ORIGINAL ARTICLE

Comparison of Sling Suspension Versus Balance and Proprioceptive Exercise for Patients with Knee Osteoarthritis

Vivi Mariani, Lanny Indriastuti
Department of Medical Rehabilitation Installation, Dr Kariadi General Hospital, Semarang

ABSTRACT

Objectives: To compare the difference between sling suspension versus balance and proprioceptive exercise's effect on pain and functional capacity of knee osteoarthritis patients before, 2 weeks after and 4 weeks after exercise.

Methods: This longitudinal study with case series design was done on 34 subjects with knee osteoarthritis grade II and III in Outpatient Clinic of Medical Rehabilitation Installation in Dr. Kariadi General Hospital Semarang from November 2009 to February 2010. They were randomly assigned into 'sling suspension' and 'balance and proprioceptive' exercise group. Each group contains 17 subjects. Subjects conducted their exercise 3 times a week for four weeks. Assessment of VAS, WOMAC modification index, TUG test were done before, 2 weeks after and 4 weeks after exercise.

Results: There were statistically significant changes in pain (measured by VAS category) and functional capacity (measured by WOMAC modification index subscale of pain, stiffness and functional activity, and TUG test) before, 2 weeks after and 4 weeks after exercise in both groups ($p<0.05$). However, there were no statistically significant difference in pain and functional capacity between groups ($p>0.05$).

Conclusions: There were no significant diffrences between sling suspension and balance and proprioceptive exercise, although both exercises gave significant improvement in VAS category, WOMAC modification index and walking time on TUG test.

Keywords: *knee osteoarthritis, sling suspension exercise, balance and proprioceptive exercise, VAS, WOMAC, TUG*

INTRODUCTION

Osteoarthritis (OA) of the knee increases in prevalence with age and is more common in women than in men. The common signs and symptoms of knee osteoarthritis included pain, stiffness, tenderness, crepitus, joint enlargement, deformity, quadriceps weakness, limitation of motion, impaired proprioception and disability.[1,2] In addition to motor deficit, impaired of proprioceptive acuity has been reported and proposed as a factor in the pathogenesis and progression of the knee osteoarthritis.[3,4] The disease limits functional activity, such as walking, standing from chair, squatting, climbing up and down stairs.[2,5]

The sensorimotor system consists of sensory, motor and central integration and processing components that work together to maintain joint homeostasis during functional activity. The control of sensorimotor system that is, proprioceptive acuity and muscle

Received in March 2012 and accepted for published in April 2012.
Correspondence address : Vivi Mariani, email : niasyaf@yahoo.co.id

contraction are essential for the maintenance of balance and production of a smooth and stable gait. Proprioceptive deficits contribute to functional instability, which could lead to further microtrauma and re-injury. Therefore restoration of sensorimotor deficits may retard the progression of knee osteoarthritis and reduce disability.[6,7]

Many studies have demonstrated that proper therapeutic exercise may improve functional outcome of knee osteoarthritis patients.[8-10] Sensorimotor training to promote proprioceptive acuity and muscle contraction for patients with knee osteoarthritis has been advocated since 1990s. A therapeutic exercise programme incorporating sensory input to facilitate dynamic joint stabilization may retrain afferent pathways to enhance the proprioception of knee joint movement and improve patient's function. A sensorimotor training has been shown to have positive effect on strength, improve balance and the ability to performs activity daily living in the elderly.[1,11]

Sensorimotor training has been studied and shows some positive effects. However, until now, there has been no standard sensorimotor training protocol available. Hurley et al.[4] has reported the effect of quadriceps isometric and isotonic, static ergocycle, functional and balance exercise training for five weeks in knee osteoarthritis patients on improvement of quadriceps strength, knee proprioceptive acuity and reduction of Laquesne index. Sekir et al.[3] study the effect of balance and propioceptive exercise as sensorimotor training, conducted twice a week for six weeks, and reported reduction of pain and improvement of balance, proprioception and functional capacity in bilateral knee osteoarthritis patients. Jan[12] study proprioceptive training using target matching foot stepping exercise and reported that after six weeks exercise, the training group walk faster and go up and down stairs faster than before exercise. Tsauo[1] reported that sensorimotor training using sling suspension exercise three times a week for eight weeks improved the patient's knee joint proprioception and their self reported function using WOMAC index.

