JOINT POSITION SENSE IN KNEE OSTEOARTHRITIC PATIENTS

by

Cheyenne Schmid

A Senior Honors Thesis Submitted to the Faculty of
The University of Utah
In Partial Fulfillment of the Requirements for the
Honors Degree in Bachelor of Science

In

Exercise and Sport Science

Approved:

Dr. Charlie Hicks-Little
Supervisor

Dr. James C. Hannon
Chair, Department of ESS

Kerry Jacques
Department Honors Advisor

Dr. Sylvia D. Torti
Dean, Honors College

August 2014
ABSTRACT

Osteoarthritis (OA) is a slow progressing degenerative joint disease affecting approximately 10% of the United States population. The incidence of OA increases with age due to the continual loading of the knee joint throughout life and is one of the main causes of chronic pain and disability in the aging population. As the elderly population continues to grow rapidly, the financial burden of this musculoskeletal disorder also increases, and with the prevalence of OA estimated to increase by 57% by the year 2020, the economic and health impact will also grow significantly. Knee OA is a high risk factor for falls in the older population. Optimal neuromuscular function is critical in order to prevent the further development and/or progression of this degenerative disease. Further, joint positioning and control are pertinent to coordination of maneuvers during functional activities and reducing the risk of falls. The purpose of this study is to compare the effects of a 12-week home exercise intervention program on joint position sense in patients with knee OA. Five radiographically diagnosed knee OA patients were recruited to participate in the study (1 male, 4 female; age 63.20 ± 8.93 years; mass 71.40 ± 11.76 kg; height 164.85 ± 4.25 cm). Pre-testing included bilateral testing of each participant’s knee joint position sense using a Biodex Isokinetic Dynamometer. Participants then completed a 12-week home exercise intervention program. Post-testing was identical to pre-testing and occurred at the end of the 12-week intervention. Healthy control participants (without any lower extremity OA, injury, surgery, or other complication) also completed pre-testing. It was anticipated that knee joint position sense would significantly improve in knee OA patients after the 12-week home exercise intervention.
program and healthy control participants would show greater joint position sense measures than knee OA patients during pre-testing with an age-related decrease in knee joint position sense observed among the healthy control participants. There was no statistically significant difference between pre-test data and post-test data for either the affected or unaffected knees of knee OA patients, no statistically significant difference between knee OA patients and healthy control subjects on pre-test data for either affected or unaffected knees, and no statistically significant difference between the different age categories (p>0.05). The preliminary findings in our study are currently inconclusive towards how a home exercise intervention program affects knee joint position sense in patients with knee OA. Future continuations of this study accounting for the limitations will be conducted to more accurately determine the effects of a home exercise intervention program on the knee joint position sense of knee OA patients.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>METHODS</td>
<td>9</td>
</tr>
<tr>
<td>RESULTS</td>
<td>14</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>18</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>22</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>23</td>
</tr>
</tbody>
</table>
INTRODUCTION

Osteoarthritis (OA) is a slow progressing degenerative joint disease that is becoming one of the main causes of chronic pain and disability in the aging population. Although not fatal, OA is a major irreversible detriment to an individual’s quality of life as it affects activities of daily living. After the publication of the Global Burden of Disease Study in 1990, awareness was raised as OA was reported to be rapidly progressing in the rankings of non-fatal burden prevalence on the global scale (1). In the more recent publication of the Global Burden of Disease Study in 2010, OA was ranked 11 among the most common causes of disability, accounting for 17.1 million years living with disability (YLDs) (1). To provide a more comprehensible statistic, currently on the national level approximately 26 million individuals in the United States suffer from OA (2), which equates to nearly 10% of the population.

