THE EFFECTS OF KINESIO TAPE™ ON PROPRIOCEPTION AND BALANCE IN INDIVIDUALS WITH AND WITHOUT KNEE PAIN

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ABSTRACT

Context: Knee pain in the elderly has been linked to decreased function and greater fall risk. Kinesio Tape™ (KT) has been used for the treatment of pain and proposed to provide proprioceptive benefits; however, limited evidence regarding the benefits to proprioception and balance currently exist. The purpose of this study was to examine the effects of KT on knee proprioception, balance, and pain in an elderly population with knee pain. **Methods:** A repeated-measures study was performed in the biomechanics laboratory, with the participants reporting every 72-hours, for four total data collections: 1) baseline, 2) immediately after tape application, 3) 72-hours after tape application, and 4) 72-hours after tape removal. Thirty-three participants (F: 24, M: 9; age: 63.91±18.03 years; height: 1.62±0.11 m; mass:70.65±18.45 kg), were recruited from the community. A control group (n=11) was administered KT tape, while participants with knee pain were randomly assigned to KT group (n=11) or Sham (incorrectly applied KT) group (n=11). Participants filled out the Knee Injury and Osteoarthritis Outcome Score (KOOS) at the first and last data collections, and the nine question pain portion during the second and third data collections. Participants completed joint position sense (JPS) testing with open-kinetic chain (OKC) knee extensions and closed-kinetic chain (CKC) double leg squats. Ten repetitions to the demonstrated reference angle (30°) from the resting position (90°) were completed during the OKC test. Ten double-leg squat repetitions were completed to the demonstrated reference angle (30°) from the standing position (0°) for the CKC test. Knee JPS was measured via 3D motion capture and angular errors from 30° were calculated from sagittal plane angles. Berg Balance Scale (BBS) was used to assess balance function. Mixed-method ANOVA (between x within) was conducted with Bonferroni post-hoc pairwise comparisons. **Results:** For BBS, a significant within-subject polynomial time contrast ($p=0.006$) was observed. Post-hoc pairwise comparisons indicated significantly lower scores for KT (52.73±2.28, $p=0.017$) and Sham (53.00±2.65, $p=0.036$) groups compared to control (55.36±0.81) at baseline; however KT group was no longer different from control (control:55.36±1.03 vs. KT:54.45±1.75, $p=0.66$) at the final time point while Sham group remained significantly lower (53.18±2.14, $p=0.014$), demonstrating KT group's improvement over time. No KT effects were observed with OKC-JPS ($p=0.805$, $\eta p^2=0.030$) and CKC-JPS ($p=0.438$, $\eta p^2=0.064$). Significant learning effects were seen over time only with CKC-JPS regardless of the group ($p<.0001$, $\eta p^2=0.301$). KOOS scores for KT and Sham groups were significantly lower from the control group at all time points. **Conclusions:** Berg Balance Scale improved over time when KT was applied to participants with knee pain; however, this improvement was not seen when KT was applied incorrectly (sham) to the participants with knee pain and when KT was applied correctly to participants without knee pain (control). Improvements in BBS at the final time point, 3-5 days after tape removal, may suggest the lasting effect of KT. The KT effects were not seen in JPS testing, which may be due to relatively larger variance and small sample sizes resulting in low statistical power. Research with a larger sample is warranted to further investigate the KT effects on JPS. Although there were improvements in BBS scores, greater changes in scores to achieve clinical significance, as well as significant improvements in JPS, would better support clinical use of KT on individuals with knee pain.