The purpose of this study was to investigate the effects of two sensorimotor exercises, that are sling suspension versus balance and proprioceptive exercise on pain and functional capacity in patients with bilateral knee osteoarthritis.

METHODS

Ethics approval for the study was obtained from the ethics committee of the Medical Faculty of Diponegoro University and Dr Kariadi General Hospital. All participants in the study were informed about the study and written informed consent was obtained from each participants.

This was a longitudinal study with case series design. In order to minimize selection bias, eligible patients were randomly assigned to either sling suspension group or balance and proprioceptive group.

The study subjects were recruited from medical rehabilitation outpatient clinic Dr Kariadi General Hospital in Semarang, Central Java between November 2009 and February 2010.

Osteoarthritis of the knee were diagnosed according to the clinical and radiological criteria established by the American College of Rheumatology.[13] The severity of OA was radiographically graded using the Kellgren-Lawrence grading system.14 The inclusion criteria included: bilateral OA, Kellgren's grade II to III, age 50 to 70 years, knee flexion more than 90°, independent ambulation distance more than 60 meters, has not received treatment in the last 2 weeks, and agreed to participate in this study. The exclusion criteria included: acute condition, knee joint contracture, visual analog scale for pain less than 4 or greater than 7, WOMAC subscale functional difficulty ≤ 16, history of lower extremity injury, fracture, or surgery in the last three months, cardiovascular disorders that would interfere exercise program, neurologic disorders causing weakness or sensory disturbance in lower extremity. The drop out criteria included: unable to attend minimum 80% of training session, absent in two training occation simultaneously, pain worsen with training and not attending evaluation session.

There were 78 patients with knee osteoarthritis who came to the outpatient clinic in the study period. Thirty seven eligible patients with bilateral knee OA were randomly assigned to sling suspension exercise group (n=18) and balance and proprioceptive exercise group (n=19). One subject from sling suspension group and two subject from balance and proprioceptive group were drop out from the study because they did not attained the training program due to working commitment. Thus, 17 subjects of each group completed the study.

The sensorimotor training in this study consisted of three exercise session per week for four weeks. Each session duration was about 20-30 minutes long, and was closely supervised on individual patients to ensure compliance. Two kind of sensorimotor training were used in this study, they were sling suspension exercise and balance and proprioceptive exercise.

Sling suspension exercise is a sensorimotor training exercise to facilitate proprioceptive acuity and dynamic joint stabilization using rhythmic active motion and angle repositioning.[1] This exercise is performed using a sling suspension system in supine position, sitting position and standing on air cushion. The exercise is done with eyes open or eyes closed in each position. The exercise was given three times a week for four weeks.

Balance and proprioceptive exercise is a sensorimotor training exercise consist of 11 exercise patterns performed to improve balance and proprioceptive function, thus it will improve functional capacity.[6] The exercise performed is walking with a designed pattern, tiptoe standing, one-legged standing, straight line walking, climbing three steps of low staircase, standing from sitting on a chair. The one-legged stand exercises is done on firm or foam surface, with head on neutral or tilted back position and with eye open or eye closed. The exercise was also given three times a week for four weeks.

We recorded age, sex, body mass index (BMI), and quadriceps muscle strength for each of the subjects.

Knee pain was subjectively measured using a 0 to 10 visual analog scale (VAS, 0 = no pain, 10 = unbearable pain), which asses the severity of knee pain in general in the last 48 hours. We categorized the VAS into: no pain (0), mild pain (<4), moderate pain (4-7), and severe pain (>7).

Functional capacity was measured using Western Ontario and McMaster University Oateoarthritis (WOMAC) index and Timed Up and Go (TUG) test.