Individuals can become affected with OA as early as age 25 with a positive correlation of the incidence rate and increasing age due to the consistent joint loading throughout the lifetime (2). Below the age of 45 men are more affected than women, but above the age of 55 women are more affected than men (3). Although OA can affect multiple joints, including the hip, hand, spine, and foot, the highest prevalence of OA occurs at the knee (2). Nearly 83% of the global OA burden is accounted for at the knee joint with 3.6% of the global population being affected (1). As the aging population continues to grow rapidly the financial burden of this musculoskeletal disorder also increases, and with the prevalence of OA estimated to increase by 57% by the year 2020 (4) the economic and health impact will also grow significantly.
Risk factors for knee OA can be divided into two categories: systemic and local biomechanical (5). The most distinct systemic risk factor for knee OA is age. Aging results in metabolic changes that contribute to cartilage thinning that leaves the cartilage more susceptible to fatigue fracture (6). Also associated with aging are increases in muscle weakness, decreases in bone compliance, and oxidative damage (2,6). Disruption of tissue homeostasis due to aging can lead to an inadequate response to joint stress or injury and cause joint tissue destruction or loss (2). Another systemic risk factor is gender. The higher prevalence of women with OA than men could be linked to hormonal factors, especially considering the spike in women affected with OA aligns with the time of menopause (2). With regards to nutrition, Vitamin D deficiency is considered a risk factor for OA; Vitamin D plays a crucial role in bone metabolism and a protective function against OA by modulating periarticular bone responses to excess loading and joint damage (2). Other systemic risk factors for knee OA include ethnicity, genetics, and metabolic syndrome.

Obesity is a local biomechanical risk factor for knee OA. Having a body mass index (BMI) greater than or equal to 30 creates metabolic and early developmental abnormalities, as well as causes increased load and impact on cartilage (6,7). Obesity and hypertension can also result from knee OA in addition to acting as positive risk factors for developing OA (2). Pain and joint dysfunction caused by knee OA most often results in decreased physical activity. Physical activity limitations lead to increases in body mass, which can lead to cardiovascular disease and diabetes (2). Another local biomechanical risk factor is previous knee injury, trauma, dislocation, infection, and/or surgery. These can initiate or enhance the degenerative process, alter joint shape,
increase local stressors, and change biomechanics. (5,7). Certain occupational and athletic repetitive physical activities can create risk factors for knee OA. Other local biomechanical risk factors for knee OA include joint alignment, muscle weakness, abnormal increases in compartmental loading, and additional joints affected with OA. (5,6,8).

One of the most complex and intricate joints of the human body is the knee. The articulating surfaces of subchondral bone at the knee joint are: 1) medial and lateral condyles and patellar surface of the distal end of the femur, 2) medial and lateral condyles of the proximal end of the tibia, 3) head of the proximal end of the fibula, and 4) posterior surface of patella (9). Both the medial and lateral condyles of the femur and tibia articulate to provide the movements of flexion and extension of the leg at the knee. These bony surfaces are covered with hyaline articular cartilage. Located between the medial and lateral femoral and tibial condyles are the medial and lateral menisci. A meniscus is a crescent-shaped structure of fibro cartilage that helps absorb shock and reduce friction. Surrounding the joint capsule is the synovial membrane that is a loose form of connective tissue. Synovial fluid is produced by the synovial membrane and fills the joint capsule, surrounding the articulating surfaces and providing lubrication (10). Healthy anatomy and function of the knee joint provides non-restricted, smooth, and painless movements.

Knee OA is a disease of the total joint that results in failed repair of joint damage (11). The term total joint refers to all the tissues located at the knee joint, including: articular cartilage, subchondral bone, ligaments, and menisci. Knee OA is caused by an imbalance in the destructive and synthetic processes of cartilage that leads to erosion of
the articular cartilage (12). This erosion or loss of cartilage results in joint space narrowing. The joint space narrowing increases the sclerosis of subchondral bone, formation of osteophytes, and subchondral bone cysts (6). These damaging hypertrophic changes in the underlying subchondral bone create pain and restrict movements (12). There is also inflammation of the synovial membrane and decreased concentration and viscosity of the synovial fluid, resulting in decreased lubrication and cushioning (12). Combining the processes of articular cartilage degradation and bone remodeling greatly impacts the functional abilities and quality of life of an individual suffering from knee OA.