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LIST OF ABBREVIATIONS

Abbreviations	Names
KT	Kinesio Tape™
KOOS	Knee Injury and Osteoarthritis Outcome Score
OKC	Open-Kinetic Chain
CKC	Closed-Kinetic Chain
JPS	Joint Position Sense
BBS	Berg Balance Scale
OA	Osteoarthritis
ASIS	Anterior Superior Iliac Crest
AAE	Absolute Angular Error
RAE	Relative Angular Error
ADLs	Activities of Daily Living
QOL	Quality of Life

CHAPTER 1. INTRODUCTION

Osteoarthritis is slow and progressive, caused by inflammation and degradation of cartilage in the affected joints.[1] Knee osteoarthritis (OA) affects between 17-30% of the population of people 65 years or older.[2] Two common findings when diagnosing knee OA are: asymptomatic radiographic OA and symptomatic knee pain but no detectable radiographic OA. This second finding could be due to cartilage changes occurring in the later course of the disease.[3]

Patients with painful knee OA usually have declines in functionality which increases risk of falling. It has been found that elderly people with OA have over a 50% chance of having an increased incidence of falling, and that those with knee OA are at higher risk of falls compared to healthy elderly individuals.[4] The primary functional limitation in people with knee OA is difficulty walking.[2] Slower walking velocity has been found to be associated with: 1) quadriceps weakness, 2) joint space narrowing, 3) increased concentrations of inflammation mediators, and 4) pain[2]; therefore, when treating OA, exercise therapy is still the leading therapeutic option because it affects cartilage metabolism and changes the cartilaginous structure through a mechanotransduction response.[1] Despite functional limitations, individuals with knee pain, especially in the older population, tend not to seek medical consultation if they have chronic joint pain or other OA symptoms due to the belief that they are part of normal aging.[3] On the contrary, they will usually seek consultation if the symptoms are of acute onset, if there are disruptions to their sleep, or if they start affecting their mobility. Instead, most try to mange their knee pain with self-management of coping strategies, along with over-the-counter pain treatments.[3]

Knee OA has been linked to somatosensory dysfunction which then leads to decreased proprioception.[5] Proprioception involves joint position sense and assists in joint stabilization while controlling and coordinating joint movement in order to protect the joint.[5] Two theorized

causes of proprioception deficits in knee OA are: alteration in skeletal muscle function[6] and OA-associated degeneration leading to mechanoreceptor damage[4]. Stimulation of cutaneous mechanoreceptors, from pressure and stretching of the skin by KT application, may be a way to improve joint movement kinesthesia and position sense in people with knee pain.

Dr. Kenzo Kase, creator of KT, states that KT has therapeutic principles due to 4 proposed mechanisms, such as restoring normal muscle function and helping improve joint balance.[7] The design of the tape attempts to mimic the epidermis thereby achieving these proposed mechanisms. Conscious recognition of the tape application diminishes within several minutes, while proprioceptive input to the brain continues.[8] H. Murray has also proposed a fifth mechanism that KT can improve proprioception through increased stimulation of cutaneous mechanoreceptors, due to KT being designed to mimic the dermis.[9]

Though there is limited literature regarding the effect of KT on joint proprioception, specifically in patients with knee OA, studies have been conducted in order to examine the effects of KT on proprioception in other populations such as: healthy individuals[10], stroke patients[11], and Patellofemoral Pain Syndrome (PFPS)[12]. The results of these studies are mixed in supporting the use of KT for improving joint position sense. In healthy individuals, there were no clear effect, but when applied to stroke patients and PFPS, participants that received KT showed greater improvement in joint position sense than the control participants. Other authors[13-15] studied the effects of tape applied to the patella on proprioception, and although the populations studied were not individuals with knee OA, their results support the use of patella taping to help improve proprioception. In regard to the authors that examined the effects of KT on knee OA patients, their results showed a decrease in pain levels[1] and an improvement in the patients'

ability to perform activities of daily living (ADLs)[2,16], when KT was applied to the quadriceps femoris muscle group.

The purpose of this study was to compare a quadriceps femoris facilitation KT application, which was applied to a healthy control group and knee pain group, and a sham KT application, which was applied to a knee pain group, and their effects on: 1) the patients' perceived pain and limitations as obtained through the Knee Injury and Osteoarthritis Outcome Scale (KOOS), 2) proprioception as examined through joint position sense (JPS) tests, and 3) balance through the completion of the 14-item Berg Balance Scale (BBS). We hypothesized that the quadriceps femoris facilitation KT application would demonstrate greater improvements in proprioception, balance, pain, and functionality on patients with knee pain compared to the sham tape application and healthy control group.

