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# Comparative Study of the Effects of Tai Chi and Strength Training on Osteoarthritis in Older Adults

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COMPARATIVE STUDY OF THE EFFECTS OF TAI CHI AND STRENGTH TRAINING ON OSTEOARTHRITIS IN OLDER ADULTS

by

ABHINANDAN BATRA

Under the Direction of Dr. Yong Tai Wang

ABSTRACT

Osteoarthritis (OA) is a degenerative joint disorder and one of the leading causes of disability in elderly. Tai Chi is seen to be effective in relieving symptoms of OA knee joint. The main aim of this study is to design a Tai Chi program and a strength training program for the elderly with knee OA and to compare the effects of these programs on the range of motion, gait, pain and balance. 20 participants age 55 and over were divided into two groups (Tai Chi and Strength training) based on predetermined criteria. Both the groups showed improvement in WOMAC scores, balance and strength following Tai Chi and strength training intervention for 2 months.

INDE WORDS: Tai Chi, Strength Training, Osteoarthritis

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by

ABHINANDAN BATRA

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Masters of Arts

in the College of Arts and Sciences

Georgia State University

2011

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by

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# 1 INTRODUCTION

Osteoarthritis (OA) is a degenerative joint disease characterized by loss of cartilage, destruction of surface of bone forming joints, decrease in joint space and formation of osteophytes (Bony projections that form on the joint surface because of rubbing of one joint surface on other, these are also called as bone spurs). It is one of the leading causes of disability in old age population. With the increasing old age population the numbers of people suffering from this problem have increased. In the United States, approximately 46 million people are affected from some form of arthritis. This number is estimated to increase to 67 million by 2030 (Center for Disease Control and Prevention, 2010). OA is most common form of arthritis. According to Center for Disease Control and Prevention (2010), one in two Americans will get some form of OA in their lifetime. At present 27 million people are suffering from OA of some joint of the body. According to Bitton (2007), OA is fifth leading cause of disability in older Americans. There are many risk factors leading to development of OA in body like obesity, trauma, inflammatory joint diseases, genetic predisposition, and abnormal bone anatomy by birth. OA can develop in any joint of body but knee and hip joint are the most common sites for developing osteoarthritis as they both are weight bearing joints. Knee joint Osteoarthritis is most common form of osteoarthritis in the population. Six percent of adults of age 30 or older in US population have knee symptoms, which is twice as many as those with hip symptoms (Felson & Zhang, 1998). In 2003 the total expenditure for arthritis and other medical conditions was around 321.8$ billion of which total expenditure on OA was around $89.1 billion (Bitton, 2007). Therefore OA has significant effect on our lives, society and economy.

## 1.1 Pathology of Osteoarthritis in Knee

Knee joint is formed by femur bone (femoral condyles) superiorly, tibia (tibial plateau) inferiorly and patella anteriorly. The surfaces of these bones are covered by articular cartilages which allow smooth movement of one bone on other and also act as a shock absorber. The articular cartilage is made up of extracellular matrix (water, collagen and proteoglycans) which forms 98% of total cartilage and chondrocytes (cells of cartilage). In normal adult cartilage is constantly degraded and repaired but the capacity of repair of cartilage is limited. Cartilage remodeling involves balanced interaction of synthesis and degradation to achieve homeostasis of extracellular matrix (Moskowitz, 2009). In OA this balance gets disturbed leading to pathological changes in the joint. Radiographic images are used to detect the changes in the joint. Knee OA is classified according to level of destruction in the joint. The Kellgren-Lawrence method (appendix A) is the validated method to classify joints according to level of destruction, with 0 representing the normal and 4 being the severe radiographic disease (Shamir et al 2009). OA in knee joint leads to pain, deformity, depression, muscle weakness, poor aerobic capacity (Felson, Lawrence et al., 2000).

## 1.2 Treatment options for OA

Treatment of OA of knee and hip is often symptom based and involves reduction in joint pain and stiffness, maintenance and improvement of joint mobility, improvement in physical activity, limiting or slowing the joint degradation, and educating patients (Zhang et al., 2008). According to Zhang and colleagues (2008), there are more than 50 different forms of treatment available to cure OA which include pharmacological, non pharmacological and surgical therapy.

The Osteoarthritis Research international (OARSI) recommends 25 form of treatment based on existing guidelines and systematic review of literature. Of these recommended forms of treatment, 11 recommendations are non surgical form of treatments which include aerobic muscle training, range of motion exercises, weight reduction, exercises in water (Zhang et al., 2008). In patients who have undergone Total Knee replacement (TKR), there is strong recommendation for exercises to maintain the joint range of motion and muscle strength to maintain mobility in knee and for better life of implant. There are many different forms of exercises combinations used both pre and post surgery depending on the symptoms and level of destruction in the knee joint. Currently, Tai Chi as a form of exercises for rehabilitation and treatment of knee is not included in the recommendation by OARSI.

## 1.3 Exercises for Osteoarthritis

Different forms of exercises which include, aerobic training, strength training, isometric exercises, range of motion exercises, flexibility exercises and balance exercises have been used for the treatment of knee OA (Diracoglu, Baskent, Celik, Issever & Aydin, 2008). These different forms of exercises have shown variable effect on the patients suffering from knee OA

(Diracoglu, Baskent, Celik,Issever & Aydin, 2008; Roddy et al, 2004) . In the study conducted by Baar, Assendelft,Dekker, Ostendorp and Bijlsma (1999), where they did a systemic review

**Table 1:** List of Treatment Recommended by OARSI

| Pharmacological | Non pharmacological | Surgical |
|---|---|---|
| • Acetaminophens<br>• NSAIDs (Non Steroidal anti inflammatory drugs)<br>• NSAIDs + PPIs<br>• NSAIDs +H2-Blockers<br>• NSAIDs + misoprostol<br>• Cox-2 inhibitors<br>• Topical NSAIDs<br>• Topical capsaicin<br>• Opioids<br>• IA corticosteroids<br>• IA hyaluronic<br>• Glucosamine<br>• Chondrotin sulphate<br>• Avocado soybean unsponifiable<br>• Vitamin E<br>• Herbal remedies<br>• Nutritional supplements<br>• Diacerhein<br>• Anti-resorptive bone-acting agents | • Self management, education and information<br>• Strengthening exercises<br>• Aerobic exercises<br>• Water based exercises<br>• Balneotherapy<br>• Spa/sauna<br>• Weight reduction<br>• TENS<br>• Ultrasound<br>• Radiotherapy<br>• Heat/ice<br>• Massage<br>• Acupuncture<br>• Insoles<br>• Braces<br>• Electrotherapy/EMG | • Lavage/debridement<br>• Patellar resurfacing<br>• Osteotomy<br>• Unicompartmental knee arthroplasty<br>• Total knee arthroplasty |

Retrieved from http://www.oarsi.org/pdfs/part_III_changes_in_evidence2010.pdf; (Zhang et al. 2010)

of 11 clinical trials for the exercise options for OA in knee and hip. It was found that exercises showed positive outcome in patients suffering from mild to moderate form of OA. In another study by Pelland and Colleagues (2004), they did a literature review of 22 trials using strengthening exercises as mode of treatment for OA in knee joint, they found that strengthening

exercises have beneficial effect on OA in knee joint but combining these exercises with other form of exercises will have more beneficial effects (Pelland et al., 2004).

