Does Knee Osteoarthritis Alter the Neuromuscular Responses to a Perturbation During Single Lower Limb Stance?

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ABSTRACT

Purpose: Evidence substantiating an association between knee osteoarthritis (OA) and altered joint protection responses is relevant to the management of knee OA. The purpose of this study was to detect neuromuscular response times of the vastus lateralis and biceps femoris muscles following a perturbation during single lower limb stance. We hypothesized that muscle response times are: (1) delayed in older adults with knee OA when compared to young and older adults (without diagnosed knee OA) and (2) dependent on the magnitude of load released. **Subjects:** Ten young adults, 10 older adults, and 7 older adults with symptomatic knee OA participated. **Methods:** While in single lower limb stance, the subjects flexed the knee into a range of 33 to 37° while a posterior load of either 6 or 9 kg was applied at the proximal tibia. The load was released after the subjects held the required position for 1 full second. Muscle response times were measured by electromyography. Separate 3 (group) by 2 (load) mixed factorial analysis of variance procedures were performed for electromyography data from the vastus lateralis and biceps femoris. **Results:** There was no difference in vastus lateralis response times between older adults with knee OA and older adults or between older adults with knee OA and young adults. Older adults did have longer vastus lateralis response times than young adults. There was no difference in biceps femoris response times between older adults with knee OA and older adults; however, both groups had longer biceps femoris response times than young adults. Furthermore, there were no differences in either vastus lateralis or biceps femoris response times between 6 kg and 9 kg loads. **Conclusion:** Although knee OA did not alter muscle responses in our study, the type of functional weightbearing perturbation described could be safely used in the physical therapy clinic to help improve balance and stability while decreasing discomfort in older adults with symptomatic knee OA.

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Key Words: knee osteoarthritis, electromyography, muscle response, perturbation

INTRODUCTION

Evidence substantiating an association between knee osteoarthritis (OA) and altered joint protection responses is important in the treatment and prevention of knee OA. Treatment strategies based on this association could potentially prevent the rapid progression of OA, whereas preventative programs could improve neuromuscular joint protection mechanisms in individuals who are at risk for knee OA. With the aging of society and an increased prevalence of knee OA in the elderly, physical therapists will play a vital role in prevention, assessment, and treatment of knee OA.

Aging is one of the highest risk factors associated with OA.[1] People older than the age of 65 accounted for 12.4% of the United States population in 1988 and 13% in 1990; with the aging of the baby boomers, it is estimated that this cohort will reach 22% by the year 2030.[1] In the United States, knee OA is the most common disease leading to disability among the elderly.[2] Symptomatic knee OA affected 9.5% of those over the age of 65.[3] Davis reported that the prevalence of tibiofemoral OA rose from 2% in men and 3.5% in women between the ages of 45 and 54 years, to 9.1% and 17.4%, in those who were 65-74 years.[4]

Although OA is generally defined as a degeneration of articular cartilage, many factors have been linked with OA. Muscle weakness,[5-8] proprioception deficits, and a knee alignment that decreases joint stability have the tendency to hasten the progression of OA. These factors may affect the neuromuscular responses about the joint. Quadriceps weakness and arthrogenic quadriceps inhibition can directly influence decreased joint stability, alter the coordination of neuromuscular reflexes, and cause early fatigue in lower limb muscles.[8-10] Various authors have studied the association between knee OA and knee proprioception with subjects in either a nonweightbearing or partial-weightbearing position.[11-17] These studies indicate that proprioception decreases with age and even more in those with knee OA. Furthermore, Hurley stated "arthritic damage to articular mechanoreceptors may evoke abnormal afferent discharge that decreases α- and γ-motoneurones excitability, impairing motor control, and proprioceptive acuity."[18]

Several studies have shown that with various muscle, ligament, and joint pathologies, there are impairments in neuromuscular responses to external stimuli.[19-21] These stimuli include tendon taps,[19] perturbations,[20] and quickly released loads.[21] Furthermore, this association may be apparent in osteoarthritic knees. Impaired shock absorbing properties of muscles surrounding the knee also contribute to a larger heel strike transient.[22] These types of repeated microtraumas may contribute to the development or progression of OA.[12] Hurley indicated that muscle weakness due to reflex inhibition or disuse atrophy can compromise neuromuscular protective mechanisms leading to excessive joint loading with subsequent articular degeneration.[23] In addition, Sharma et al have theorized that "disruption of the afferent component of protective neuromuscular reflexes may lead to increased, repetitive, poorly distributed load across the articular surface, resulting in OA."[13]

In addition to proprioception deficits and changes in muscle strength associated with knee OA, there are also numerous age related changes in postural control and balance. Among these are the following: decreased nerve conduction velocity in aging,[24-26] increased muscle response latencies to perturbations,[27-30] and increased falls after an initial slip when going from sit to stand.[31] However, no age related change in lower limb muscle latencies in the elderly in response to a perturbation have been reported.[32,33] The extent to which age related decline exists in neuromuscular responses following a perturbation in single lower limb stance has yet to be determined.