CHAPTER 2. METHODS

2.1 Research Design

A repeated measures design was used to investigate effects of a quadriceps femoris KT application and a sham tape application on the participants' balance, KOOS scores, and JPS of the affected knee. Participants with knee pain were randomly allocated to either quadriceps femoris KT or sham KT tape application, and were compared to a healthy control group, which received the same tape application as the KT group. Data were collected at four points: at baseline, immediately after tape application (72-hours after baseline), immediately after tape removal (72-hours after tape application), and 72-hours after tape removal. Data collections were conducted within a 10-day time span, due to a 72-hour application period and a 72-hour "wash-out" period after the tape had been removed.[1,7,16]

2.2 Participants

Thirty-four participants (F: 25, M: 9; age: 64.2 ± 17.8 years; height: 1.6 ± 0.1 m; weight: 69.9 ± 18.6 kg), were recruited from the community and informed consent was obtained from each participant as part of the University Human Studies Program. One participant in the KT group had an allergic reaction to the tape and was unable to leave it on for the full 3-days, making the final sample size 33. Due to technical difficulty, another participant in the KT group was missing the recorded JPS for their third data collection, however the remaining parts of the data were utilized. A healthy, pain-free control group (n=11) was administered KT, while participants with knee pain were randomly assigned to KT group (n=11) or Sham group (n=11). The exclusion criteria for the healthy control group were: 1) pain with rest in affected knee(s), 2) pain with normal movements/activities of daily living, 3) pain and/or limitations when going up and down stairs, and/or 4) stiffness in affected knee(s).

Participants in the knee pain groups self-reported complaints of pain (at rest and/or with normal movements and ADLs), functional limitations (especially going up and down stairs), and stiffness in their affected knee(s). Exclusion criteria for this study included: 1) other current lower limb injury, 2) currently a candidate for knee replacement surgery, 3) open wounds around the knee or quadriceps area, 4) requirement for assistance during walking, 5) skin sensitivity to tape, 6) neurological conditions, 7) inability to follow instructions, 8) current back pain, 9) rheumatoid arthritis of the lower body, 10) unable to sit in a chair with feet on the floor, and/or 11) unable to straighten their knee fully. Each participant with knee pain was randomly assigned to a tape application group (KT or sham KT), by flipping a coin, with "heads" being KT group. The healthy control group reported no knee pain and were taped the same way as the KT group. Group anthropometrics can be found in Table 1.

Table 1. Anthropometric Measurements (Mean ± SD)

	Variables			
Group	n	Age (years)	Weight (kg)	Height (m)
KT	11	68.5 ± 15.6	68.0 ± 21.6	1.6 ± 0.1
Sham	11	71.8 ± 10.6	73.4 ± 19.4	1.6 ± 0.1
CON	11	51.5 ± 20.5	70.5 ± 15.1	1.7 ± 0.1

CON = Control group; KT = Kinesio Tape™ group; SD = Standard Deviation

2.3 Instrumentation

Joint Position Sense tests were recorded at all data collections by using an 18-camera motion capture system (Vicon Nexus 2.5.0 Motion Systems, Vicon LA, Culver City, CA). Kinematic data was collected at 240 Hz and processed with Visual-3D v4 software (C-Motion, Inc., Germantown, MD). A 29 retroreflective marker set was applied to each participant and placed on the following landmarks: bilaterally at the-1st, 2nd and 5th metatarsophalangeal (MP) joints, base of 5th metatarsal, medial malleolus, lateral malleolus, posterior calcaneus, medial femoral epicondyle, lateral femoral epicondyle, anterior superior iliac spine, posterior superior

iliac spine, and acromioclavicular joint; unilaterally at the - jugular notch, xiphoid process, C7 spinous process, T10 spinous process, inferior angle of right scapula; with four arrays located-bilaterally at the mid-thigh and mid-shank. After a standing calibration, the medial malleolus, medial femoral epicondyle, and 1st MP joint markers were removed.