Some people suffering from OA may be reluctant to perform exercises (Ananian, Wilcox, Saunders, Watkins, Evans., 2006). In a qualitative study conducted by Ananian and colleagues (2006) where they looked for the barriers in doing exercises among OA patients, it was found out that the barriers in doing exercises were divided into four broad categories which include physical, social, environmental and psychological factors. Of all the barriers pain was considered to be the major barrier in patient suffering from OA and lack of knowledge about the exercise program and its safety was also considered a major issue (Ananian et al., 2006). The problem with these forms of exercises is that there is no proper dosage, intensity and standardized protocol developed for prescribing these exercises and there are no studies conforming the long term effect of exercises on OA. Also we don't know which exercise program is better than the other one (Baar, Assendelft, Dekker, Ostendorp & Bijlsma, 1999; Roddy et al, 2004)

## 1.4 Tai Chi and its benefits

Tai Chi exercise is an ancient Chinese healing/martial art which involves deep diaphragmatic breathing combined with slow gentle graceful movements. It is a form of exercise which combines characteristics of meditative practice and aerobic exercise (Lee et al., 2010). Tai Chi exercise has evolved as a popular form of exercise because of its beneficial effects on health. Tai Chi exercise is said to have both physical and psychological benefits on the body. Physical benefits may include: improving coordination and balance, increasing flexibility and strength, and improving the cardiovascular system and reflexes. Psychosocial benefits may include: improving self-esteem, confidence, mood, functional ability, concentration, and relaxation,

reducing stress, pain, fatigue, and forming better work and study habits. Considerable scientific evidence support the various benefits of Tai Chi in different population. In a study conducted by Hain, Fuller, Weil and Kotsias. (1999) they studied the effect of eight weeks Tai Chi exercises program on the balance of 22 persons (age group 20-60, 61-75, 75 and older) suffering from mild balance disorder, Tai chi exercises were beneficial in improving the balance particularly in age group 75 and older. By practicing Tai Chi intervention for 3 months, 30 college students showed significant improvement in their mental health scores (Wang, Taylor, Pearl & Chang, 2004). In a 12 month study conducted by Lan, Lai, Chen, Wong (1998), a group of people in age group 58 to 70 years showed 16.1 % increase in $VO_{2max,}$ 11 degrees increase in flexibility of thoracic and lumbar spine. There was also increase in the strength of knee flexors and extensors. Another study conducted by Thomas et al. (2005) compared the effects of Tai Chi, resistance training and usual physical activity on cardiovascular risk factors for the period of 12 months, they found out that Tai Chi had no significant effect on any of the risk factors compared to resistance training and usual physical activity. Jing, Dong, Youlian, Dong, Youlian. (2009) examined the effect of Tai Chi exercises on lower extremity muscles in old age patients; they found increase in the strength and coordination of knee flexors but there was no significant improvement in the strength of knee extensors and muscles of ankles as was reported in the study by Lan et al. (1998). It was proposed that limited time intervention could be cause of less significant improvement when compared with the study by Lan et al. (1998). Wolf et al. (2003), who explored the effect of Tai Chi, education and computerized balance training on the occurrence of fall and biomedical, functional and psychosocial indicators of frailty on elderly population 70 years and older. It was found out that there was an increase in range of motion of lower extremity and reduction in fear of falling response in the group who were given Tai Chi

intervention for 15 weeks. As seen above different studies have shown variable effects of Tai Chi on mental health, balance and strength of lower extremity muscles but the results of the study are variable due to difference in time of intervention and research protocol.

## 1.5 Tai Chi and Osteoarthritis

Although Tai Chi is not a recommended form of treatment by OARSI but some studies have also shown Tai Chi to be effective in treatment for OA in the body. Brismee and colleagues (2007), tested the effect of Tai Chi program on individuals 70 years and older for a period of 12 weeks, it was found out that participants showed significant reduction in knee pain and stiffness and better WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) scale functions. Reduction in pain and stiffness was also reported in the 12 weeks clinical trial conducted by Song, Lee, Lam and Bae. (2003), in women suffering from OA. In a systemic review Lee, Pittler and Ernest (2007), compared research on controlled clinical trials across the literature to see the effects of Tai Chi on OA. On comparing five randomized clinical trial (RCT) and seven non randomized clinical trials (CCT), Lee at al. (2007) found out that three RCT shoed reduction in pain as compared to two RCT which showed no reduction in pain. Two RCTs showed improvement in physical activity but other RCTs failed to do so. Although studies have shown the positive effect of Tai Chi on OA patients but the results are still variable. The variation in the results can be due to difference in intervention technique, duration of intervention and variability in the testing samples (Lee, Pittler & Ernest, 2007)

## 1.6 Strength Training and Osteoarthritis

Various studies have shown strength training beneficial in treatment of OA knee joint (Schilke, Johnson, Housh & O'Dell, 1996). According to Schilke, Johnson, Housh and O'Dell

(1996), isometric and isotonic exercises of muscles of knee joint are prescribed to relieve the various symptoms related to OA knee joint such as pain, stiffness, strength and to slow down the progress of OA in the knee joint. Increase in muscle strength can help in providing additional support to the knee joint (Baker et al, 2001; Mikeskey et al, 2006; Schilke, Johnson, Housh & O'Dell, 1996). In a study by Schilke, Johnson, Housh and O'Dell (1996), where they looked at the effects of isokinetic resistance exercises of flexor and extensors of knee on 10 subjects with OA knee joint for period of 8 weeks. It was found that people in experimental group showed significant decrease in pain, stiffness and increase in mobility and strength in muscles around knee joint. Similar results were reported in the study by Baker and colleagues (2001) where they looked at the effects of progressive home based 4 month strength training exercises program o patient suffering from OA knee joint aged 55 and over, the patients reported significant reduction in pain and stiffness on WOMAC scale and increase in strength of muscles around knee. On the other hand in the study by Milesky and colleagues (2006) where they looked at the effect of strength training and range of motion exercises on the lower extremity strength of the patients with knee OA for a 30 month period it was found out that both strength training and range of motion exercise group showed loss in strength after 30 month but rate of lost was slower in strength training in comparison to range of motion group. Overall most of the studies have shown strength training as an important and most common form of treatment prescribed by the clinician to slower the progression and improving the symptoms associated with OA knee joint (Baker et al, 2001; Hurley & Scott, 1998; Maures, Stern, Kinossian, Cook & Schumacher, 1999; O'Reily, Muir & Doherty, 1999 & Schilke, Johnson, Housh & O'Dell, 1996). Though the studies have shown strength training to be important in relieving the symptoms of OA knee joint but the type of training and exercise dosage varied from study to study.

## 1.7 Hypothesis

As discussed earlier that there is no proper criteria for the treatment of OA knee joint with different non pharmacological treatment methods. Tai Chi is not included in the OARSI recommendation but it has shown positive effects in patients suffering from OA knee joint. On the other hand strength training is very common form of non pharmacological treatment prescribed for OA knee joint but there is no proper dosage and pattern available for these exercises. The results with all forms of treatment are still variable. The main aim of this study is to design a program that is feasible for old age OA patients and to examine the effect of Tai Chi program and compare it to strengthening exercises by taking into account knee pain, lower limb muscle strength, range of motion in OA patients. It is hypothesized that strength training and Tai Chi program are helpful in alleviating symptoms of OA knee joint such as pain, balance, increase in range of motion and muscle strength and because of low impact nature of Tai Chi exercises they will be better suited for alleviating the symptoms of pain, stiffness and balance in old age population suffering from OA knee joint.