Individuals with knee OA may experience symptoms of joint pain, tenderness, stiffness, aching, discomfort, functional limitations, crepitus, local inflammation, and/or difficulties performing activities of daily living (2,5,13). Another symptom experienced is loss of functional stability at the knee and other lower extremity joints (14), creating a risk factor for falls in older adults. Elderly patients (age 63-94) with knee OA visit physicians twice as often, experience more days with restricted activity, and more days in bed as compared with age-matched individuals without knee OA (15). The functional disability caused by knee OA can lead to disuse atrophy of the lower extremity resulting in quadriceps muscle weakness (16). Quadriceps muscle weakness in individuals with knee OA could also be attributed to arthrogenous muscle inhibition (16). Afferent neural input can become altered from the affected knee joint and lead to decreased efferent motor neuron stimulation of the quadriceps which can lead to both slower reflexes and stabilization of the knee joint, ultimately leading to an increased risk of falling (16). The common knee OA symptom of walking disability is a known risk factor for all-cause
mortality (2). Knee OA has shown a 50% increase in all-cause mortality when compared
to age- and gender-matched subjects (2).

Consequently, the damaging effects of knee OA can result in changes in knee
joint proprioception. Proprioception is critical in the neuromotor control and function of
the knee as it provides the conscious representation of one’s body in space, specifically
knee joint position and motion in this paper (17, 18). Conscious representation is due to
afferent sensory neural information being delivered to the central nervous system through
impulses from specialized nerve endings called mechanoreceptors (19). Mechanoreceptors are found in the skin, ligaments, tendons, muscles, joint capsules, and
menisci contained within and surrounding the highly sensory innervated knee joint, as
well as throughout the entire body (20). Mechanoreceptors are involved in the first
subsystem contributing to the sensory input of proprioception— the somatosensory system
(21). They provide information regarding joint range and compression by converting
mechanical energy of physical deformation into electrical energy of a nerve action
potential (22). There are two types of mechanoreceptors: quick-adapting (QA) and slow-
adapting (SA) (21). QA receptors begin to decrease the neural impulse discharge near
the beginning of a continuous stimulus, while SA receptors continue the neural impulse
discharge throughout the entirety of the stimulus (21). Joint motion is most likely
mediated by QA receptors. Joint position sense and position change sensation are most
likely mediated by SA receptors (21).

The second subsystem contributing to the sensory input of proprioception is the
vestibular system. Afferent information is sent from the semicircular canals and
vestibules of the ear to help maintain body posture by controlling eye musculature,
sustaining upright posture, and remaining consciously aware of one’s joint position and motion (21). The third subsystem contributing to the sensory input of proprioception is the visual system that simply provides afferent information from visual cues aiding the orientation of the body in space (21).

The combination of afferent sensory neural information from the somatosensory, vestibular, and visual subsystems allows for efferent motor neural impulses to aid in unconscious joint stabilization. Joint proprioception is crucial as its mechanisms help detect the velocity, direction, and amplitude of needed adjustments of the leg to aid the body during unexpected events by initiating rapid compensatory responses and regulation of motor output, such as, lower extremity muscle activation (18). These rapid responses are necessary for the maintenance of balance and thus, production of a stable, smooth gait by initiating reflexes to stabilize joints and avoid injury (23, 24).

Proprioception can be divided into two separate components: kinesthesia and joint position sense (19). Kinesthesia is the awareness of joint movement and the rate of the movement— the dynamic aspect of proprioception (25). Joint position sense is the conscious awareness of joint position in space with respect to other parts of the body – the static aspect of proprioception (25). Kinesthesia can be assessed by measuring the threshold to detection of passive motion, while joint position sense can be assessed by measuring the reproduction of passive positioning and/or active positioning (21). Proprioceptive awareness and proper functioning of the knee joint are critical for the adaptation of the locomotor pattern to external demands, such as changes in terrain, loss of balance, and unexpected obstacles (18). Adaptations are achieved by continuous proprioceptive input that modulates the programmed locomotor pattern according to the
information from mechanoreceptors (18). Joint proprioception is also important in coordination of complex maneuvers during functional activity (24). A complementary relationship between static and dynamic restraints is necessary for maintaining proper joint alignment through adequate balance of forces across the joint (26, 27).