In summary, current physical therapy interventions for knee OA focus on decreasing pain and improving knee range of motion, muscle strength, balance, and functional mobility. Many of these interventions are applied with the subject in a nonweightbearing or partial-weightbearing position instead of the functional weightbearing position of upright stance. However, Fitzgerald and colleagues recently described a physical therapy treatment program that included single and double limb standing perturbations that may help improve the neuromuscular responses in people with knee OA.[34] It is unclear what role these interventions have on the altered neuromuscular responses that may be apparent in knee OA. Furthermore, very little is known if such interventions can indeed prevent rapid progression of knee OA. Overall, it is likely that the design of effective treatment strategies will rely on a better understanding of neuromuscular joint protection.

The purpose of this study was to detect neuromuscular response times of the vastus lateralis and biceps femoris muscles following a quick release perturbation during single lower limb stance. We hypothesized that muscle response times of the vastus lateralis and biceps femoris are delayed in older adults with symptomatic knee OA when compared to young and older adults (without diagnosed knee OA). We further hypothesized that muscle response times are dependent on the magnitude of load released.

METHODS

Subjects

Five young male and 5 young female adults with asymptomatic knees were recruited from the student body, staff, and faculty of the University of Illinois at Chicago (UIC) community. Five older male and 5 older female adults with asymptomatic knees were recruited from the UIC community and Chicago area senior centers. One older male adult and 6 older female adults with symptomatic knee OA were recruited from the UIC Rheumatology Department. Subjects provided informed consent as approved by the UIC Institutional Review Board. All subjects were assessed through a medical screening form.

Young and older adults with asymptomatic knees reported that they were free from OA of the hips, knees, and feet, as well as the following conditions that may affect their ability to perform the testing procedures: musculoskeletal, neurological, cardiovascular, and pulmonary impairments.

Subjects with symptomatic knee OA had a Kellgren-Lawrence radiograph grade of 2 or greater in one or both knees, as read by a rheumatologist. The Kellgren-Lawrence grading system scores of tibiofemoral radiographic severity are: 0 = normal, 1 = possible osteophytic lipping, 2 = definite osteophytes and possible narrowing of joint space, 3 = moderate multiple osteophytes, definite narrowing of joint space, some sclerosis, and possible deformity of bone contour, and 4 = large osteophytes, marked narrowing of joint space, severe sclerosis, and definite deformity of bone contour.[35]

Subjects with symptomatic knee OA reported that they were free from the following conditions that may affect their ability to perform the testing procedures: significant injury to the back or any joint in the lower limb; rheumatoid arthritis in hips, knees, or feet; neurologic disorders including stroke and transient ischemic attacks; unstable cardiovascular and/or respiratory conditions; and a history of uncontrolled diabetes or alcohol abuse.

Procedures

Surface electromyography (EMG) data were collected for the vastus lateralis and biceps femoris muscles. For EMG data collection, an eight-channel amplifier (CyberAmp 380, Axon Instruments, Inc, Union City, Calif) with a notch filter of 60 Hz was used. The silver/silver chloride surface EMG electrodes (Electronic Quantifications Inc, Chalfont, Pennsylvania) had a preamplifier gain of x35 and 20 mm pad-spacing.

The tested lower limb was chosen at random for the young and older adults. In older adults with knee OA, the lower limb more affected with knee OA was tested. Subjects were tested without shoes. The subject's skin was rubbed with an alcohol pad and the EMG electrodes were placed over the midregion of each muscle group oriented along the muscle belly. For the vastus lateralis, the electrode was placed approximately 25% of the distance from the lateral knee space to the anterior superior iliac spine. For the biceps femoris, the electrode was placed approximately 50% of the distance from the ischial tuberosity to the fibular head. The ground electrode was placed on the anterior superior iliac spine. Cross talk and proper electrode placement were evaluated by manual muscle testing.

The subject was placed in a full-body safety harness to prevent falling to the ground in the case of a complete loss of balance. The arms of a custom-made knee electrogoniometer were aligned with the lateral malleolus and the greater trochanter and secured by elastic straps. A 6-inch ace wrap over the electrodes and the electrogoniometer arms provided stability. The axis of the electrogoniometer coincided with the axis of the knee joint. To provide consistent foot placement, tape was positioned on the force plate surface (AMTI, Watertown, Mass) perpendicular to the foot of the stance lower limb. A leather cuff strap secured a cable to the subject's proximal tibia. This cable was connected to a SABA mobile pulley system (NorAm, Follo Industrier A/S, Norway) placed 1 meter behind the subject and supplied the posterior preload prior to cable release (Figure 1).