## 1.8 Purpose of the Study

The study would help us in understanding the effects of both forms of exercises (Tai Chi and strength training exercises) in better way and which form is better suited as a non surgical form of treatment in older population with OA knee joint. The study would help us to develop more suitable, risk free and feasible form of exercises for old age people with knee OA. The effects of these exercises would allow old age people to live in a more independent life and reduce the chance of developing more severe form of OA. This will also provide people with an

alternative form of treatment to take reduce the probability of OA knee joint and prolong the degeneration process in osteoarthritis knee joint.

## 2 METHODS

### 2.1 Participants:

In the proposed study 20 participants aged 60 and above with self reported OA and medical record showing diagnosis of OA were recruited from two senior centers in metropolitan Atlanta. The participants were included in the study by the word of mouth. Senior centers in the metropolitan Atlanta were contacted by email, phone and meeting. Participants were informed about the purpose of the study, its benefits, time commitment and potential risk. To be part of the study the individual should be aged 55 and over, suffering from OA knee joint Grade I-III (confirmed from physician report) .The exclusion criteria for the study comprised of OA symptoms in the hip or ankle joint, the total or partially hip or knee arthroplasty (removal of deformed fragment and replacement with prosthesis), previous experience with Tai Chi, recreational physical activity more than twice per week, inability to walk without a walking aid, arthroscopic surgery or intra articular injection within 3 month, low back pain referred to the lower limbs, and not able to see, hear and follow instructions. Twenty participants who met the aforementioned criteria signed an informed consent form which stated the potential benefits, type and duration of study, risk factors involved, voluntary participation and confidentiality of data process. A copy of consent form was given to the participants for the records. The participants were randomly divided into two groups by taking out slips from a box with person on odd attempts going to strength training group and person with even attempts going to Tai Chi group. The participants were then asked to have the pre test which was as explained below. Out of 10

people in each group 8 people from each group completed the study. One person from strength training group had to undergo surgery and had to drop out the study while the other participant was not able to perform exercise for complete duration of time and used to get tired early and stopped doing exercises. On the other hand in the Tai Chi group one participant got sick in the middle of the study and was not able to complete the study in time while the other participant left the study as she did not think the exercises to be beneficial for her.

## 2.2 Pretest:

Pretest comprised of measuring the participants' health status in terms of pain, stiffness and problem in doing activities of daily living, range of motion, balance and muscle strength. At the beginning of the testing session, the participants first filled out the WOMAC scale. The ROM tests of the two lower limb joints of hip and knee were measured, respectively using a handheld goniometer when the participant was lying supine on a treatment table. The flexion, extension, abduction, adduction, internal rotation and external rotation ROM of hip joint and flexion of knee joint were measured three times. The average of three measurements was used for further analyses. Manual Muscle testing of the muscles of lower limb was done by a physical therapist while the participant performed different movements related to the specific muscles and checked for muscle strength as described by manual muscle testing (Appendix D). The participant were then asked to perform the Berg Balance scale task (Appendix C)

The description of measurement is as follows:

**WOMAC scale (Western Ontario and McMaster Universities Osteoarthritis Index):** The WOMAC scale is the widely used to measure the level of disability for people suffering from OA of knee and hip. The scale has four subgroups of pain, stiffness, physical function,

social function and emotional functions with 5, 2, 17, 7 and 10 questions respectively. Each question was rated on Likert scale of 0 to 4. The emotional functions and social function scale were the part of the index at the point of development but were later were removed. According to Bellamy (2005), though emotional and social function does not appear in OARSI guidelines but they are one of domain in IMMPACT (Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials) guidelines. WOMAC scoring has been found to be valid and reliable index in patient suffering from OA of knee and hip (Bellamy, 2005; McConell, Kolopack & Davis, 2001). According to Roos, Klassbo and Lohmander (1999) where they tested the WOMAC index for Swedish population, the scale was found to be internally consistent. Main focus of this questionnaire is to look for joint pain, stiffness loss of ADL's and effect of disability on social and emotional functions (Appendix B).

**Range of Motion:** Active range of motion of hip and knee was measured with the help of goniometer. The range of motion for hip included hip flexion/extension, hip abduction/adduction, hip internal rotation/external rotation. The range of motion for knee included knee flexion. The participants was asked to lie on the couch (both in supine and prone position), or sit in long sitting position as required for taking each measurement. The participants performed each movement three times actively. The mean degree of movement in each joint was calculated.

**Balance:** The balance of the participants was measured by means of the Berg Balance Scale. Berg balance scale includes 14 test items related to individual balance abilities, functional balance or balance during movement (Lajoie & Gallagher, 2004). The berg balance scale is seen to be associated with 91% sensitivity and 97% specificity (Lajoie & Gallagher, 2004). The total

score on Berg Balance scale is 56 with and a person scores less than 45 is considered to be at risk of falling (Appendix C).

**Muscle strength:** Muscles strength of the hip and knee was measured with the manual muscle testing (Kendall, McCreary & Provance, 1993). According to this technique the muscle strength of the patients in the muscle of hip and knee was graded manually form 0 to 10 grades as explained by Kendall, McCreary and Provance (1993) (Appendix D). The muscle to be measured for the strength included quadriceps and hamstrings at hip and knee.

## 2.3 Schedule:

The participants who were eligible for the study were randomly divided into strength training group and tai chi group for a period of two months, two times each week with total 16 sessions.

**Strength training group**: This group performed strength training exercises for muscles of hip, knee and ankle. The participants performed these exercises in a group twice a week for eight weeks approximately one hour each time under the supervision of the researcher. Each strength training session was divided into three parts (Appendix E): *1) Warm up period*: Involving repetitive low intensity range of motion exercises for 5 min *2) Strengthening period*: Participants will be asked to perform strengthening exercises for hip, knee and ankle (about 40 min) *3) Cool down:* Involving static stretching of the muscle for 5 minutes to provide relaxation.

**Tai Chi Group**: This group performed Tai Chi (10 forms) twice a week for eight weeks. The participants performed exercises in group one hour each time under the supervision of Tai Chi Instructor for approximately one hour. The session was divided into three parts *1) Warm up period*: Involving repetitive low intensity range of motion exercises for 5 min 2) *Exercise period*:

participants will perform 10 forms of standing Tai Chi under the supervision of instructor for 40 minutes. *3) Cool Down*: Involving static stretching of the muscle for 5 minutes to provide relaxation.

## 2.4 Post Test

After the completion of intervention schedule, all the subjects took part in the post test which was the same measures as used in pre test.

## 2.5 Statistical Analysis:

In this experiment the independent variables are type of exercises (Strength training and Tai Chi exercises) and the dependent variables include strength, range of motion, balance, flexibility, muscle strength and score on WOMAC scale. All the measurements were measured both before and after the intervention. Independent t test and paired t test were used to calculate between the group difference and within the group difference, respectively for all the variables. SPSS software version 19 was used to calculate the variations in 29 pairs of variable including WOMAC questionnaire, Berg Balance, muscle strength and range of motion. The values are expressed as mean± standard deviation (SD). The differences were considered statistically significant at $p< 0.05$ and very significant at $p<0.01$.

# 3 RESULTS

The study was carried out from February to May in two senior centers in metropolitan Atlanta. Out of 10 participants in each group 8 participants in each group completed the study. The data of one participant in Tai Chi group was not used fully as there was some missing pre test data. Both within the group and between the group analyses were performed.

### 3.1 WITHIN GROUP ANALYSIS

**Demographic variables:** The mean age (SD) of participants in strength training group and Tai Chi group was 82.8± 10.6 and 82±11.35 years old, respectively (Table 2). Both the groups had equal ratio of (3) male and (5) female subjects. Seven people in strength training group performed other form of exercises more than three or more times per week while six people in Tai Chi groups perform other forms of exercises three or more time per week (Table 2). Only one person in Tai Chi group didn't perform any other form of exercises in Table 2.