Any alteration to proprioceptive awareness can have drastic effects on performance by impairing one’s functional status (21). Alterations can result from any pathology affecting muscle function, muscle fatigue, capsuloligamentous structure injury, osteoarthritic changes, and aging (22). The resulting articular deafferentation and reductions in proprioceptive acuity can contribute to a subtle pattern of micro-trauma/re-injury and further degenerative changes in the joint (21). The aforementioned damaging changes within an OA-affected knee joint lead to diminished kinesthetic awareness of the knee joint and decreased proprioceptive ability. Optimal neuromuscular function is therefore of critical importance in the knee OA population in order to prevent the further development and/or progression of this degenerative disease. Individuals with knee OA are shown to have more difficulty matching knee angles (joint position sense), while sitting, in response to passive displacement cues than healthy age-matched controls (28). The deficit is partly attributed to the disease-related destruction of knee joint mechanoreceptors. There is also a correlation with increased age and decreased knee joint position sense in individuals without knee OA (29).

With regards to treatment for knee OA, exercise is strongly encouraged as a non-pharmacological aid in reducing pain and disability (30). Exercise can facilitate corrections in walking pattern and improvements in muscle strength, joint stability, range of motion, balance, work capacity, aerobic fitness, and self-perception of physical
functioning (31). Little research has been conducted regarding the effect a traditional home exercise rehabilitation program prescribed to knee OA patients has on their knee joint position sense. By improving knee joint position sense in knee OA patients, an improved functional ability will hopefully be attained, resulting in an increase in quality of life and function in knee OA patients. The purpose of this study is to compare the effects of a 12-week home exercise intervention program on knee joint position sense in patients with knee OA, as well as to compare knee joint position sense of knee OA patients to healthy age- and gender-matched control participants (without any lower extremity OA, injury, surgeries, or other complications). We hypothesize that knee joint position sense will significantly improve in knee OA patients after the 12-week home exercise intervention program and healthy control participants will show greater joint position sense measures than knee OA patients during pre-testing with an age-related decrease in knee joint position sense observed among the healthy control participants.
METHODS

The primary purpose of this study was to compare the effects of a 12-week home exercise intervention program on knee joint position sense in patients with knee OA. Secondary purposes were to compare knee joint position sense of knee OA patients to healthy age- and gender-matched control participants (without any lower extremity OA, injury, surgeries, or other complications), as well as to study the effects of aging on knee joint position sense.

Study Design

Five patients with knee OA (1 male, 4 female; age 63.20 ± 8.93 years; mass 71.40 ± 11.76 kg; height 164.85 ± 4.25 cm), 4 healthy age- and gender-matched control subjects (4 female; age 62.25 ± 10.63 years; mass 70.31 ± 19.13 kg; height 160.66 ± 5.63 cm), and 5 additional healthy control subjects (4 male, 1 female; age 61.80 ± 11.76 years; mass 71.21 ± 3.67 kg; height 172.47 ± 7.85 cm) were recruited to participate in this investigation (Table 1). Deviations in degrees (°) from the target joint position angle of both knees in all subjects were measured.