2.4 Taping Technique and Application Procedures

The KT for quadriceps femoris activation was applied unilaterally using the directions of Anandkumar et al.[17] The participant was supine with leg fully extended, and 3 "I" strips were used. The length of the KT was determined by measuring from 10cm below the participant's anterior superior iliac spine (ASIS) to the superior pole of the patella, cutting the tape to half that length, and then adding a 5cm square for the anchor on each side, and the tension was determined by the lines on the back of the tape.[7] "The base of the first strip was applied 10-cm below the anterior superior iliac spine. Following this, the tape was pulled with a 50% tension along the course of the rectus femoris until the superior border of the patella. The knee was then flexed to 45° with the remaining strip applied in a paper-off tension (without tension) extending over the superior border of the patella. The base of the second ''I'' strip was applied below the greater trochanter and the tape was pulled with a 50% tension along the course of the vastus lateralis until the lateral border of the patella. The knee was then flexed to 45° and the remaining strip was applied with a paper-off tension (without tension) around the lateral border of patella towards the tibial tuberosity. The base of the third strip was applied from the middle 1/3rd of the medial aspect of the thigh. The tape was pulled with a 50% tension along the course of vastus medialis towards the medial border of the patella. The knee was then flexed to 45° and the remaining strip was applied with a paper off tension (without tension) around the medial border of patella ending towards the tibial tuberosity."[17]

The sham tape application consisted of one "I" strip, applied from origin to insertion of the rectus femoris, with paper off tension, starting with the leg straight and then bending to 45°. The length of the tape was from 10-cm below the ASIS to the superior border of the patella. The healthy control group received the same application as the KT group. The KT was applied on the dominant leg on the controls, while the participants with knee pain received their respective tape application on their most symptomatic knee. All participants were instructed to leave the tape on for 72 hours, and to only remove it if they had any skin irritation due to the tape or if there was excessive peeling. Most participants were able to maintain the tape well for the 72-hour period, but those who reported excessive peeling saw it most with the middle piece. There was a 72-hour period after all participants had removed their tape and before the final data collection.

2.5 Functional Test

The participants completed the testing after maker placement. Joint Position Sense was tested in an open-kinetic chain position (OKC-JPS)[5] and a closed-kinetic chain position (CKC-JPS)[18]. Open-kinetic chain Joint Position Sense (OKC-JPS) was evaluated by having the participant sit on a table with their legs hanging off the edge. The examiner passively moved the participant's right knee to 30°, a normal degree of flexion during the stance-phase of walking.[19] This angle was measured by using a standard long-arm goniometer, with the stationary arm in line with the greater trochanter, the fulcrum on the lateral condyle, and the moving arm in line with the lateral malleolus. The examiner held the participants leg at the desired angle for 3 seconds before their knee was returned to normal resting position for the familiarization trial. Each participant then attempted to reproduce the demonstrated angle ten times[19] with their eyes closed. The participant then performed OKC-JPS on the left limb.

Closed-kinetic chain Joint Position Sense (CKC-JPS) testing was conducted by having the participants stand with feet shoulder-width apart, instructing them to squat until the target knee angle of 30° was reached. The demonstrated angle was held for 3 seconds and then the participants returned to the starting position. The table remained in front of the participants for balance and support. The participants attempted to reproduce the demonstrated angle ten times, with their eyes closed. Each trial consisted of the participant moving their knee(s) to the target angle, holding it for 3 seconds, and then returning to the starting position. The average angle within the 3 second testing period was calculated for each JPS test.

The values used for JPS were Absolute Angular Error and Relative Angular Error. Absolute Angular Error (AAE) is the absolute value of the difference between the reference angle (30°) and the reproduced angle. The average AAE is the mean AAE of the 10 trials. Relative Angular Error (RAE) is the same as the AAE but no absolute value is taken, which gave either a positive or negative number, indicating the direction of error. The mean of 10 trials was taken for each participant. Participants were told that if at any point a task becomes too painful to perform, they were allowed to stop that task, rest until the pain subsides, and move on to the next task. This was done to makes sure that the participants would be able to complete the data collection and so that their range of motion would not be inhibited by pain.