Table 2: Demographic pre test variables in both groups

| Variables | Strength Training | Tai Chi |
|---|---|---|
| Age | 82.8±10.6 years | 82±11.35 years |
| Sex (M/F) | 3/5 | 3/5 |
| Level of exercise<br>• Zero times per week<br>• One time per week<br>• Two times per week<br>• Three or more times per week | <br>0<br>1<br>0<br>7 | <br>1<br>0<br>1<br>6 |

**WOMAC scores:** Both the group showed significant improvement in the arthritis symptoms with decrease in WOMAC scores in Table 3. The WOMAC total scores for strength training group (52 to 40.5) and Tai Chi group (52.28 to 38.57) were found to be statistically significant at $p<.05$ (Table 3). Both the groups also showed significant reduction in pain score at $p<.05$ with mean score for strength training group changing from 6.37 to 4.2 (Table 3) and that of Tai Chi group changing from 7.57 to 4.57 (Table 3). Though the stiffness scores decreased but no significant change was found after the intervention. The Tai Chi group also showed significant

reduction in WOMAC scores for emotional functions with a reduction from 11.28 to 6.57 at p<.05 (Table 3).

Table 3: Within Group Comparison of WOMAC sub scales and Berg Balance in Tai Chi and Strength Training Group.

| VARIABLE | **STRENGTH TRAINING** | | **TAI CHI** | |
|---|---|---|---|---|
| | PRE | POST | PRE | POST |
| | MEAN (SD) | MEAN (SD) | MEAN (SD) | MEAN (SD) |
| WOMAC TOTAL | 52(34.32) | 40.5(32.36)* | 52.28(23.29) | 38.57(26.24)* |
| WOMAC PAIN | 6.37(4.80) | 4.12(4.08)* | 7.57(3.59) | 4.57(4.15)* |
| WOMAC STIFFNESS | 2.87(2.35) | 2.12(1.88) | 3.42(2.22) | 3(2.82) |
| WOMAC PHYSICAL FUNCTION | 25.62(18.14) | 20.75(17.30) | 23.14(14.81) | 19.85(15.76) |
| WOMAC SOCIAL FUNCTION | 6.87(9.80) | 5.12(3.94) | 7.71(7.25) | 5(5.32) |
| WOMAC EMOTIONAL FUNCTION | 10.2(6.18) | 8.6(10.39) | 11.28(6.42) | 6.57(4.64)* |
| BERG BALANCE | 36.75(6.13) | 46(5.18)* | 39.14(7.84) | 47.42(5.91)** |

*Significant change at p<.05 ** Very Significant change at p<.001

**Berg Balance scores:** Both the groups showed statistically significant improvement in the berg balance scores. The mean score for strength training group increasing from 36.75 to 46 at significance level of p<.05. Tai Chi groups showed very significant improvement in Berg Balance score with mean increase from 39.14 to 47.42 at p<.001.

**Range of Motion:** Both strength training and Tai Chi group showed no significant improvement in range of motion of hip and knee joint movements on lower extremities (Table 4).

Table 4: Within Group Comparison of Range of Motion in Tai Chi and Strength Training Group

| VARIABLE | **STRENGTH TRAINING** | | **TAI CHI** | |
|---|---|---|---|---|
| | PRE | POST | PRE | POST |
| | MEAN (SD) | MEAN (SD) | MEAN (SD) | MEAN (SD) |
| HIP FLEXION RT | 97(13.78) | 97.75(15.13) | 108.09(10.53) | 107.38(11.83) |
| HIP FLEXION LT | 91.7(18.8) | 96.12(15.63) | 106.38(13.59) | 110.52(16.20) |
| HIP EXTENSION RT | 27.75(14.90) | 28.62(15.02) | 21.80(4.89) | 23.04(3.71) |
| HIP EXTENSION LT | 25.37(15.60) | 25.58(12.88) | 22.76(10.11) | 23.28(10.07) |
| HIP ABDUCTION RT | 45.70(14.04) | 46(17.7) | 43.28(17.08) | 38.61(13.02) |
| HIP ABDUCTION LT | 42.5(12.43) | 40.37(12.98) | 40.66(15.24) | 38.04(12.47) |
| HIP ADDUCTION RT | 23.5(6.16) | 24.2(7.40) | 33.33(10.80) | 33.71(11.43) |
| HIP ADDUCTION LT | 22.62(10.37) | 24(8.61) | 33.57(12.41) | 33.19(10.31) |
| HIP INTERNAL ROTATION RT | 29.25(14.55) | 30.04(13.79) | 37(16.06) | 37.28(16.56) |
| HIP INTERNAL ROTATION LT | 26.16(13.65) | 24.50(13.15) | 33.61(16.40) | 35.90(15.27) |
| HIP EXTERNAL ROTATION RT | 30.41(10.41) | 28.25(8.63) | 37.76(13.83) | 42.47(15.96) |
| HIP EXTERNAL ROTATION LT | 31.29(14.35) | 29.75(10.99) | 38.71(16.70) | 41.61(17.49) |
| KNEE FLEXION RT | 111.33(9.01) | 114.75(8.77) | 126(10.61) | 127.8(15.43) |
| KNEE FLEXION LT | 111.33(11.85) | 109.70(14.62) | 120.66(17.41) | 121.16(16.50) |

**Muscle Strength:** Tai Chi group showed no significant increase in the muscle strength for any of the muscle measured around hip and knee. On the other hand, the strength training group showed significant increase in muscle strength for quadriceps at knee right leg, quadriceps at hip both legs, hamstrings at knee both legs and hamstrings at hip both leg at $p<.05$ (Table 5)

Table 5: Within Group Comparison of Muscle Strength In Tai Chi and Strength Training Group

| VARIABLE | **STRENGTH TRAINING** | | **TAI CHI** | |
|---|---|---|---|---|
| | PRE | POST | PRE | POST |
| | MEAN (SD) | MEAN (SD) | MEAN (SD) | MEAN (SD) |
| QUAD AT KNEE RT | 7.37(1.06) | 8(1.06)* | 7.87(.64) | 8.12(.83) |
| QUAD AT KNEE LT | 7.5(1.19) | 8.12(.99) | 7.87(.99) | 8(.92) |
| QUAD AT HIP RT | 6.87(1.12) | 8(.75)* | 7.75(1.16) | 7.62(.91) |
| QUAD AT HIP LT | 6.87(1.35) | 8(.53)* | 7.25(1.38) | 7.75(.88) |
| HAMSTRING AT KNEE RT | 7.5(1.06) | 8.3(.91)* | 7.5(.53) | 7.87(1.12) |
| HAMSTRING AT KNEE LT | 7.5(1.06) | 8.5(.92)* | 7.37(.74) | 7.62(1.30) |
| HAMSTRING AT HIP RT | 7.25(1.03) | 8.12(.83)* | 7.12(1.12) | 7.37(1.18) |
| HAMSTRING AT HIP LT | 7.12(1.12) | 8.12(.83)** | 7.25(1.03) | 7.25(1.28) |

*Significant change at $p<.05$ **Very significant change at $p<.001$

## 3.2 BETWEEN THE GROUP ANALYSIS

The analysis between Tai Chi group and strength training group was conducted by taking the difference of their post test and pre test scores and running the independent t-test. On the analysis no significant difference was found in the WOMAC scores and Berg balance scores (Table 6), range of motion (Table 7). The muscle strength (Table 8) difference between two groups was also not found to be statistically significant, except the significant improvements were found in the quadriceps at the hip right leg and the hamstring at the hip left leg for strength training group with the scores 1.12 and 1.00 higher than that of Tai Chi groups, respectively, $p<0.05$ (Table 8)