Table 1. Demographic Characteristics of Subjects (Mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Knee OA</th>
<th>Healthy Controls</th>
<th>Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>63.2 ± 8.93</td>
<td>62.25 ± 10.63</td>
<td>61.8 ± 11.76</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.85 ± 4.25</td>
<td>160.66 ± 5.63</td>
<td>172.47 ± 7.85</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>71.4 ± 11.76</td>
<td>70.31 ± 19.13</td>
<td>71.21 ± 3.67</td>
</tr>
</tbody>
</table>

Subject Recruitment

Subjects radiographically diagnosed with mild to moderate knee OA through the Kellgren Lawrence (KL) radiographic grading scale (Grades II and III) were recruited to
participate in the study. Radiographic knee OA that receives a KL grade of II is characterized by the presence of definite osteophytes and possible joint space narrowing on anteroposterior weight-bearing radiograph. A KL grade III is characterized by multiple osteophytes, definitive joint space narrowing, sclerosis, and possible bony deformity (32). Subjects who met the knee OA severity diagnosis based on the KL scale were contacted, screened for additional inclusion criteria, and informed about the study. Additional inclusion criteria for the knee OA patients were: age greater than or equal to 50 years, physician diagnosis of unilateral knee OA, and symptomatic unilateral or bilateral knee pain greater than 3 on Visual Analog Scale. Exclusion criteria for knee OA patients were: age less than 50 years, advanced end stage knee OA, physician diagnosis of bilateral knee OA, neurologic or neuromuscular disease affecting either knee, arthritis, history of lower limb joint replacement or open reduction internal fixation surgery of hip, knee, or ankle fracture, diagnosis of symptomatic OA in hips or ankles, and usage of prescription anti-inflammatory medication. The inclusion criterion for healthy control subjects was age greater than or equal to 50 years. The exclusion criterion for healthy control subjects was any history of lower limb joint replacement, surgery, injury, OA, or other complications. Interested volunteers signed the institutional review board (IRB)-approved informed consent form. Pre-testing was then scheduled to take place at the University of Utah Sports Medicine Research Lab.

Protocol

Subjects reported to the research facility for pre-testing. Height and weight was taken and subjects were positioned in a seated position in a Biodex Isokinetic Dynamometer machine. The leg being tested was strapped to a lower leg fulcrum arm
adjusted to the length of the tibia bone. Straps were placed around the ankle of the subjects. The subject also had a strap placed above their knee to hold their thigh in a stable and secured position. Subjects were then asked to move their leg into knee extension and flexion. This allowed the subject to become accustomed to the movement of the lower leg with the lower leg fulcrum arm attached. The subjects were then blindfolded and the investigator moved the subject’s lower leg passively into full knee extension and flexion three times. The investigator then moved the lower leg to a defined position of 45 degrees of knee flexion and held it in that position for 10 seconds. Whilst held in that position the investigator informed the blindfolded subject to try to memorize that exact knee position. After the 10 seconds the investigator moved the lower leg into full knee extension and full knee flexion. After this the investigator asked the blindfolded subject to actively move their leg to the position that they were held at for the 10-second period. Subjects were instructed to click a button positioned by their hand when they felt they were at the defined position. The Biodex system recorded the angle the knee was positioned in when the subject clicked the button. The same procedural steps were taken for a further 3 trials of the 45 degree knee angle. This was then repeated for the contralateral leg. This concluded the pre-testing. The healthy control subjects only participated in the pre-testing.
Within 2 days of pre-testing, knee OA subjects started the 12-week home exercise rehabilitation program. The home exercise intervention program consisted of quad sets, short-arc knee extensions, straight leg raises, heel slides, pillow squeezes, hamstring stretch (assisted with towel), and walking (the exercise progression is shown in Table 2). These exercises were chosen based on successful rehabilitation programs designed by physicians, physical therapists, and athletic trainers that used these exercises to treat knee OA (33). After completion of the 12-week home exercise intervention program the knee OA subjects reported back to the research facility for post-testing. The post-testing was identical to the pre-testing.
Table 2. Exercise Progression of Home Exercise Intervention Program