The WOMAC is a disease spesific, self reported health status measure, that includes subscales for pain (5 items), stiffness (2 items) and functional difficulty (17 items), that was developed for patients with hip or knee osteoarthritis. The reliability and validity of WOMAC scores have been established.[15,16,17] In this study, we used WOMAC modification index (23 items) since 1 item of functional difficulty (getting in or out of bathtub) was not applicable in our study subjects. WOMAC questionnairre with standardized answer options are given (5 Likert scale), each items has score from 0 to 4 (0=none, 1=mild, 2=moderate, 3=severe, 4=extreme). A WOMAC score can be generated by summing the rating for each item in the subscales, which results in a maximum 20 for pain subscale, 8 for stiffness subscale, and 64 for functional difficulty subscale.

TUG test was performed as a physical performance measure of function for balance and gait. Fitzgerald et al., has reported a good reliability of TUG test in knee OA patients.[15,18] The subject was seated on a standard-height chair. Stopwatch was started on a command "go", and the patient stood up from the chair, and walked for 3 meters distance, then turned and walked back to the chair, and the stopwatch were stopped after the patient seated on the chair again. The subjects were asked to perform this test at their fastest speed. The test was repeated 3 times and the fastest time (in seconds) was recorded.

We used SPSS software for Windows for statistical analysis. The obtained data was processed with coding, entry, cleaning and editing. Baseline data was presented with descriptive statistics. For VAS category, Friedman test was used for within group difference (before, 2 weeks after and 4 weeks after exercise) and chi-square test was used for between groups difference. GLM repeated measure test and independent sample t-test

were used for within group and between groups WOMAC functional difference, respectively. The data of WOMAC pain, WOMAC stiffness, and TUG showed non normal distribution, therefore, we used Friedman test and Mann-Whitney U test for within group and between groups difference, respectively. The level of significance was set at $P < 0.05$.

RESULTS

Patient's demographic data are shown in table 1. There were no significant difference in age, gender, BMI category, OA severity and quadriceps strength. The average age was 55 years old ± 55.3. Most patient was female and obese (BMI ≥ 25).

Table 1. Baseline characteristic of the study subjects

Characteristic	Sling suspension group (n=17)	Balance and proprioceptive group (n=17)
*Gender:**		
Male	1 (5.9)	3 (17.6)
Female	16 (94.1)	14 (82.4)
*Age (years):***	55.4 ± 4.3	55.7 ± 6.2
*BMI category:**		
Normal	1 (5.9)	0 (0.0)
Obesity	4 (23.5)	5 (29.4)
Obese	12 (70.6)	12 (70.6)
*Kellgren's grading:**		
Grade II	14 (82.4)	13 (76.5)
Grade III	3 (17.6	4 (23.5)
*Onset (months):****	6 (3-60)	6 (3-48)
*1 RM quadriceps femoris (kg):***		
Right	8.2 ± 2.3	8.7 ± 2.7
Left	7.9 ± 2.2	8.3 ± 2.2
*VAS category:**		
Moderate pain	17 (100.0)	17 (100.0)
WOMAC index		
pain:***	10 (3-13)	8 (4-12)
stiffness:***	5 (1-6)	4 (2-6)
functional difficulty:**	31.4 ± 7.0	28.4 ± 6.9
*TUG test (seconds)****	9.6 (7.3-17.8)	10.2 (7.4-13.2)

*n (%); **mean ± SD; ***median (min-max)

Baseline VAS category for knee pain in all subjects was moderate pain. Two weeks after exercise, knee pain in 8 subjects (47.1%) from sling suspension group and 11 subjects (64.7%) from balance and proprioceptive group has reduced to mild pain. At the end of the forth week, knee pain in 14 subjects (82.4%) from sling suspension group has reduced to mild pain, whereas in balance and proprioceptive group 11 subjects (82.4%) had mild pain and 2 subjects (11.8%) had no pain. (table 2) Following exercise program, the proportion of subjects with moderate pain decreased significantly in both groups and there was no significant difference between groups

Comparison of pain category changes between 'sling suspension' and 'balance and proprioceptive' groups showed no significant difference (table 3). Thus, 'sling suspension' and 'balance and proprioceptive' groups had the same effect in reducing pain category in our knee osteoarthritis patients.