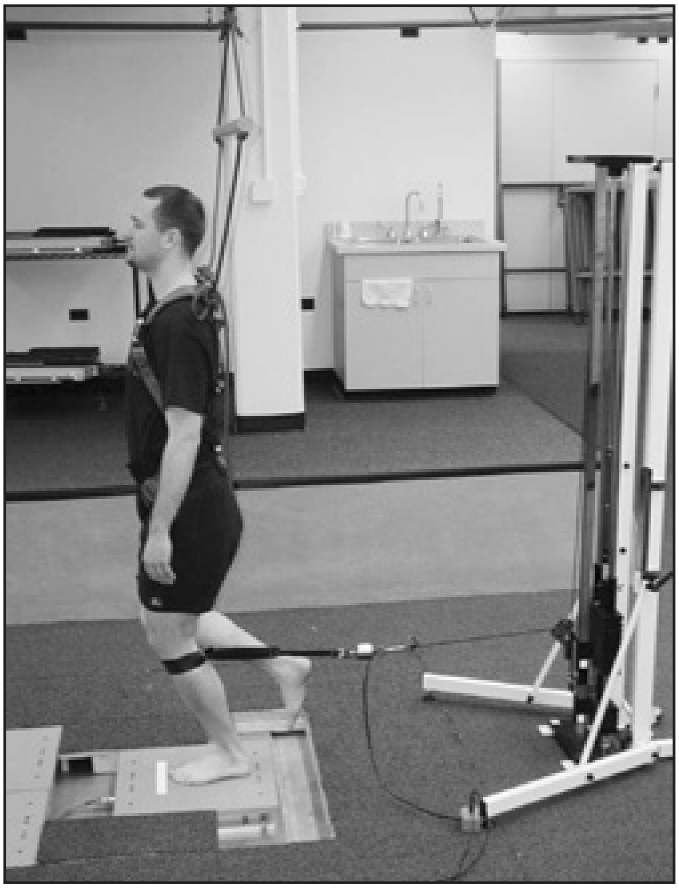

Figure 1. Experimental set up showing subject, force plate, safety harness, and preload mechanism with electromagnet. For simplicity, the 4-point cane, EMG electrodes, electrogoniometer, and floor fill-ins are not shown.

Subjects stood with both feet on the force plate and the contralateral hand gently holding a 4-point cane for balance. Throughout the duration of every trial, all subjects stayed in contact with the 4-point cane. Subjects were instructed to keep the trunk as straight as possible throughout the experiment. Subjects were instructed to watch a visual cueing system that provided feedback regarding the test knee angle. Subjects were instructed to lift the nontest lower limb off the ground approximately 10 cm with the knee slightly bent. Upon an auditory cue, a green light came on indicating the start of the trial and data collection. At this time, the subjects performed a single lower limb squat while flexing the test knee into a required range of 33˚ to 37˚ for 1 second. Subjects performed a minimum of 3 practice trials with no load so that they were comfortable obtaining the required knee position. Following the practice trials, subjects then performed a series of perturbation trials with an attached load. Once the test knee flexed into the required range for 1 second, an electromagnet disengaged to release the preload cable allowing unexpected knee flexion. Each subject performed 10 trials with a preload of 6 kg and 10 trials with a preload of 9 kg. Subjects were given at least 30 seconds of rest between each trial and up to 5 minutes sitting rest between load conditions.

Data Processing

Custom programs were written for data collection, processing, and analysis. All analog data signals (electrogoniometer and EMG) were digitized at 1000 Hz and stored for off-line analysis. LabView Version 6.0.2 graphical programming software (National Instruments) was used for data acquisition. To process and analyze the data, MATLAB Version 5.2 (The Math Works Inc, Natick, Mass) was used. EMG signals were digitally band pass filtered at 10-200 Hz following data collection. All digitized EMG signals were full wave rectified and low pass filtered using a 2nd order dual pass (zero lag) Butterworth filter with a 50 Hz cut-off frequency.

Mechanical perturbation onset of the stance lower limb was automatically identified as an abrupt increase in the knee flexion angle as measured by the electrogoniometer following load release. All trials were visually verified and corrected if necessary. Manual corrections were made in approximately 57% of the trials in the following situations: (1) the computer picked a point within the increasing knee flexion angle that was temporarily flat (6-11 ms), (2) the computer picked a small fluctuation within the increasing knee flexion angle, or (3) the computer picked a small fluctuation within the baseline prior to the abrupt increase in the knee flexion angle. Rejected from this study were trials that had unacceptable perturbation releases. These were defined as trials in which the release mechanism occurred right at the beginning or end of a trial, or not at all. These trials had either insufficient data or no data recorded to determine mechanical perturbation onset.

Following the identification of mechanical perturbation onset, muscle response times were automatically determined when the myoelectric activity of each muscle first exceeded the mean + 2 SD from the baseline EMG activity. Baseline EMG activity of each muscle was determined as the mean EMG activity of the first 160 ms of the 200 ms prior to trigger signal. The 40 ms prior to trigger signal was not used because of the possibility of artifact from the release of the electromagnet. The program used a moving 9-point (1 point = 1 ms) window. Muscle response times were determined when 7 of the 9 points in the window exceeded the mean + 2 SD from the baseline EMG activity. For the muscle response times, the computer marked the beginning of this 9-point window.

