	9 ± 0.3	0.0001	2.2 ± 0.3	3.1 ± 0.1	0.0001
Comparison of 1 RM hamstring muscle	1.5 ± 0.5	2.68±0.4	0.0001*	1.80 ± 0.4	2.9 ± 0.2	0.0001*
Comparison of Average BBS	51.1 ± 2.3	54.3 ± 1.9	0.0001*	52.8 ± 1.8	52.9 ± 1.9	0.341
Comparison of Average TUG	7.7 ± 0.9	7.1 ± 0.7	0.002*	7.6 ± 0.7	7.4 ± 0.9	0.324

* Significant difference (p<0,05)

Table above shows homogeneity test with p <0,05 was done on age, body weight, height, BMI, gender and grade of knee OA to know diversity of demographic characteristics and to determine their effect on the research results. In both groups there were no significant differences in age, weight, height, BMI, gender and grade of knee OA.

The statistical test of the average increase of RM 1 quadriceps muscle before and after exercise in the treatment group showed a significant increase with p = 0.0001. In the control group also showed a significant increase with p = 0.000. Comparison of average RM 1 quadriceps muscle between treatment group and control group showed improvement, but did not show significant difference with p = 0.867. The statistical analysis of the average increase RM 1 hamstring muscles before and after exercise in the treatment group showed a significant increase with p = 0.0001. Comparison of average RM 1 hamstring muscle between treatment group and control group showed no increase and did not show significant difference with p = 0,901).

The BBS before and after intervention in the treatment group showed a significance with p = 0.0001. while in control group showed an increase but not significant with p = 0.341. The average BBS values between treatment group and control group showed a significant increase with p = 0.0001 The average of decreased TUG before and after intervention in the treatment group showed a significant decrease with p = 0.002. While in the control group showed a decrease but not significant with p = 0.324. The average TUG between treatment group and control group showed not significant decreased with p = 0.095

Discussion

The results shows that the increase in quadriceps and hamstring muscle strength in both groups was due to the training intervention using EN-tree pulley, and it had not shown the feedback mechanisms of proprioceptive organ sensitivity improvement. The results of this study were consistent with previous study in 2011, which examined 231 subjects with knee OA dividing into treatment groups receiving dexterity and perturbation exercise on strengthening exercises and control groups receiving only strengthening exercises. It was estimated that elderly with knee OA tended to avoid extreme movements that required balance and agility, thus the addition of perturbation and dexterity exercises did not give optimal results [12].

Based on subject's occupation in treatment group, 5 subjects had sedentary lifestyles such as retirees, grandchildren sitter, housewives with maids, tailors, and workers with long sitting time in the office. Researchers argued that sedentary lifestyle classified in low-level activities that led to static body movements [13]. This static condition made the mechanical function of knee joint neglected therefore the optimization of mechanoreseptor organ stimulation especially dynamic mechanoreceptors such as pacinian's corpuscles through strain, pressure and burden of knee joint became minimum or lost [14].

It was argued that the short intervention period was relatively rapid for a rehabilitation process, therefore the impact of proprioceptive exercise and balance was not fully visible at the time of assessment. Another study supported the findings in this study that dexterity and perturbation exercise included in proprioceptive exercises had not shown an increase in quadriceps and hamstring muscle strength leading to increased functional activity [15].

A subsequent study of 63 knee OA patients performed joint proprioception assessment with joint motion detection threshold (JMDT), measurement of quadriceps and hamstring muscle strength with isokinetic dynamometer and functional assessment with 100 meters walking test and GUG [16]. The effect of muscle weakness was stronger on the limitations of functional ability than in accurate proprioception. A study had not shown any feedback mechanism between proprioceptive function and muscle strength, although this had been proven by other study [17].

The BBS value improvement was in accordance with a study demonstrated the effect of perturbation exercise on parental balance function with a history of instability or fall. The subjects were divided into 2 groups consisting of those receiving the perturbation and control group who receiving flexibility and relaxation exercises. That study showed proprioceptive function improvement through perturbation exercises. It had also been proven in this study that the BBS score increased significantly indicating an improvement in proprioceptive function of subjects [18].

Conclusion

It was found that the addition of dexterity and perturbation exercise in muscle strengthening exercises twice a week for 4 weeks was more effective in improving the functional balance (BBS) than strengthening exercises alone of knee OA patients, the addition of dexterity and perturbation exercise in muscle strengthening exercises twice a week during 4 weeks was no more effective in improving the functional balance (TUG) compared to strengthening exercises alone in knee OA, the addition of dexterity and perturbation exercise in muscle strengthening exercises twicw a week for 4 weeks was no more effective in improving quadriceps muscle strength and hamstring muscle compared to strengthening exercises alone in patients with knee OA.

Ethical Clearance: This research involves participants in the process using a questionnaire that was accordant with the ethical research principle based on the regulation of research ethic regulation. The present study was carried out in accordance with the research principles. This study implemented the basic principle ethics of respect, beneficence, non-maleficence, and justice.

Conflict of Interest : The authors report that there is no conflict of interest related with this paper.

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