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weeks 1-2</th>
<th>Weeks 3-4</th>
<th>Weeks 5-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quad Sets</td>
<td>6 reps x 2 sets</td>
<td>8 reps x 3 sets</td>
<td>-</td>
</tr>
<tr>
<td>Straight Leg Raises</td>
<td>8 reps x 2 sets</td>
<td>10 reps x 3 sets</td>
<td>12 reps x 3 sets</td>
</tr>
<tr>
<td>Heel Slides</td>
<td>8 reps x 2 sets</td>
<td>10 reps x 3 sets</td>
<td>12 reps x 3 sets</td>
</tr>
<tr>
<td>Short-Arc Knee Extensions</td>
<td>-</td>
<td>-</td>
<td>6 reps x 3 sets</td>
</tr>
<tr>
<td>Walking</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hamstring Stretch (w/towel)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pillow Squeeze</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weeks 7-8</th>
<th>Weeks 9-10</th>
<th>Weeks 11-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quad Sets</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Straight Leg Raises</td>
<td>12 reps x 3 sets</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Heel Slides</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Short-Arc Knee Extensions</td>
<td>8 reps x 3 sets</td>
<td>10 reps x 3 sets</td>
<td>12 reps x 3 sets</td>
</tr>
<tr>
<td>Walking</td>
<td>Light pace 15 min.</td>
<td>Light pace 15 min.</td>
<td>Light pace 15 min.</td>
</tr>
<tr>
<td>Hamstring Stretch (w/towel)</td>
<td>3 sets x 20 secs.</td>
<td>3 sets x 20 secs.</td>
<td>3 sets x 20 secs.</td>
</tr>
<tr>
<td>Pillow Squeeze</td>
<td>-</td>
<td>3 sets x 10 reps</td>
<td>3 sets x 12 reps</td>
</tr>
</tbody>
</table>

**Data Analysis**

The means and standard deviations of joint position sense data were first calculated. T-tests were then used to examine the effects of group, time, and age on joint position sense measures. An *a priori* level of significance was set at $P \leq 0.05$ for all comparisons.
RESULTS

Means and standard deviations for joint position sense measures of affected and unaffected knees during pre- and post-testing for knee OA patients (deviations in degrees) are shown in Table 3 and Figure 2. There was no statistically significant difference between pre-test data and post-test data for either the affected or unaffected knees of knee OA patients (p>0.05).

Table 3. Knee OA Pre and Post Data (Mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Knee OA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected Knee Pre (°)</td>
<td>4.26 ± 1.93</td>
</tr>
<tr>
<td>Affected Knee Post (°)</td>
<td>4.23 ± 2.48</td>
</tr>
<tr>
<td>Unaffected Knee Pre (°)</td>
<td>5.06 ± 2.39</td>
</tr>
<tr>
<td>Unaffected Knee Post (°)</td>
<td>5.1 ± 4.76</td>
</tr>
</tbody>
</table>

Figure 2: Deviations in degrees (°) from target joint position angle of affected and unaffected knees during pre- and post-testing of knee OA patients.
Means and standard deviations of joint position sense pre-testing measures for knee OA patients affected and unaffected knees and post-testing comparisons of affected knee and unaffected knee (deviations in degrees) are shown in Figure 3. There was no statistically significant difference between knee OA patients pre-testing between legs or knee OA patients post-testing between legs (p>0.05).

Figure 3: Deviations in degrees (°) from target joint position angle of knee OA pre-test affected knee compared to pre-test unaffected knee and post-test affected knee compared to post-test unaffected knee.

Means and standard deviations for joint position sense measures of affected and unaffected knees during pre-testing from knee OA patients, healthy control subjects, and additional healthy subjects (deviations in degrees) are shown in Table 4 and Figure 4. There was no statistically significant difference between knee OA patients and healthy control subjects on pre-test data for either affected or unaffected knees (p>0.05).
### Table 4. Affected and Unaffected Knee Pre-Testing Data (Mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Knee OA</th>
<th>Healthy Controls</th>
<th>Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected Knee (°)</td>
<td>4.26 ± 1.93</td>
<td>4.1 ± 1.67</td>
<td>4.34 ± 1.95</td>
</tr>
<tr>
<td>Unaffected Knee (°)</td>
<td>5.06 ± 2.39</td>
<td>2.8 ± 1.51</td>
<td>4.74 ± 2.81</td>
</tr>
</tbody>
</table>

Figure 4: Deviations in degrees (°) from target joint position angle of affected and unaffected knees during pre-testing of knee OA patients, healthy control subjects, and additional healthy subjects.