Each trial was interactively verified following the automatic detection of the muscle response time. For visual assistance, a horizontal line was placed on the EMG traces at the mean + 2 SD of the baseline EMG. Manual corrections were made in 4.4% of the trials for the vastus lateralis muscle and 3.0% of the trials for the biceps femoris muscle. Manual corrections were made when the computer picked what looked to be a small burst of activity that was consistently seen in the baseline.

The muscle response times were then separated into the following 4 categories: no response, less than 30 ms, 30-150 ms, and greater than 150 ms. The range of the muscle response times under investigation for this study was 30-150 ms.[36] Shultz and colleagues determined that neuromuscular responses and activation patterns to perturbations in single lower limb stance are different from those in partial or non-weightbearing positions.[36] The 30-150 ms time frame was chosen because we wanted to measure the first neuromuscular response following the perturbation that may include the long loop response that has been reported to consistently occur under active muscle conditions.[37,38] Trials with no responses, muscle response times less than 30 ms, or muscle response times greater than 150 ms were not included in the statistical analysis. Figures 2, 3, and 4 show a sample trial of electrogoniometer and EMG traces from each of the subject groups.

Statistical Analysis

One-way analysis of variance (ANOVA) was performed to determine between group differences for age and body mass index. Separate 3 (group) by 2 (load) mixed factorial ANOVAs were performed for EMG data from the vastus lateralis and biceps femoris. "Group" was the between-group independent variable and "load" was the repeated measures independent variable. "Muscle response time" was the dependent variable. Data were analyzed with SPSS Statistical Software Package, version 11.0 (SPSS Inc, Chicago, IL). The Tukey honestly significant difference (HSD) *post hoc* test was used to detect significant main effects. A significance level of 0.05 was used throughout.

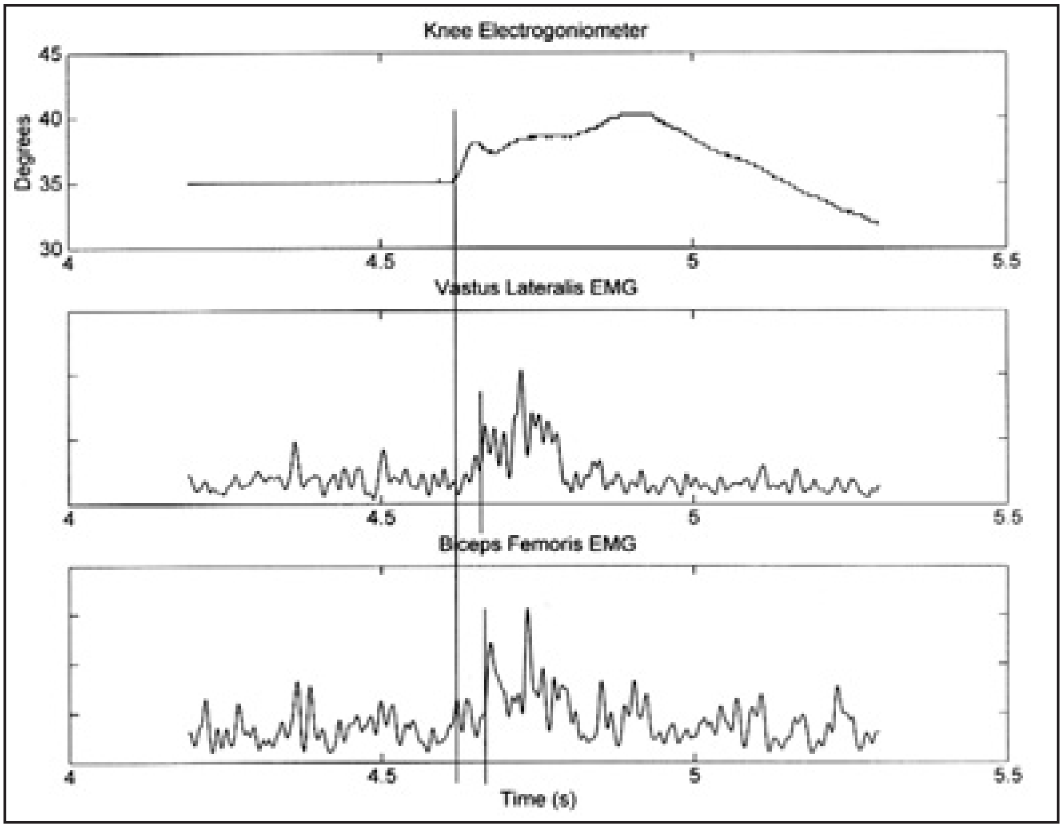

Figure 2. Electrogoniometer, vastus lateralis electromyography (EMG), and biceps femoris EMG traces of a sample trial from a young adult subject. The large vertical line indicates onset of mechanical perturbation. The smaller vertical lines indicate muscle response times. Vastus lateralis response time = 41 ms. Biceps femoris response time = 46 ms.