Table 2. Comparisons of before, 2 weeks after and 4 weeks after exercise status in each training group

Variable		Sling suspension group	*p*	Balance and proprioceptive group	*p*
VAS category[$]	Before:		<0.05*		<0.05*
	- Moderate	17 (100)		17 (100)	
	2 weeks after:				
	- Mild	8 (47.1)		11 (64.7)	
	- Moderate	9 (52.9)		6 (35.3)	
	4 weeks after:				
	- No pain	0 (0.0)		2 (11.8)	
	- Mild	14 (82.4)		14 (82,4)	
	- Moderate	3 (17.6)		1 (5.9)	
WOMAC pain[#]	Before	10 (3-13)	<0.05*	8 (4-12)	<0.05*
	2 weeks after	6 (2-13)		4 (1-8)	
	4 weeks after	3 (1-11)		3 (1-6)	
WOMAC stiffness[#]	Before	5 (1-6)	<0.05*	4 (2-6)	<0.05*
	2 weeks after	4 (1-6)		2 (1-6)	
	4 weeks after	3 (0-5)		2 (0-6)	
WOMAC functional difficulty[§]	Before	31.6 ± 7.0	<0.05*	28.4 ±6.9	<0.05*
	2 weeks after	22.6 ± 10.1		17.2 ± 5.6	
	4 weeks after	15.7 ± 11.4		10.9 ± 6.1	
TUG test[#] *(seconds)*	Before	9.6 (7.3-17.8)	<0.05*	10.2 (7.4-13.2)	<0.05*
	2 weeks after	8.7 (6.4-14.2)		8.7 (6.7-11.6)	
	4 weeks after	8.6 (6.3-12.1)		8.4 (6.0-11.5)	

[$] n(%), [#] Median (min-max); [§] mean±SD
* Friedman test; ** GLM Repeated measure

Functional capacity was measured subjectively using WOMAC modification index and objectively using TUG test. All three subscales of the WOMAC modification index, which are pain, stifness and functional difficulty, were reduced significantly in 2 weeks and 4 weeks after exercise in both groups (table 2). It means that 'sling suspension' and 'balance and proprioceptive' exercise could reduce score in all subscales of the WOMAC modification index. There was no significant difference in WOMAC score changes in both groups (table 4). Both exercises had the same effect in reducing the WOMAC modification index.

Table 3. Comparisons of pain changes before, 2 weeks after and 4 weeks after exercise between groups

Variable	Sling suspension group n (%)	Balance and proprioceptive group n (%)	*P**
ΔVAS 0 – VAS 2			>0.05
Pain category not changed	9 (53.0)	6 (35.2)	
Pain category decreased	8 (47.0)	11 (64.8)	
ΔVAS 2 – VAS 4			>0.05
Pain category not changed	11 (64.8)	10 (58.8)	
Pain category decreased	6 (35.2)	7 (41.2)	

*Chi square test
ΔVAS 0 – VAS 2: The changes of VAS category before and 2 weeks after exercise;
ΔVAS 2 – VAS 4: The changes of VAS category 2 weeks and 4 weeks after exercise

Table 4. Comparisons of functional capacity changes before, 2 weeks after and 4 weeks after exercise between groups