Means and standard deviations of joint position sense measures for knee OA patients, healthy control subjects, and additional healthy subjects separated according to age (deviations in degrees) are shown in Figure 5. There was no statistically significant difference between the different age categories (p>0.05).
Figure 5: Deviations in degrees (°) from target joint position angle of affected and unaffected knees during pre-testing of knee OA patients, healthy control subjects, and additional healthy subjects according to age.
DISCUSSION

The primary purpose of this study was to compare the effects of a 12-week home exercise intervention program on knee joint position sense in patients with knee OA. We hypothesized that the home exercise intervention program would elicit a significant decrease of deviations in degrees from target joint position angle when comparing pre- and post-test data of knee OA patients. Our results, however, did not indicate any statistically significant difference between knee OA patient pre- and post-test knee joint position sense measures (Table 3 and Figure 2). No previous research regarding the effects of a home exercise intervention program on joint position sense in knee OA patients has been conducted so comparisons to previous studies cannot be performed.

When examining the data it is evident that the knee OA patients’ unaffected knee had more error than the knee OA patients’ affected knee. No previous research specifically comparing knee OA patients’ joint position sense in the unaffected versus affected knee has been conducted so comparisons to previous studies cannot be performed. The OA affected knee showing less error may have been due to the patients using pain resulting from the OA pathology to gauge the correct position. Since the unaffected knee lacked the OA pain the correct position may have been more difficult to determine, thus resulting in greater error. Another possible explanation is the compensatory effect. The knee OA patients may have favored their unaffected knee during daily activities since the development of their knee OA, leading to greater depreciation of the unaffected knee joint, specifically damaging the mechanoreceptors. This damage would result in decreased ability to correctly determine knee joint position
sense, thus resulting in greater error. The change from pre- to post-test measures for knee OA patient affected knee was -0.03 degrees. The change from pre- to post-test measures for knee OA patient unaffected knee was +0.04 degrees. The lack of a significant improvement in knee joint position sense measures resulting from the home exercise intervention program could be attributed to the small area for individual improvement possible, and not due to the ineffectiveness of the home exercise program. There was a slight improvement of 0.03 degrees with the OA affected knee. Data collection may have been skewed because knee OA patients reported using their sensation of knee pain to gauge the correct knee flexion angle instead of relying solely on proprioceptive abilities. These limitations are pertinent in understanding the implementation of the home exercise intervention program and should be further investigated in future studies.

A secondary purpose of this study was to compare knee joint position sense pre-test measures of knee OA patients to healthy age- and gender-matched control subjects. We hypothesized that healthy control subjects would show greater accuracy of knee joint position sense. Our results did not indicate any statistically significant difference between knee OA patient pre-test data and healthy control subject pre-test data (Table 4 and Figure 4). These results were not in agreement with previous research (28, 29). Specifically with observations made by Marks, Quinney, & Wessel (28) who reported that knee osteoarthritic subjects had greater deviations in degrees from target joint position angle than healthy subjects (p<0.05). Marks, Quinney, & Wessel only included female subjects in the study, whereas we included both male and female subjects. Marks, Quinney, & Wessel had a mean age of 54.6 years for knee OA patients and 48.2 years for healthy controls, whereas our mean age was 63.2 years for knee OA patients and 62.25
years for healthy control subjects. We recruited specific age-matched healthy control subjects to accurately compare with knee OA pre-test measures. Marks, Quinney, & Wessel age-matched in their study, but did not produce demographic characteristics as closely matched as our values, and in general used younger subjects than our study. Pai et al (29) included bilateral knee OA patients compared to our unilateral knee OA patients. Pai et al had a mean age of 68.2 years for knee OA patients and 71.3 years for healthy controls. Our study produced more closely age-matched controls. Pai et al used subjects that were in general older than those used in our study. The differences in age between knee OA patients and healthy controls with Marks, Quinney, & Wessel and Pai et al may have led to significant differences in knee joint position sense more so because of aging differences than strictly knee OA pathology differences. Our study’s knee OA patients and healthy control subjects were more closely matched which more accurately eliminates any potential aging differences.