RESULTS

All subjects were able to complete the experimental protocol. A summary of subject characteristics is found in Table 1. Older adults and older adults with knee OA were older than the young adults [F(2,24) = 260.207, *P*<0.05 (*P* = .000)]. Young adults and older adults had a smaller body mass index than older adults with knee OA [F(2,24) = 10.787, *P* < 0.05 (*P* = .000)]. There was no difference in body mass index between young adults and older adults. Of the 7 older adults with knee OA, 5 were classified as grade 2 severity and 2 were classified as grade 3 severity.

Table 1. Subject Characteristics*

Characteristic	Young adults (n=10)	Older adults (n=10)	Older adults with knee OA (n=7)
Age (years)	26.0 ± 5.2	72.1 ± 5.3	74.0 ± 4.9
Height (m)	1.75 ± 0.08	1.70 ± 0.10	1.62 ± 0.11
Weight (kg)	69.9 ± 10.3	77.1 ± 12.8	85.2 ± 19.2
Body mass index (kg/m^2)	22.6 ± 2.5	26.7 ± 4.4	32.2 ± 5.7

*Values are mean ± SD

Figure 5 shows the response times for the vastus lateralis and biceps femoris muscles. The proportion of vastus lateralis response times within 30-150 ms was: young adults (110/200 trials = 55.0%), older adults (108/200 trials = 54.0%), and older adults with knee OA (83/140 trials = 59.3%). The proportion of biceps femoris response times within 30-150 ms was: young adults (91/200 trials = 45.5%), older adults (75/200 trials = 37.5%), and older adults with knee OA (54/140 trials = 38.6%).

For vastus lateralis response times, there was no main effect for load [F(1,89) = 2.886, *P* > 0.05 (*P* = .093)] and no group x load interaction [F(2, 89) = 1.423, *P* > 0.05 (*P* = .246)]. However, there was a main effect for group [F(2,89) = 4.787, *P* < 0.05 (*P* = .011)] (Figure 5, Tables 2 and 3). *Post hoc* Tukey HSD tests for group revealed no difference between vastus lateralis response times of older adults with knee OA and older adults and no difference between older adults with knee OA and young adults (*P* > 0.05). Older adults did have longer vastus lateralis response times than young adults (*P* < 0.05).

For biceps femoris response times, there was no main effect for load [F(1,50) = .066, *P* > 0.05

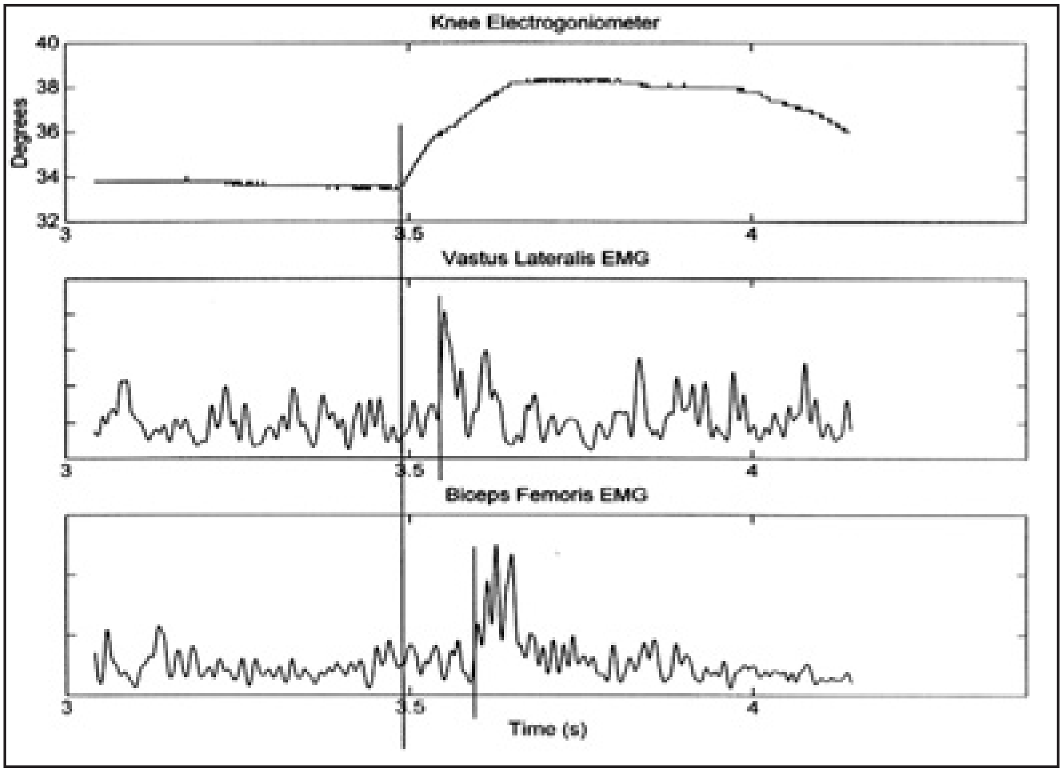

Figure 3. Electrogoniometer, vastus lateralis electromyography (EMG), and biceps femoris EMG traces of a sample trial from an older adult subject. The large vertical line indicates onset of mechanical perturbation. The smaller vertical lines indicate muscle response times. Vastus lateralis response time = 57 ms. Biceps femoris response time = 106 ms.