Table 6: Between the Group Comparison of WOMAC sub scales and Berg Balance in Tai Chi and Strength training group

| VARIABLE | **STRENGTH TRAINING** | **TAI CHI** |
|---|---|---|
| | MEAN (SD) | MEAN (SD) |
| WOMAC TOTAL | -11.50(12.58) | -13.71(9.69) |
| WOMAC PAIN | -2.25(1.58) | -3(1.63) |
| WOMAC STIFFNESS | -.75(1.03) | -.42(2.50) |
| WOMAC PHYSICAL FUNCTION | -4.8(6.66) | -3.2(4.3) |
| WOMAC SOCIAL FUNCTION | -1.7(7.5) | -2.7(5.31) |
| WOMAC EMOTIONAL FUNCTION | -1.6(5.78) | -4.7(5.0) |
| BERG BALANCE | 9.2(6.67) | 8.2(3.19) |

Table 7: Between The Group Comparison of Range of Motion in Tai Chi and Strength Training Group

| VARIABLE | **STRENGTH TRAINING** | **TAI CHI** |
|---|---|---|
| | MEAN (SD) | MEAN (SD) |
| HIP FLEXION RT | .75(4.29) | .71(4.07) |
| HIP FLEXION LT | 4.41(5.90) | 4.14(9.41) |
| HIP EXTENSION RT | .87(2.21) | 1.2(1.90) |
| HIP EXTENSION LT | .20(3.69) | .52(4.02) |
| HIP ABDUCTION RT | .29(5.02) | -4.66(8.42) |
| HIP ABDUCTION LT | -2.12(3.39) | -2.61(4.95) |
| HIP ADDUCTION RT | .70(4.39) | .38(2.75) |
| HIP ADDUCTION LT | 1.37(3.69) | -.38(3.66) |
| HIP INTERNAL ROTATION RT | .79(1.50) | .28(2.61) |
| HIP INTERNAL ROTATION LT | 3.58(10.32) | 8(13.68) |
| HIP EXTERNAL ROTATION RT | -2.16(7.43) | 4.71(5.33) |
| HIP EXTERNAL ROTATION LT | -1.54(6.23) | 2.9(4.99) |
| KNEE FLEXION RT | 3.41(8.98) | 1.8(6.46) |
| KNEE FLEXION LT | -1.62(5.82) | .50(5.11) |

Table 8: Between The Group Comparison of Muscle Strength in Tai Chi and Strength Training Group

| VARIABLE | **STRENGTH TRAINING** | **TAI CHI** |
|---|---|---|
| | MEAN (SD) | MEAN (SD) |
| QUAD AT KNEE RT | .62(.74) | .25(.46) |
| QUAD AT KNEE LT | .62(.91) | .12(.64) |
| QUAD AT HIP RT | 1.12(.64)* | -.12(.99) |
| QUAD AT HIP LT | 1.12(1.12) | .50(1.06) |
| HAMSTRING AT KNEE RT | .87(.83) | .37(.74) |
| HAMSTRING AT KNEE LT | 1(.75) | .25(1.03) |
| HAMSTRING AT HIP RT | .87(.64) | .25(1.03) |
| HAMSTRING AT HIP LT | 1.00(.53)* | .00(.92) |

*significant change at $p<.05$

# 4 DISCUSSION

## 4.1 WITHIN THE GROUP

As there is no permanent cure for OA knee joint various preventing measures like exercises are being used to slower the progress and prevent OA knee joint. The present study looking at the effect of 8 weeks intervention of Tai Chi and strength training on OA knee joint resulted in significant reduction of knee pain and improvement of arthritic symptoms in elderly with knee osteoarthritis in both strength training and Tai Chi group. The study showed significant improvement in total WOMAC scores, and WOMAC scores for pain and emotional function in the Tai Chi group. The results are in accordance with the studies conducted by Song, Lee, Lam, and Bae (2007) and Brismee and colleagues (2007) where they also reported significant improvement in overall knee pain on WOMAC scale. The present study also reported significant improvement in emotional function subscale of WOMAC. Though this scale is not used in any of the previous study but studies by Lee and colleagues (2009) showed significant improvement on mental subscale of SF36 tool. The present study didn't show significant change in the scores for physical function and stiffness. Though score for physical function on WOMAC subscale reduced considerably but they were not found to be significant. The studies by Song, Lee, Lam and Bae (2007), Brismee and colleagues (2007) and Fransen, Nairn, Winstanley, Lam and Edmonds (2007) showed significant improvement in physical function and stiffness but time period of intervention in these studies was longer12 weeks in each study) in comparison to our study. The study by Lee and colleagues (2009) which was conducted for similar amount of time as the present study also reported improvement in physical functions and stiffness but they were not statistically significant. These findings validate the point of longer intervention time for more significant results and Tai Chi exercises if done for longer period of

time may have more positive outcome on patient with OA knee joint in the improvements of joint pain and stiffness. The present study also showed very significant improvement in balance in people with OA in Tai Chi group. Though only one previous study by Song, Lee, Lam and Bae (2003) have looked at the balance in the women with OA knee joint and found Tai Chi to have significant effect of balance but no study has used Berg Balance scale to test balance in patient suffering from OA knee joint. The improvement in the berg balance score in Tai Chi group was similar to that of the other studies looking at the role of Tai Chi on balance in elderly people by Fuzhong and colleagues (2004).

Although Tai Chi group showed improvement in balance and WOMAC scores but no significant changes were found in ROM and muscle strength. This suggests that Tai Chi may not have an effect on flexibility of lower extremities of the patients with OA at knee joint. Similar findings were reported in the study by Brismee and colleagues (2007) and Song, Lee, Lam and Bae (2003) where they looked at range of motion and flexibility for knee joint. The major reason behind no change of range of motion might be that the people in the study are in very old age and due to lack of balance are not able to perform the exercise to full extent (Brismee et al, 2007). There was also no improvement shown in the hip- knee flexors and extensors in Tai Chi group in this study. No other study looked at strength of muscle at hip joint. Two other studies have reported the knee muscle strength in patient with OA at knee joint doing Tai Chi. Study by Song, Lee, Lam and Bae (2003) reported no improvement in strength of muscle in knee joint after 12 weeks of intervention in women with OA at knee joint while study by Song, Robert, Lee, Lam and Bae (2010) reported increase in endurance of knee extensor following 6 months of Tai Chi. According to Song, Lee, Lam and Bae (2003) longer time period may be required to induce strength in muscle of lower limb from Tai Chi.

On the other hand strength training group reported similar changes following intervention for 8 weeks with decreased total WOMAC score, WOMAC pain score and increase balance. The strength training group also reported significant increase in the muscle strength of the hip-knee flexor and extensors. The results of the study for strength training group were similar to that of the previous studies by Baker and colleagues (2001) and Reily, Muir and Doherty (1998) where they reported reduction in WOMAC total, pain, stiffness and physical function scale after strength training for 4 months and 6 months, respectively. The results of the present study in relation to stiffness and social function were found to be encouraging but not significant. The main reason of lacking significant improvement may be due to the relatively shorter Tai Chi intervention period.