Another purpose of this study was to study the effects of aging on knee joint position sense. We hypothesized that there would be a positive correlation with increased deviations in degrees from target joint position angle and increased age. Our results, however, did not show a statistically significant difference in knee joint position sense measures across the different ages (Figure 5). These results were contradictory to previous research (29, 34). Pai et al (29) showed a significant age-related decrease in proprioceptive accuracy in subjects without knee OA (p<0.05). They did not include the knee OA patients in the age analysis and included young controls (age: 30.8 ± 6.9 years). Skinner, Barrack, & Cook (34) also showed a significant decline in joint position sense with age, but also did not include individuals with knee OA in their statistics (p<0.05).
We included knee OA patients within the study and excluded any subjects younger than 50 years old; therefore, these studies do not provide an accurate comparison to our study. The mean deviation in degrees from the target joint position angle for the age group 50-59 affected knee pre-test was 4.23, for the age group 60-69 affected knee pre-test was 4.3, and for the age group 70-79 affected knee pre-test was 4.25. The majority of the knee OA patients in our study were in the 60-69 age group, so the increase in degrees of joint position deviation occurring at that age range could be related more so to OA effects than aging effects. Since Pai et al and Skinner, Barrack, & Cook excluded the knee OA patients from the age analysis the results were more accurate towards determining aging effects on knee joint position sense while eliminating any OA effects. The inclusion of young controls by Pai et al allowed for a broader analysis of the effects of aging on knee joint position sense. A limitation with the age analysis in our study was the varying levels of physical fitness for the subjects. Additionally, a larger sample size is needed in each age group category to further explore the effect of aging and by increasing the sample size it would also aid in eliminating any discrepancies in the data due to differences in physical fitness.

It must be noted that there were many limitations to this study that most likely affected the results. Limitations included the small sample size, patient compliance, lack of improvement possibility, differences in physical fitness, and use of non-proprioceptive abilities. Increasing the sample size in future studies would result in more accurate conclusions as to the effects of a home exercise intervention program on knee OA joint position sense (current study N=4). Five knee OA patients were initially recruited to participate in the study. All 5 performed pre-testing, but one knee OA patient was unable
to perform post-testing due to conflicting medical issues that arose during the study intervention period. Patient compliance to the program also affects the accuracy of the study, which is difficult to measure and control because of the involvement of human subjects self-reporting their compliance to the exercise intervention. Future continuations of this study accounting for these previous limitations will be conducted to more accurately determine the effects of a home exercise intervention program on knee joint position sense in knee OA patients.

CONCLUSION

In summary, our findings are currently inconclusive towards how a home exercise intervention program affects knee joint position sense in patients with knee OA. There were no statistically significant differences in knee joint position sense between knee OA patients pre- and post-test data, between knee OA patients pre-test between legs or knee OA patients post-test between legs, between knee OA patients and healthy control subjects on pre-test data, or between the different age categories. Previous research has suggested that exercise has facilitated corrections in walking patterns and revealed improvements in muscle strength, joint stability, range of motion, balance, work capacity, aerobic fitness, and self-perception of physical functioning in knee OA patients (31). Continued research on exercise prescriptions for knee OA patients, specifically focused on joint position sense, is crucial as exercise has shown to be a key non-pharmaceutical treatment for the increasing number of people suffering with knee OA worldwide.
REFERENCES


Name of Candidate: Cheyenne Schmid

Birth date: March 2, 1992

Birth place: Ogden, Utah

Address: 2420 West Old Highway Road
Morgan, Utah, 84050