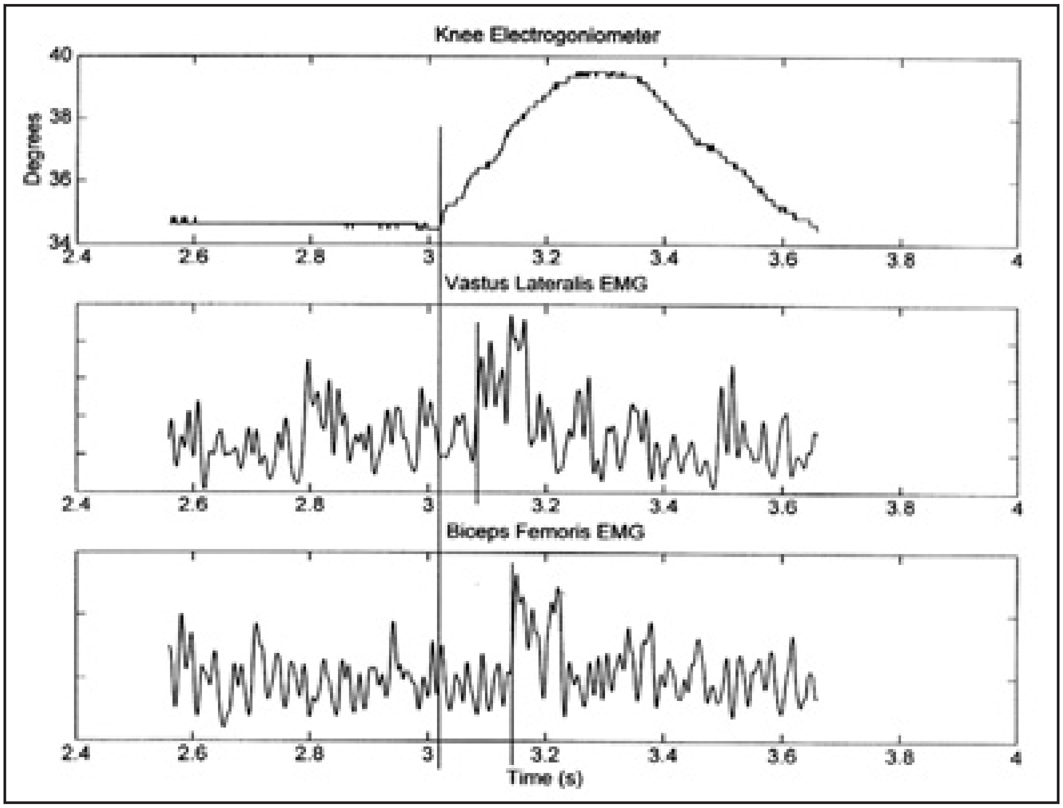

Figure 4. Electrogoniometer, vastus lateralis electromyography (EMG), and biceps femoris EMG traces of a sample trial from an older adult with knee OA. The large vertical line indicates onset of mechanical perturbation. The smaller vertical lines indicate muscle response times. Vastus lateralis response time = 66 ms. Biceps femoris response time = 126 ms.

(P = .798)] and no load x group interaction [F(2,50) = .308, $P > 0.05$ (P = .737)]. However, there was a main effect for group [F(2,50) = 10.906, $P < 0.05$ (P = .000)] (Figure 5, Tables 4 and 5). *Post hoc* Tukey HSD tests revealed no difference between biceps femoris response times of older adults with knee OA and older adults; however, both groups had longer biceps femoris response times than young adults ($P < 0.05$).

DISCUSSION

In both the vastus lateralis and biceps femoris muscles, our hypothesis that muscle response times are delayed in older adults with symptomatic knee OA when compared to young and older adults was not supported by the results. Our second hypothesis that muscle response times are dependent on magnitude of load released was not supported by the results since there were no differences in either vastus lateralis or biceps femoris response times between 6 kg and 9 kg loads.

The results indicated that the vastus lateralis and biceps femoris response times of the older adults with knee OA did not differ from the older adults. This may have occurred for 3 major reasons. First, for both muscles in both groups, there was large inter-subject variability that may explain the lack of significant difference in muscle response times between these older populations. For such large variability, the sample size may have been too small to detect a difference between these groups. With power = 0.80 and a medium effect size of 0.25, a recommendation of 52 subjects per groups would be sufficient. With power = 0.80 and a large effect size of 0.40, a recommendation of 21 subjects per group would be sufficient.[39]