Between JPS tests, balance assessment was completed with the BBS, a 14-task long screening tool that is used clinically to evaluate geriatric patients' balance ability while both standing and in motion[13]. The BBS consists of tasks that replicate actions that the participant would perform in daily life, such as going from standing to sitting, standing back up, picking up a shoe from the ground, and turning to look over their shoulders, to name a few. The BBS has been shown to have an absolute reliability of 7.7 (calculated by running a one-way ANOVA and

taking the with-in subject SD and multiplying it by 2.77) and intraclass correlation coefficient of 0.97 in older populations that live in residential care facility.[20]

2.6 Procedures

Each participant completed the Knee Injury and Osteoarthritis Outcome Score (KOOS), a 38-item questionnaire, split into five categories (Symptoms, Pain, Activities of Daily Living (ADL), Sports and Recreation, and Quality of Life (QOL), that allowed the participants to self-report their symptoms and limitations due to knee OA or other knee pathologies[21]. The questions were scored on a range of 0 to 4, and each subscale had a maximum score of 100 (no symptoms and full knee function) and a minimum score of 0 (extreme knee pain and decrease in knee function). Participants completed the whole form both at the first (baseline) and the fourth (final) data collection. The participants also filled out the 9-question long pain section of KOOS during the second and third data collections. Participants also answered one separate question on their pain level for the day: "do you feel any pain now?"; participants would rate on a scale of none, mild, moderate, severe, and extreme, which was taken from the KOOS pain section. The height and weight of each participant were measured prior to the start of the functional testing. The retroreflective markers were then placed on the participants and the participants underwent gait analysis, until three successful (the participants' entire foot struck the force plate) trials were completed per leg. Then the participants performed one set of 10 repetitions of OKC-JPS on each leg. Participants then completed the BBS. Participants then completed one set of 10 repetitions in a closed kinetic chain (CKC) position for the final task. Each participant came in 4.7 ± 5.6 days after baseline had been recorded and the respective KT was applied according to the group assignment. Outcome measurements were recorded again immediately after the application, 3.2 ± 0.5 days after the tape application, and finally 3.4 ± 0.6 days after the tape had been removed.

During the final data collection, the participants filled out a final follow-up KOOS, and were re-taped if they found it to be beneficial.

2.7 Statistical Analysis

All data were analyzed using SPSS Version 26.0 with an alpha level of $p<0.05$. A mixed method (between x within) Analysis of Variance (ANOVA) was used to assess the effect of the independent variables of group (KT, sham tape, control) and time (baseline, acute tape (72-hours after baseline), 72-hours post tape, and 72-hours post tape removal) on each dependent variable (OKC-JPS outcomes, CKC-JPS outcomes, Berg Balance Scale scores, and KOOS pain). Bonferroni post-hoc pairwise comparison was conducted to determine the difference between groups and what the observed power was. Pillai's Trace was used to determine significance of multivariate tests, and Mauchly's Test of Sphericity was conducted to test the assumption of homogeneity of variance of dependent variables in ANOVA analysis. With-in subject tests were also conducted to examine if there were any decrease in angular error over time for all participants.

Due to the inclusion of only two time points for the Symptom, ADL, Sports and Recreation, and QOL scores of KOOS, the results of those four categories were analyzed using Multivariate Analysis of Variance (MANOVA) with Levene's Test to examine the homogeneity of variance. Three variables (Symptoms at the final data collection, and both ADL scores) violated the assumption of homogeneity of variance; therefore, a non-parametric Kruskal-Wallis test was conducted to determine between group differences.