Strength training group also showed no significant variation in the range of motion similar to Tai Chi group but there was significant increase in the strength of the hip and knee muscles following a 2-month intervention. No previous studies looked at the effect of strength training on the hip joint muscle in patients with OA knee joint. But the studies have shown strength training to be effective in improving quadriceps strength on the knee joint. Study by Hurley and Scott (1998); Maurer and colleagues (1999); Baker and colleagues 2001; Hurley and Scott, 1998; Maures, Stern, Kinossian, Cook and Schumacher showed improvement in quadriceps muscle strength which is similar to our study

.Both the groups showed improvements in arthritic symptoms for people with OA knee joint. This finding validates one of the proposed hypotheses that both Tai Chi and strength training would have beneficial effects on reducing pain, stiffness, improving balance and strength in people with OA knee joint.

## 4.2 BETWEEN THE GROUP

In the present study no significant difference was found on comparing two groups for their effects on symptoms of people suffering from OA knee joint. Both the groups showed improvement but one type of intervention could not be considered better than other one. Only significant variation was found in the muscle strength of quadriceps and hamstring at the hip joint in strength training group was significantly better than Tai Chi group. But this significant change was also not seen in both the lower extremities which create doubt over its consistency. Other than this though no significant variation was found in the emotional function and balance between the groups but Tai Chi was seen to be more effective in improving balance and emotional function in within group comparison and strength training was seen to be more effective in improving strength in within group comparison. The main reason behind lack of significant changes on between the groups may be due to a shorter intervention period and small sample size. As per this study both Tai Chi and Strength training are equally beneficial in improving symptoms of OA knee joint. This statement support the proposed null hypothesis that both Tai Chi and strength training are equally beneficial in improving symptoms of elderly with OA knee joint

# 5 CONCLUSION

The present study has shown both Tai Chi and strength training to be an effective option in treating OA knee joint in elderly. The study also showed both Tai Chi and strength training to be effective in alleviating the symptoms of OA knee in a relatively shorter period of time. The results of the present study were found to be similar to the results of the previous studies looking at the effect of strength training and Tai Chi on OA knee joint. Though the present study showed

both forms of exercises beneficial for people with OA knee joint but no significant difference was found predicting Tai Chi to be better than strength training. The results of the present study demonstrated that Tai Chi 10 forms can be used as an alternative and risk free form of treatment for the old adults suffering from OA knee joint. Our study didn't look at the variation of gender , effect of longer intervention and follow up after the intervention has been stopped to look for how long positive effects can be maintained. The age group used in the present study was very vast and the outcome variables were more subjective. Future studies should look at these changes in larger sample size with longer intervention. Future research should also use more experimental tools rather than subjective tools for outcome measures such as dynamometer to measure muscle strength, 3D motion analysis to measure gait pattern and balance and radiographic imagery to look at the anatomical changes in the knee joint. The generalization of the results of the present study should be used cautiously because of its small sample size.

## 6 LIMITATIONS

The present study showed the beneficial effects of Tai Chi and strength training exercises in improving arthritic symptoms in patients suffering from OA knee joint. The limitation of the study can be as follows. Though the participants were randomly assigned to the group, the numbers of subjects were really small and individual variance could reduce the study power. The Eight week intervention may be too short to see the more significant changes in the participating subjects. Most of the tests used in the study were subjective and can lead to some error and less accuracy. The present study only looked at the immediate effect of the intervention and no follow up was carried out to look at the detraining phase and which exercises have more long lasting effects. Self reported OA was used as inclusion criteria. These are some of the limitations of the study. For the future research more laboratory experimental

tools should be used to measure different variables associated with OA knee joint as the results can be more accurate. For example we can use dynamometer to measure the muscle strength and electronic goniometer to measure range of motion. A longer intervention time and large sample size can help us reduce the variance within the participants and also a follow up test may be conducted to determine long time effect.

# 7 REFERENCES

Altman, R.D. (1987). Criteria for classification of osteoarthritis of knee and hip. *Scandinavian Journal of Rheumatology (65),* 31-39.

Ananian, C.D., Wilcox, S., Saunders, R., Watkins, K., & Evan, A. (2006). Factors that influence exercises in adults with arthritis in three activity levels. *Preventing Chronic Disease 3(3).*

Baker, K.R., Nelson, M.E., Felson, D.T., Layne, J.E., Sarno, R., & Roubenoff, R. (2001). The efficacy of home based progressive strength training in older adults with knee osteoarthritis: a randomized controlled trial. *The Journal of Rheumatology 28(7),* 1655-65.

Baar, M.E., Assendelft, W.J., Dekker, J., Oostendorp, R.A., & Bijlsma, J.W.(1999). Effectiveness of exercise therapy in patients with osteoarthritis of hip and knee. *Arthritis and Rheumatism 42(7).* 1361-1369.

Bellamy,N. (2005). The WOMAC knee and hip osteoarthritis indices: development, validation, globalization and influence on the development of the AUSCAN hand osteoarthritis indices. *Clinical and Experimental Rheumatology 23.* 148-153.

Bitton, Ryan. (2009). The economic burden of osteoarthritis. *American Journal of Managed Care, 15, S230- S235.*

Brismee, J.M., Paige, R.L., Chyu,M.C., Boatright, J.D., Hagar, J.M., McCaleb, et al. (2007). Group and home based Tai Chi in elderly subjects with knee osteoarthritis: a randomized control trial. *Clinical Rehabilitation 21(2),* 99-111.

Center for Disease Control and Prevention (2010). Ostreoarthritis, Retrieved from http://www.cdc.gov/stroke/

Diracoglu, D., Baskent, A., Celik, A., Issever, H., & Aydin, R. (2008). Long term effects of kinesthesia/balance and strengthening exercises on patients with knee osteoarthritis: a one year follow up study. *Journal of Back and Musculoskeletal Rehabilitation 21(4).* 253-262.

Felson, D. T. and Y. Zhang. (1998). An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. *Arthritis & Rheumatism* 41(8): 1343-55.

Felson, D. T., R. C. Lawrence. et al. (2000). Osteoarthritis: new insights. Part 1: the disease and its risk factors. *Annals of Internal Medicine* 133(8): 635-46

Fransen M, Nairn L, Winstanley J, Lam P, Edmonds J.(2007) Physical activity for osteoarthritis management: a randomized controlled clinical trial evaluating hydrotherapy or Tai Chi classes. *Arthritis and Rheumatology.57(3).*407

Hain, C.T., Fuller, L., Weil, L., & Kotsias, J, (1999). Effects of tai chi on balance. *Archives of Otolaryngology Head, Neck Surgery 125.* 1191-1195.

Hurley,M.V., & Scott,D.L. (1998). Improvement in quadriceps sensorimotor functions and disability of patients with knee osteoarthritis following a clinically practicable exercise regime. *British Journal of Rheumatology. 37(11).* 1181-7.

Jing, Li., Dong, Xu ., Youlian, H., Dong, Xu., Youlian, H. (2009). Change in muscle strength, endurance, and reaction of the lower extremities with tai chi intervention. *Journal of Biomechanics 42(8),* 967-971.

Kendall, F.P., McCreary, E,K., & Provance, P.G. (1993). Muscles testing and function. Lippincott, William and Wilkins.

Lan, C.,Lai, J.S.,Chen, S.Y.,Wong, M.Y. (1998). 12 month tai chi training in elderly: its effect on health fitness. *Medicine & Science in Sports & Exercise 30 (3),* 345-351.

Lajoie, Y., & Gallagher, S.P. (2004). Predicting falls within elderly community: comparison of postural sway, reaction time, the berg balance scale and activities- specific balance confidence (ABC) scale for comparing fallers and non fallers. *Archives of Gerontology and Geriatrics (38),* 11-26.