Second, it is possible that the arthritic changes in the older

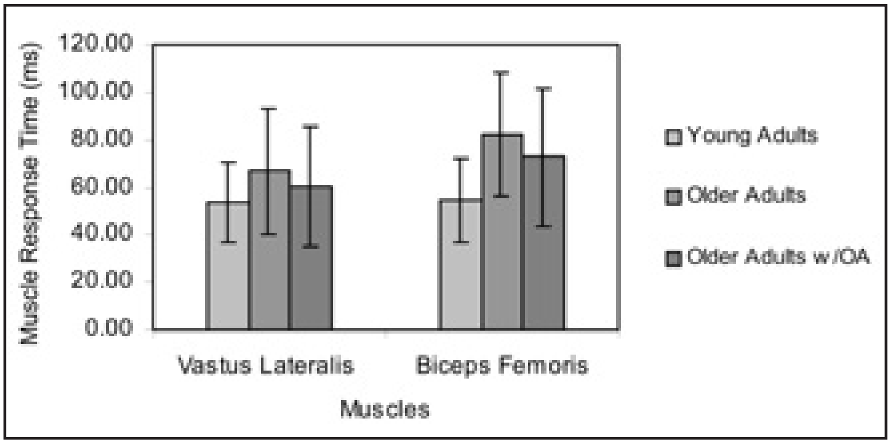

Figure 5. Muscle response times for young adults, older adults, and older adults with knee osteoarthritis (OA). Error bars indicate SDs.

Table 2. Vastus Lateralis Response Times (ms)*

Load	Young Adults	Older Adults	Older Adults with knee OA	Total
6 kg	57.52 ± 18.47	65.88 ± 27.54	65.65 ± 30.12	62.82 ± 25.53
9 kg	49.82 ± 13.28	67.82 ± 25.34	55.54 ± 18.48	57.89 ± 21.03
Total	53.67 ± 16.42	66.85 ± 26.27	60.60 ± 25.26	

*Values are mean ± SD

Table 3. Summary of 3 (group) by 2 (load) Mixed Factorial ANOVA for Vastus Lateralis Response Times

Source of Variation	df	SS	MS	F	P
Between Subjects					
Group	2	5738.37	2869.18	4.787	.011*
Error	89	53343.17	599.36		
Within Subjects					
Load	1	1271.61	1271.61	2.886	.093
Load x Group	2	1254.48	627.24	1.423	.246
Error	89	39220.75	440.68		

*Indicates significance, $P < 0.05$

Table 4. Biceps Femoris Response Times (ms)*

Load	Young Adults	Older Adults	Older Adults with knee OA	Total
6 kg	57.00 ± 22.10	80.89 ± 27.06	73.15 ± 23.59	69.53 ± 26.15
9 kg	52.05 ± 11.37	83.37 ± 26.21	72.38 ± 34.13	68.26 ± 27.39
Total	54.52 ± 17.54	82.13 ± 26.31	72.77 ± 28.75	

*Values are mean ± SD

Table 5. Summary of 3 (group) by 2 (load) Mixed Factorial ANOVA for Biceps Femoris Response Times

Source of Variation	df	SS	MS	F	P
Between Subjects					
Group	2	15722.43	7861.21	10.906	.000*
Error	50	36039.93	720.80		
Within Subjects					
Load	1	29.77	29.77	.066	.798
Load x Group	2	277.15	138.58	.308	.737
Error	50	22518.00	450.36		

*Indicates significance, $P < 0.05$

adults with knee OA were not severe enough to influence muscle response times. These arthritic changes typically include loss of articular cartilage, subchondral bone thickening, joint space narrowing, and osteophytes;[40] but there may also be joint pain and mechanical disruption due to pathologic alterations in the synovium, bone, ligaments, muscles, and nerves.[17] Our hypothesis of delayed muscle response times to a perturbation in people with mild knee OA was built upon decreased muscle strength, decreased proprioception, and reports of the OA knee giving out during activities of daily living.

Third, a difference in muscle response times may not be apparent because of the state of the muscles prior to the perturbation. In our study, the vastus lateralis and biceps femoris muscles were contracting prior to the perturbation. Myers and colleagues have found that muscle response latencies following a perturbation are dependent on the level of contraction.[41] They showed that latencies were longer when muscles were in a relaxed state prior to the perturbation compared to muscles under 20% and 50% of maximum voluntary contraction. Following a perturbation, relaxed muscles take time to reach threshold; whereas, contracting muscles have motoneurons at or near threshold and would respond faster following the disturbance.

Shultz and colleagues stated that single limb functional weightbearing neuromuscular responses are different than seated, resting, and partial weightbearing conditions.[36] They tested 64 young adults and muscle response times were measured using an average of 5 trials per muscle for each subject. They reported vastus lateralis muscle response times of 94.27 ± 18.57 ms for an internal rotation perturbation and 95.34 ± 20.86 ms for an external rotation perturbation. They also reported lateral hamstring muscle response times of 76.86 ± 22.39 ms for an internal rotation perturbation and 70.41 ± 15.64 ms for an external rotation perturbation. The vastus lateralis and biceps femoris muscle response times for the young adults in our study (Tables 2 and 4) were less than those reported by Shultz; however, the standard deviations were similar. The discrepancy in vastus lateralis and biceps femoris response times may be partially explained by the different release mechanisms and their influence on the trunk and supporting lower limb. In our study, the perturbation device used 6 kg and 9 kg loads to produce a forward moment with unexpected knee flexion. In the study by Shultz, the perturbation device produced a "sudden, unanticipated forward and either internal rotation or external rotation moment of the trunk and femur relative to the weight-bearing tibia."[36]