CHAPTER 3. RESULTS

3.1 Knee Injury and Osteoarthritis Outcome Scores

Pain scores violated the assumption of homogeneity of variance (Mauchly's W=0.575, p=0.007); therefore with-in subject effects were examined using Huynh-Feldt corrections. Pain did not change over time (F=2.152, p=0.107, ηp^2=0.067), nor was there a time x group interaction effect (F=0.258, p=0.943, ηp^2=0.017). There was a significant group effect indicating that KT (T0: 72.64 ± 17.15, p=0.006; T1: 73.00 ± 15.25, p=0.002; T2: 76.73 ± 17.94, p=0.005; T3: 74.82 ± 20.01, p=0.013) and Sham (T0: 68.82 ± 19.02, p=0.001; T1: 69.55 ± 18.47, p<0.001; T2: 72.00 ± 15.86, p=0.001; T3: 73.45 ± 19.07, p=0.001) groups were significantly different from the Control group (T0: 94.73 ± 7.54 ; T1: 96.00 ± 6.60; T2: 97.55 ± 4.28; T3: 96.27 ± 6.34) at each time point (Table 2 and Figure 1).

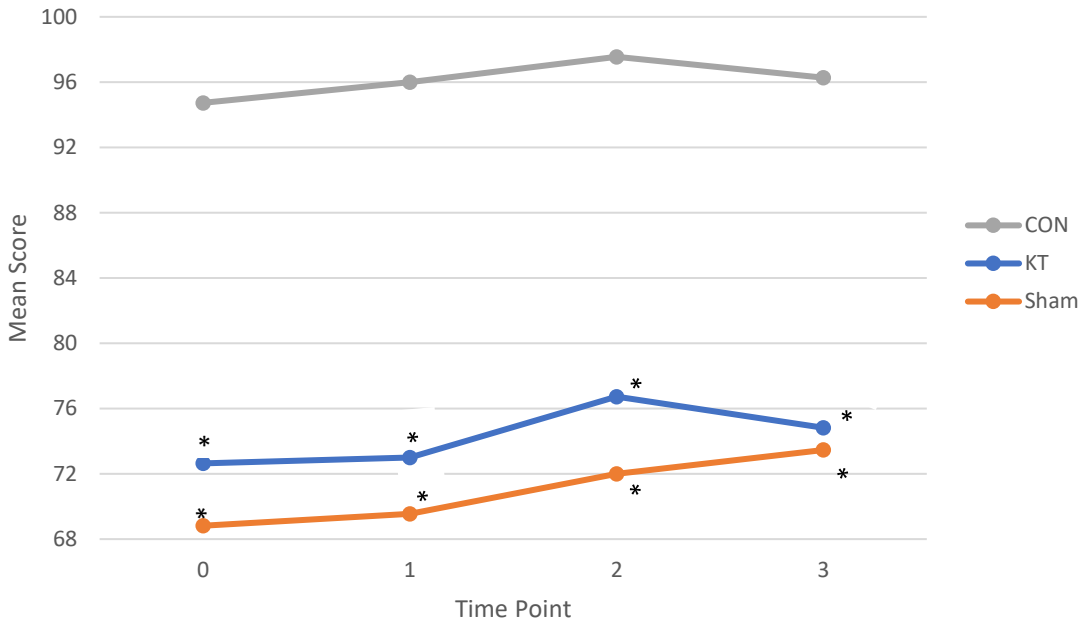

Figure 1. Comparison of KOOS Pain Scores Between Groups Across Time
*= Indicates significance difference from controls at each time point (p<0.05)
KOOS= Knee Injury and Osteoarthritis Outcome Scale; CON= Control group; KT= Kinesio Tape™ group; Sham= Sham Kinesio Tape™ group

Three variables violated the assumption (Symptoms-3: Levene Statistic=6.83, p= 0.004; ADL-0: Levene Statistic=20.66, p<0.001; ADL-3: Levene Statistic=19.84, p<0.001) so a Kruskal-Wallis test was conducted for them. Significant differences were found for all three variables (Symptoms-3: p=0.002; ADL-0: p<0.001; ADL-3: p=0.003), with KT and Sham having lower scores than controls. Significance was also seen in the KT and Sham groups compared to the control group at all time points (Table 2).