Variable	Sling suspension group	Balance and proprioceptive group	*P*
ΔWOMAC pain 0 - 2#	2 (0-6)	3 (0-6)	>0.05*
ΔWOMAC pain 2 - 4#	2 (0-9)	1 (0-4)	>0.05*
ΔWOMAC stiffness 0 - 2#	1 (0-4)	1 (0-4)	>0.05*
ΔWOMAC stiffness 2 - 4#	1 (0-2)	0 (0-2)	>0.05*
ΔWOMAC functional 0 - 2§	8.8 ± 5.7	11.1 ± 7.1	>0.05**
ΔWOMAC functional 2 - 4§	6.9 ± 4.7	6.4 ±5.2	>0.05**
ΔTUG 0 – TUG 2	1.0 (-0.2-6.8)	0,8 (-0.6-2.6)	>0.05*
ΔTUG 2 – TUG 4	0.3 (-0.2-2.1)	0,3 (-0.2-1.9)	>0.05*

#median (min-max); §mean±SD
*Mann-Whitney U test; **Independent sample t-test
ΔWOMAC 0 – 2: The changes of WOMAC before and 2 weeks after exercise;
ΔWOMAC 2 – 4: The changes of WOMAC 2 weeks and 4 weeks after exercise;
ΔTUG 0 – TUG 2: The changes of TUG before and 2 weeks after exercise;
ΔTUG 2 – TUG 4: The changes of TUG 2 weeks and 4 weeks after exercise

The median value of time in seconds for TUG test were significantly reduced from 9.6 seconds to 8.7 seconds in 2 weeks and 8.6 seconds in 4 weeks after exercise in sling suspension group. And the median value of time in seconds for TUG test were significantly reduced from 10.2 seconds to 8.7 seconds in 2 weeks and 8.4 seconds in 4 weeks after exercise in balance and proprioceptive group (table 2). There was no significant difference in time changes between groups (table 4). Both exercises had the same effects in reducing the time for TUG test.

Thus, 'sling suspension' and 'balance and proprioception' exercise improved functional capacity in our subjects measured by WOMAC modification index and TUG test.

DISCUSSION

This study has shown that relatively brief sensorimotor training using sling suspension exercise or balance and proprioceptive exercise could reduce pain and functional capacity in our knee osteoarthritis patients. Although strengthening of quadriceps muscle is the key element in management of knee osteoarthritis, training for sensorimotor control may be useful for knee osteoarthritis patients. Both exercises in this study has the same positive effects, so that we can use either one of them as a sensorimotor training regime on the knee osteoarthritis patients.

Knee pain is a common symptom of knee osteoarthritis. In this study, we measure knee pain intensity using VAS category. Both 'sling suspension' and ' balance and proprioceptive' exercise groups had improvement in VAS category 2 weeks and 4 weeks after exercise. Sekir et al.3 used balance and proprioceptive exercise for six weeks in bilateral knee osteoarthritis patients. They evaluate perceived knee pain during daily activities using VAS score and found they were improved after training. Lin et al.[19] compared proprioceptive exercise, strengthening exercise and control group and reported pain reduction in proprioception exercise and strengthening exercise groups. The effect of pain on proprioceptive function has not been clearly established. There is negative association between pain and proprioception acuity and muscle strength. Thus, changes in pain with exercise would correlate with changes in proprioception acuity and muscle strength.[20,21]

Functional capacity in this study was measured using WOMAC modification index and TUG test. Both groups significantly improved WOMAC modification index and the time in TUG test. There was no difference between groups in WOMAC and TUG changes.

Tsauo1 used sling suspension exercise for eight weeks in knee osteoarthritis patients and found improvement in WOMAC subscale functional, but time for figure of eight walking test was not significantly improved. Sekir et al.[3] used balance and proprioceptive exercise and reported faster time in raising from chair and walking along 15 meters. Comparing proprioception training and strength training, Lin et al.[19] found improvement of WOMAC subscale functional and walking speed in both groups. They reported faster walking speed on a spongy surface, which requires higher neuromuskuler control of lower extremities, in the proprioception group. This is consistent with greater improvement in knee joint proprioception in proprioception training. The strength training group showed faster walking speed up and down stairs, which demand greater knee extension strength.