There is no direct comparison with our results to that in the literature of older adults or older adults with knee OA. Vastus lateralis and biceps femoris response times following a perturbation in single lower limb stance have not been reported in these groups. In our study, both vastus lateralis and biceps femoris response times were longer in the older adults than in the young adults. The outcome of this study also confirmed an age related increase in the biceps femoris response times in the older adults with knee OA. These outcomes are somewhat supported by the literature in that lower limb muscle response times following a stance perturbation increase with age.[29, 30]

The results from our study support the possibility that knee OA does not alter muscle response times following a perturbation during single lower limb stance. Specific to this perturbation task, the vastus lateralis and biceps femoris muscle response times of all groups were adequate for knee joint stabilization. All subjects were able to maintain upright posture following the perturbations; no one experienced complete knee collapse. Although decreases in quadriceps muscle force, proprioception, and joint stability are associated with knee OA, a relationship was not identified between knee OA and altered lower limb muscle responses needed for joint protection.

Muscle response time following a perturbation may not be the most appropriate EMG variable to study in older adults with knee OA. One EMG variable that may be worth studying is the amplitude of the neuromuscular response. Research has shown that patients with neurological disorders can have changes in their response amplitudes following a perturbation even though they have normal latencies.[42,43] Patients with Parkinson disease often show decreased response amplitudes; whereas, patients with a midline cerebellar disorder show increased response amplitudes. The type of neuromuscular response amplitude following a perturbation is currently unknown in knee OA patients. Studying the neuromuscular response amplitude in knee OA patients may provide clues in how to effectively treat this disease by better understanding muscular joint protection.

Some limitations of our study include the following: (1) lack of randomization on load order, (2) an uneven number of male and female subjects in the older adults with knee OA group, (3) no provision of a pain scale to older adults with knee OA, and (4) the experience of fatigue by older adults with knee OA. Randomization of load order was successful in the young and older adults but not in the older adults with knee OA. The first 2 older adults with knee OA tested had difficulty maintaining balance when the 9 kg load was the first load applied. Because of this, the knee OA subjects started with the 6 kg load for the first 10 trials and then progressed to the 9 kg load for the second 10 trials. In each of the young and older adult groups, there were 5 males and 5 females; however, there was 1 male and 6 female older adults with knee OA. This gender unevenness could be explained by the subject availability during the recruiting process and/or the general propensity that women are more affected with knee OA than men.[4]

Although a formal pain scale was not used, 4 of the 7 older adults with knee OA reported that their tested knee felt better following the experiment. To qualify the knee discomfort, we could have used a visual analog or numeric pain scale or the Western Ontario and McMaster Universities Osteoarthritis Index that qualifies knee pain, stiffness, and functional disability.[44] The older adults with knee OA fatigued during the second set of trials based on verbal feedback. This may have been because older adults with knee OA had a higher body mass index than both young and older adults (Table 1). Some authors speculate that obesity increases the load across the knee joint and this causes OA.[45, 46] However, whether or not obesity increases the load across the knee joint depends on the activity being performed such as sit to stand[47] or walking.[48] The authors propose that there is an adjustment in the neuromuscular system in obese subjects that leads to decreased knee loads during self-selected gait speed.[48]

Due to excess cost and unnecessary x-ray exposure, young and older adults did not receive knee x-rays for comparison with the older adults with symptomatic knee OA. We cannot be certain, therefore that older adults with asymptomatic knees did not have knee OA. If they did, the results should be reinterpreted. A probable conclusion would be that knee discomfort (pain) does not alter vastus lateralis and biceps femoris muscle response times following a single lower limb stance perturbation in older adults with knee OA.

Fitzgerald and colleagues reported single and double lower limb stance perturbation training in a patient with knee OA.[34] Following the physical therapy program, the patient reported a significant decrease in knee pain and a better feeling of stability during daily activities. The authors concluded that further research is required to explain how agility and perturbation training can influence the neuromuscular system in people with knee OA. Future studies should look at not only the muscle response times but also the amplitude of the muscle responses. A future project may include studying one of the following tasks described by Fitzgerald and colleagues: single lower limb stance on foam surface with perturbation, roller board perturbation, or tilt board technique with perturbation.[34]

CONCLUSION

As people live past the age of 65, they are at risk for developing painful knee OA with a progressive decline in functional abilities. Proper assessment of neuromuscular impairments is important when choosing effective physical therapy interventions to treat this population. Although knee OA did not alter muscle responses in our study, the type of functional weightbearing perturbation described could be safely used in the physical therapy clinic to help improve balance and stability while decreasing discomfort in older adults with symptomatic knee OA.

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