Table 2. Group by Time Pairwise Comparison (Mean ± SD) of KOOS Pain, Symptoms, Sports/Recreation, ADL, and QOL

		T0 (Baseline)		T1		T2		T3	
		Mean ± SD	95% CI	Mean ± SD	95% CI	Mean ± SD	95% CI	Mean ± SD	95% CI
KOOS Pain	KT	72.6 ± 17.2*	63.2, 82.1	73.0 ± 15.3*	64.2, 81.8	76.7 ± 17.9*	68.1, 85.4	74.8 ± 20.0*	64.7, 84.9
	Sham	68.8 ± 19.0*	59.3, 78.3	69.6 ± 18.5*	60.7, 78.4	72.0 ± 15.9*	63.4, 80.7	73.5 ± 19.1*	63.4, 83.5
	CON	94.7 ± 7.5	85.2, 104.2	96.0 ± 6.6	87.2, 104.8	97.6 ± 4.3	88.9, 106.2	96.3 ± 6.3	86.2, 106.4
KOOS Symptoms	KT	66.2 ± 19.6*	56.4, 76.0					69.3 ± 21.8*[a]	58.7, 79.8
	Sham	69.2 ± 17.5*	59.4, 79.0					71.8 ± 18.2*[a]	61.3, 82.3
	CON	93.8 ± 7.6	84.0, 103.6					94.9 ± 8.3[a]	84.4, 105.4
KOOS Sports	KT	72.3 ± 21.4*	60.0, 84.6					78.2 ± 18.8	66.2, 90.1
	Sham	72.2 ± 25.5*	59.9, 84.5					76.8 ± 26.4	64.9, 88.8
	CON	95.9 ± 9.2	84.0, 108.2					95.9 ± 9.2	84.0, 107.9
KOOS ADL	KT	74.9 ± 18.0*[a]	65.1, 84.7					77.1 ± 22.5*[a]	66.4, 87.8
	Sham	72.5 ± 20.6*[a]	62.6, 82.3					76.6 ± 19.7*[a]	65.8, 87.3
	CON	97.7 ± 3.7[a]	87.9, 107.6					97.6 ± 3.8[a]	86.9, 108.4
KOOS QOL	KT	39.5 ± 17.1	27.4, 51.5					45.6 ± 21.6	33.4, 57.8
	Sham	45.5 ± 17.1	33.4, 57.5					52.6 ± 20.5	40.4, 64.8
	CON	89.3 ± 14.4	77.2, 101.3					89.2 ± 17.0	77.0, 101.4

* Indicates significance from control group at $p<0.05$

[a]= Indicates use of Kruskal-Wallis test

SD= Standard Deviation; KOOS= Knee Injury and Osteoarthritis Outcome Score; ADL= Activities of Daily Living; QOL= Quality of Life; KT= Kinesio Tape™ group; Sham= Sham group; CON= Control group

3.2 Berg Balance Scale

With-in subject and Time x Group interaction effects approached significance (Time: $p=0.064$, $\eta p^2=0.077$; Time x Group: $p=0.094$, $\eta p^2=0.111$) while significant within-subject polynomial time contrasts for Time (linear, $p=0.006$) and Time x Group (linear, $p=0.018$) were observed (Figure 2). Post-hoc pairwise comparisons (Table 3) indicated significantly lower scores for KT (52.7 ± 2.3, $p=0.017$) and Sham (53.0 ± 2.7, $p=0.036$) groups compared to control (55.4 ± 0.8) at baseline; however KT group was no longer different from control (control: 55.4 ± 1.0 vs. KT: 54.5 ± 1.8, $p=0.66$) at the final time point while Sham group remained significantly lower (53.2 ± 2.1, $p=0.016$), demonstrating KT group's improvement overtime.