Hurley et al.[4] have reported that in patients with knee osteoarthritis, articular damage led to quadriceps weakness and diminished proprioceptive acuity. Proprioceptive acuity ensured accurate timing and placement of the lower limb at heel strike, and eccentric quadriceps activity after heel strike minimizes the affect of joint loading. Changed sensory input from articular mechanoreceptors may decrease quadriceps strength and proprioceptive acuity, leading to potentially harmfull impact forces after heel strike, thereby accelerating articular damage. The decrease in proprioception may increase load on the knee joint when walking, increased laxity of the joint and lead to higher energy demand during walking, thereby reducing the walking speed. Poor proprioception could lead to decreased postural control, which increased risk of falling.[20,22,23]

Sensorimotor training aims to improve sensorimotor control and achieve compensatory functional stability. Sensorimotor control is the ability to produce controlled movement through coordinated muscle activity and functional stability (or dynamic stability) is the ability of the joint to remain stable during physical activity. The exercise were mainly performed in closed kinetic chain in various position (eg. lying, sitting, standing), direction, and load, and also performed functional weightbearing exercise in various positions and at stable to unstable surface, with opened or closed eye, resembling the condition of daily living. The goal is to obtain equilibrium in static and dynamic situations without undesirable compensatory movements, with the aim of acquiring postural control in conditions of daily life and more strenuous activities.[8,24,25]

The impairment in quadriceps sensorimotor function, particularly in quadriceps strength and proprioception acuity, may impair patient's balance and gait, make the patient feel weak, unstable and decrease their confidence. As a consequence, this will reduce their mobility and ADL function. Exercise which improve sensorimotor function may improve balance, produce more smooth and stable gait, and improve their functional capacity.[1,3,6,19,25] In this study, sensorimotor training was given using sling suspension exercise or balance and proprioceptive exercise, and we found that both exercises has the same benefit in our knee osteoarthritis patients in reducing pain and improving their functional capacity.

There were several limitation to this study. Body mass index and muscle strength might be the confounding variabels in this study, but they were not analyzed due to abnormal data distribution. All subjects were assumed to have proprioceptive impairment although we did not assess proprioception acuity of the knee joint in this study.

Future study should be done with larger sample population to achieve normal data distribution. Further studies should measure the muscle strength and proprioceptive acuity of knee joint, and also should compare the sensorimotor training, such as sling suspension exercise and balance and proprioceptive exercise to the standard exercise regime that are used now.

CONCLUSIONS

Both 'sling suspension' and 'balance and proprioceptive' exercise had the same benefit in improving VAS category of perceived knee pain and functional capacity measured by WOMAC modification index and walking time on TUG test in patient with knee osteoarthrits.