Lee, E.,Chae, Y., Song, R., Eom, A., Lam, P., Heitkemper M. (2010). Feasibility and effect of tai chi self help education program for Korean gastric cancer survivors. *Oncology Nursing Forum 37 (1), E1- E6*

Lee, H.J., Park H.J., Chae, Y., Kim, S.Y., Kim, S.N., Kim, S.T., Kim, J.H., Yin. C.S., & Lee H (2009). Tai Chi Qigong for the quality of life of patients with knee osteoarthritis: a pilot, randomized, waiting list controlled trial. *Clinical Rehabilitation.23(6):*504-11.

Lee, S.M., Pittler, M.H., & Ernst, E.(2007). Tai Chi for osteoarthritis: a systemic review. *Clinical Rheumatology 27 (2),* 211-218.

Maurer,B.T., Stern,A.G., Kinossian,B., Cook,K.D., & Schumacher,H.R.(1999). Osteoarthritis of the knee: isokinetic quadriceps exercises versus educational intervention. *Archives of Physical Medicine and Rehabilitation. 80(10).* 1293-9.

McConell, S., Kolopack,P., & Davis,A.M. (2001) The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): a review of its utility and measurement properties. *Arthritis Care and Research 45(5).* 453-461.

Mikesky, A.E., Mazzuca, S.A., Brandt, K.D., Perkins, S.M., Damush, T., & Lane, K.A. (2006). Effect of strength training on incidence and progression of osteoarthritis knee joint. *Arthritis and Rheumatism, 55(5),* 690-9.

Moskowitz, Roland W. (2009). The burden of osteoarthritis: clinical and quality of life issues. *American Journal of Managed Care, 15,* S223- S229.

Ni, G.X., Song, L., Yu, B., Huang, C.H., &,Lin, J.H. (2010). Tai chi improves physical function in older Chinese women with knee osteoarthritis. *Journal of Clinical Rheumatology.16(2):*64-7.

O'Reilly,S.C., Murer, K.R., & Doherty, M. (1999). Effectiveness of home exercise on pain and disability from osteoarthritis of the knee: a randomised controlled trial. *Annals of The Rheumatic Diseases, 58,* 50-9.

Roddy, E., Zhang, W., Doherty, M., Arden, N.K., Barlow,J., Birell,F. et al. (2005). Evidence-based recommendations for the role of exercises in the management of osteoarthritis of the hip and knee- the MOVE consensus. *Rheumatology 44(1).* 67-73.

Roos, E.M., Klassbo,M., & Lohmander, L.S.(1999). WOMAC osteoarthritis index. Reliability, validity and resposivness in patients with arthroscopically assessed osteoarthritis. Western Ontario and MacMaster Universities. *Scandinavian Journal of Rheuamtology 28(4),* 210-5.

Schilke, J.M., Johnson, G.O., Housh, T.J., O'Dell, J.R. (1996) Effect of muscle strength training on the functional status of the patients with osteoarthritis the knee joint. *Nursing Research, 45(2),* 68-72.

Shamir L., Ling S., William W., Angelo B., Orlov N., Tomasz J. et al. (2009). Knee X-Ray image analysis methods for automated detection of osteoarthritis. *IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, 56 (2),*407-41.

Song, R., Lee, E.O., Lam, P., & Bae, S.C. (2003). Effects of Tai Chi exercise on pain, balance, muscle strength, and perceived difficulties in physical functioning in older women in osteoarthritis: a randomized clinical trial. *The Journal of Rheumatology 30(9), 2039-2044*

Song, R., Lee, E.O., Lam, P., & Bae, S.C.(2007) Effects of a Sun-style Tai Chi exercise on arthritic symptoms, motivation and the performance of health behaviors in women with osteoarthritis. *Journal of Korean Academy of Nursing 37(2):249-56.*

Song, R., Roberts, B.L., Lee, E.O., Lam, P.,& Bae, S.C.(2009). A randomized study of the effects of t'ai chi on muscle strength, bone mineral density, and fear of falling in women with osteoarthritis. J Altern Complementary Medicine. 16(3).227-33.

Thomas, G.N., Athena, W.L., Tomlinson, B., Lau, E., Lam, C.W. et al. (2005). Effects of tai chi and resistance training on cardiovascular risk factors in elderly Chinese subjects: a 12 month longitudinal, randomized, control, intervention study. *Clinical Endocrinology 63,* 663-66.

Wang, Y.T., Taylor, L., Pearl, M., & Chang, L.S. (2004). Effects of Tai Chi exercises on physical and mental health of college students. *The American Journal of Chinese Medicines 32(3).* 453-459.

Wolf, L.S., Barnhart, X.H., Kutner, G.N., Mcneely, E., Coogler, Carol et al (2003). Reducing frailty and falls in older person: an investigation of tai chi and computerized balance training. *The American Geriatrics Society 51,* 1794-1803.

Wood-Dauphinee S, Berg K, Bravo G, Williams JI (1997). The Balance Scale: Responding to clinically meaningful changes. *CanadianJournal of Rehabilitation, 10*. 35-50.

Zhang, W., Moskowitz, R.W., Nuki, G., Abramson, S., Altman R.D. et al. (2008). OARSI recommendations for the management of hip and knee osteoarthritis, part II: OARSI evidence – based, expert consensus guidelines. *Osteoarthritis and Cartilage (16),* 137-162.

# 8 APPENDIX A

## WOMAC™ Questionnaire

### The WOMAC (Western Ontario and McMaster Universities) Index of Osteoarthritis

Overview:

The WOMAC (Westren Ontario and McMaster Universities) index is used to assess patients with osteoarthritis of the hip or knee using 24 parameters. It can be used to monitor the course of the disease or to determine the effectiveness of anti-rheumatic medications.

Pain:

(1) Walking

(2) Stair climbing

(3) Nocturnal

(4) Rest

(5) Weight bearing

Stiffness:

(1) Morning stiffness

(2) Stiffness occurring later in the day

Physical function:

(1) Descending stairs

(2) Ascending stairs

(3) Rising from sitting

(4) Standing

(5) Bending to floor

(6) Walking on flat

(7) Getting in or out of car

(8) Going shopping

(9) Putting on socks

(10) Rising from bed

(11) taking off socks

(12) Lying in bed

(13) Sitting

(14) Sitting

(15) Getting on or off toilet

(16) Heavy domestic duties

(17) Light domestic duties

While the index was being developed performance of social functions and the status of emotional function were also included. These were not included in the final instrument.

Social function:

(1) leisure activities

(2) community events

(3) church attendance

(4) with spouse

(5) with family

(6) with friends

(7) with others

Emotional function:

(1) anxiety

(2) irritability

(3) frustration

(4) depression

(5) relaxation

(6) insomnia

(7) boredom

(8) loneliness

(9) stress

(10) well-being

| Scoring and Interpretation **Response** | **Points** |
|---|---|
| none | 0 |
| slight | 1 |
| moderate | 2 |
| severe | 3 |
| extreme | 4 |

# 9 APPENDIX B

BERG BALANCE SCALE

## 1. Purpose

The Berg's utility includes grading different patients' balance abilities, monitor functional balance over time and to evaluate patients' responses to treatment.

## 2. Content

The Berg is a test of 14 items; it is performance based and has a scale of 0-4 for each item (higher score for independent performance) with a maximum score of 56.
The Berg is considered the gold standard assessment of balance with good intra-rater reliability and inter-rater reliability and good internal validity (Dauphne, Berg, Bravo & Williams, 1997).