REFERENCES

1. Tsao JY. The effects of sensorimotor training on knee proprioception and function for patients with knee osteoarthritis: a preliminary report. Clinical rehabilitation. 2008; 22: 448-57.
2. Setiyohadi B. Osteoartritis selayang pandang. In: Setiyohadi B, Kasjmir YI, editors. Makalah lengkap Temu Ilmiah Reumatologi 2003. Jakarta: Ikatan Reumatologi Indonesia; 2003. p.27-31.
3. Sekir U, Gur H. A Multi station proprioceptive exercise program in patients with bilateral knee osteoarthrosis: functional capacity, pain and sensorimotor function. A randomized controlled trial. Journal of sport science and medicine. 2005; 4: 590-603.
4. Hurley MV, Scott DL. Improvements in quadriceps sensorimotor function and disability of patients with knee osteoarthritis following a clinically practicable exercise regime. British Journal of Rheumatology. 1998; 37:1181-87.
5. Cailliet R. Knee pain and disability. 3rd edition. Singapore: FA Davies Company; 1993.
6. Barret DS, Cobb AG, Bentley G. Joint proprioception in normal, osteoarthritic and replaced knees. The journal of bone and joint surgery. 1991; 73B: 53-6.
7. Lephart S, Fu FH. Proprioception and neuromuscular control in joint stability. Leeds: Human kinetics; 2000.
8. Sisto SA, Malanga G. Osteoarthritis and therapeutic exercise. Am J Phys Med Rehabil. 2005; 85 (suppl): S69-78.
9. Roddy E, Zhang W, Doherty, Arden NK, Barlow J, Birrell F, et al. Evidenced based recommendations for the role of exercise in the management of osteoarthritis of the hip or knee – the MOVE consensus. Rheumatology. 2005; 44: 67-73.
10. Ilyas E. Pendekatan terapi fisik pada osteoarthritis. In: Nuhonni SA, Tulaar ABM, Kusumastuti P, Pradanasari R, Wahyuni LK, editors. Bunga rampai rehabilitasi medik. Naskah lengkap pertemuan ilmiah tahunan I. Jakarta: PERDOSRI; 2002.p.53-63.
11. Nagai T, Sell TC, Lephart SM. Effect of age and osteoarthritis on knee proprioception. US musculoskeletal review. 2007: 69-70.
12. Jan MH. Efficacy of a target matching foot stepping exercise on proprioception and function in patients with knee osteoarthritis. Journal of orthopaedic sports physical therapy. January 2008; 38 (1): 19-25.
13. Brandt KD, Slemenda CW, Moskowitz RW, Goldberg VM. Osteoarthritis. In: Schumacher HR, Klippel JH, Koopman WJ, editors. Primer on the rheumatic diseases. 10th ed. Atlanta: Arthritis Foundation; 1993. p.184-90.
14. Isbagio H, Effendi ZA. Osteoartritis. In: Soeparman, Waspadji S, Isbagio H, editors. Buku ajar ilmu penyakit dalam. 2nd ed. Jakarta: BP FKUI; 1987. p.680-3.
15. Fitzgerald GK, Childs JD, Ridge TM, Irrgang JJ. Agility and perturbation training for a physically active individual with knee osteoarthritis. Physical therapy. April 2002; 82 (4): 372-82.
16. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J Stit LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988; 15: 1833-40.
17. Hartono IM. Studi komparasi antara WOMAC index dengan Kellgren Lawrence grading system pada penderita osteoartritis genu. Semarang: FK UNDIP; 2007.
18. Piva SR, Fitzgerald GK, Irrgang JJ, Bouzubar F, Staz TW. Get up and go test in patients with knee osteoarthritis. Arch Phys Med Rehabil. 2004; 85: 284-9.
19. Lin DH, Lin CH, Lin YF, Jan MH. Efficacy of 2 non weight bearing interventions, proprioception training versus strength training, for patients with knee osteoarthritis: a randomized control trial. Journal of orthopaedic and sport

physical therapy. 2009; 39 (6): 450-7.
20. Lund H, Juul-Kristensen B, Hansen K, Christensen R, Christensen H, Danneskiold-Samsoe B, et al. Movement detection impaired in patients with knee osteoarthritis compared to healthy controls: a cross sectional case-control study. J Musculoskelet Neuronal Interact. 2008; 8 (4):391-400.
21. Shakoor N, Furmanov S, Nelson DE, Li Y, Block JA. Pain and its relationship with muscle strength and proprioception in knee OA: results of an 8 week home exercise pilot study. J Musculuskelet Neuronal Interact. 2008; 8(1):35-42.
22. Riemann BL, Lephart M. The sensorimotor system, part I: the physiologic basis of functional joint stability. Journal of athletic training. 2002; 37 (1): 71-9.
23. Riemann BL, Lephart M. The sensorimotor system, part II: the role of proprioceptive in motor control and functional joint stability. Journal of athletic training. 2002; 37 (1): 80-4.
24. Ageberg E, Link A, Roos EM. Feasibility of neuromuscular training in patients with severe hip or knee OA: the individualized goal-based NEMEX-TJR training program. BMC Musculoskeletal disorders. 2010; 11: 126
25. Bayramoglu M, Toprak R, Sozay S. Effects of osteoarthritis and fatique on proprioception of the knee joint. Arch Phys Med Rehabil. 2007 (88): 346-50.