## 3. Assessment

1. **Sitting to standing**
   INSTRUCTIONS: Please stand up. Try not to use your hands for support

   4 able to stand without using hands and stabilize independently

   3 able to stand independently using hands

   2 able to stand using hands after several tries

   1 needs minimal aid to stand or to stabilize

   0 needs moderate or maximal assist to stand

2. **Standing unsupported**
   INSTRUCTIONS: Please stand for two minutes without holding

   4 able to stand safely for 2 minutes

   3 able to stand for 2 minutes with supervision

   2 able to stand for 30 seconds unsupported

   1 needs several tries to stand for 30 seconds unsupported

0 unable to stand for 30 seconds unassisted

3. **Sitting with back unsupported but feet supported on floor or on a stool**
   INSTRUCTIONS: Please sit with arms folded for 2 minutes

4 able to sit safely and securely for 2 minutes

3 able to sit for 2 minutes under supervision

2 able to sit for 30 seconds

1 able to sit for 10 seconds

0 unable to sit without support for 10 seconds

4. **Standing to sitting**
   INSTRUCTIONS: Please sit down

4 sits safely with minimal use of hands

3 controls descent by using hands

2 use back of legs against chair to control descent

1 sits independently but has uncontrolled descent

0 needs assistance to sit

5. **Transfers**
   INSTRUCTIONS: Arrange chair(s) for a pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs, (one with and one without armrests), or a bed and a chair.

4 able to transfer safely with minor use of hands

3 able to transfer safely definite need of hands

2 able to transfer with verbal cueing and/or supervision

1 needs one person to assist

0 needs two people to assist or supervise to be safe

**6. Standing unsupported with eyes closed**
INSTRUCTIONS: Please close your eyes and stand still for 10 seconds

4 able to stand 10 seconds safely

3 able to stand 10 seconds with supervision

2 able to stand 3 seconds

1 unable to keep eyes closed 3 seconds but stays steady

0 needs help to keep from falling

**7. Standing unsupported with feet together**
INSTRUCTIONS: Place your feet together and stand without holding

4 able to place feet independently and stand for 1 minute safely

3 able to place feet together and stand for 1 minute with supervision

2 able to place feet together independently to hold for 30 seconds

1 need help to attain position but able to stand 15 seconds feet together

0 needs help to attain position and unable to hold for 15 seconds

**8. Reaching forward with outstretched arm while standing**
INSTRUCTIONS: Lift arm to 90º. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at end of fingertips when arm is at 90º. Fingers should not touch the ruler while reaching forward). The recorded measure is the distance forward that the finger reaches while the subject is in the most forward lean position. (When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

4 can reach forward confidentially >25 cm (10 inches)

3 can reach forward >12.5 cm safely (5 inches)

2 can reach forward >5cm safely (2 inches)

1 reaches forward but needs supervision

0 loses balance while trying/requires external support

**9. Pick up object from the floor from a standing position**

INSTRUCTIONS: Pick up the shoe/slipper, which is placed in front of your feet.

4 able to pick up slipper safely and easily

3 able to pick up slipper but needs supervision

2 unable to pick up, reaches 2-5cm (1-2 inches) from slipper, keeps balance

1 unable to pick up and needs supervision while trying

0 unable to try/needs assist to keep from losing balance or falling

**10. Turning to look behind over left and right shoulders while standing**

INSTRUCTIONS: Turn to look directly behind you over toward left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

4 looks behind from both sides and weight shifts well

3 looks behind one side only, turn to other side demonstrates less weight shift

2 turns sideways only but maintains balance

1 needs supervision when turning

0 needs assist to keep from losing balance or falling

**11. Turn 360 degrees**

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

4 able to turn 360 degrees safely in 4 seconds or less

3 able to turn 360 degrees safely one side only in 4 seconds or less

2 able to turn 360 degrees safely but slowly

1 needs close supervision or verbal cueing

0 needs assistance while turning

**12. Placing alternate foot on step or stool while standing unsupported**

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.

4 able to stand independently and safely and complete 8 steps in 20 seconds

3 able to stand independently and complete 8 steps >20 seconds

2 able to complete 4 steps without aid with supervision

1 able to complete >2 steps needs minimal assist

0 needs assistance to keep from falling/unable to try

**13. Standing unsupported one foot in front**

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT)

Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width)

4 able to place foot tandem independently and hold 30 seconds

3 able to place foot ahead of other independently and hold 30 seconds

2 able to take small step independently and hold 30 seconds

1 needs help to step but can hold 15 seconds

0 loses balance while stepping or standing

**14. Standing on one leg**

INSTRUCTIONS: Stand on one leg as long as you can without holding.

4 able to lift leg independently and hold >10 seconds

3 able to lift leg independently and hold 5 – 10 seconds

2 able to lift leg independently and hold ≥ 3 seconds

1 tries to lift leg, unable to hold 3 seconds but remains standing independently

0 unable to try or needs assist to prevent fall

**TOTAL SCORE** **(Maximum = 56)**

**Interpretation of Berg Scores**

Please take note that these values are based on the Berg score alone and the patient mobilising without the assistance of a walking device. They do not take into account other falls risk factors

- A score of 45 or less indicates a greater risk of falls
- In the range of 56-54 each 1 point drop was associated with a 3-4% increase in falls risk
- In the range of 54-46 each point drop was associated with a 6-8% falls risk
- Below 36 falls risk is close to 100%

Retrieved from www.stvincents.ie/.../**Berg**%20**balance**%20**scale_SVUH_MedEL_tool**.doc

# 10 APPENDIX C

## MANUAL MUSCLE TESTING PROCEDURES

### Key to Muscle Grading

| | Function of the Muscle | Grade | | |
|---|---|---|---|---|
| No Movement | No contractions felt in the muscle | 0 | 0 | Zero |
| | Tendon becomes prominent or feeble contraction felt in the muscle, but no visible movement of the part | T | 1 | Trace |
| Test Movement | MOVEMENT IN HORIZONTAL PLANE | | | |
| | Moves through partial range of motion | 1 | 2- | Poor- |
| | Moves through complete range of motion | 2 | 2 | Poor |
| | ANTIGRAVITY POSITION<br>Moves through partial range of motion | 3 | 2+ | |
| Test Position | *Gradual* release from test position | 4 | 3- | Fair- |
| | Holds test position (no added pressure) | 5 | 3 | Fair |
| | Holds test position against slight pressure | 6 | 3+ | Fair+ |
| | Holds test position against slight to moderate pressure | 7 | 4- | Good- |
| | Holds test position against moderate pressure | 8 | 4 | Good |
| | Holds test position against moderate to strong pressure | 9 | 4+ | Good+ |
| | Holds test position against strong pressure | 10 | 5 | Normal |

Retrieved from
http://www.niehs.nih.gov/research/resources/collab/imacs/docs/activity/musc_grad_test_proc.pdf

# 11 APPENDIX D

## Resistance Training Program for Study

The Routine

1) Warm Up

- 5 minute “range of motion” exercises

2) Weight Training with Ankle Weights (2-5 sets of 10 reps)

- Sitting Leg Extension
- Standing Hamstring Curl
- Straight Leg Raise
- Standing Abduction
- Standing Adduction
- Standing Hip Flex

3) Cool down

- Stretching (seated and standing)
- Encourage to ice

Progression

| | |
|---|---|
| Week 1 | 2x10 |
| Week 2 | 2x10 |
| Week 3 | 2x10 |
| Week 4 | 3x 10 (depending on progress) |

| | |
|---|---|
| Week 5 | 3x10 |
| Week 6 | 4x10 |
| Week 7 | 5x10 (add weight here – approximately 1 pound) |
| Week 8 | 5x10 |

Starting weight: 2 pounds;

- Adjust so that last 2 reps are effortful/lightly challenging