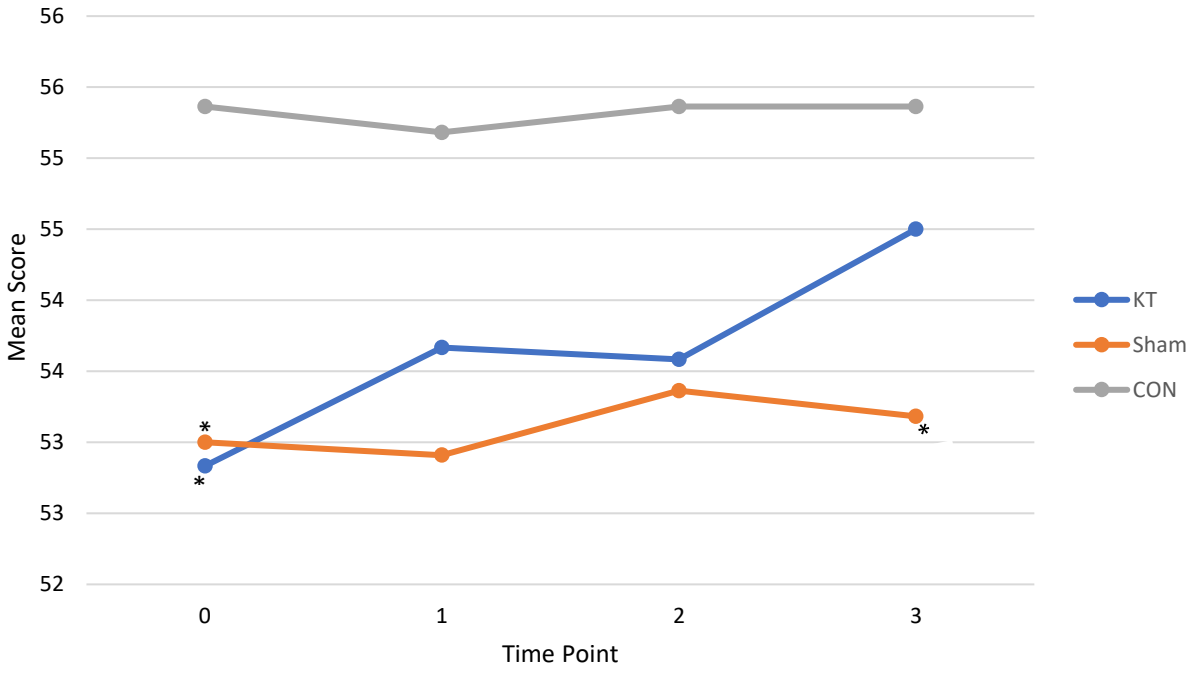

Figure 2. Changes in Mean Berg Balance Scale Over Time
*= Indicates significant difference from control group at each time point ($p<0.05$)
KT= Kinesio Tape™ group; Sham= Sham Kinesio Tape™ group; CON= Control group

Table 3. Group by Time Pairwise Comparison (Mean ± SD) of BBS, OKC-JPS, and CKC-JPS

		T0 (Baseline)		T1		T2		T3	
		Mean ± SD	95% CI	Mean ± SD	95% CI	Mean ± SD	95% CI	Mean ± SD	95% CI
	KT	52.7 ± 2.3*	51.2, 54.3	53.6 ± 2.6	51.9, 55.4	53.6 ± 2.2	52.1, 55.0	54.5 ± 1.6	53.3, 55.6
BBS	Sham	53.0 ± 2.7*	51.2, 54.8	52.9 ± 3.1	50.8, 55.0	53.4 ± 2.4	51.7, 55.0	53.2 ± 2.1*	51.8, 54.6
	CON	55.4 ± 0.8	54.8, 55.9	55.2 ± 1.3	54.3, 56.1	55.4 ± 1.0	54.7, 56.1	55.4 ± 1.0	54.7, 56.1
AAE	KT	12.1 ± 7.7	9.0, 19.2	10.4 ± 6.4	5.8, 15.0	10.8 ± 5.9	6.8, 14.8	11.4 ± 7.7	6.3, 16.6
OKC-JPS	Sham	9.9 ± 8.2	4.3, 15.4	9.8 ± 7.3	4.9, 14.7	9.3 ± 7.2	4.4, 14.1	8.8 ± 5.8	6.3, 16.6
(degree)	CON	12.1 ± 7.7	7.0, 17.3	8.2 ± 7.3	3.3, 13.1	11.3 ± 6.1	7.2, 15.4	10.7 ± 8.1	5.2, 16.1
RAE	KT	-10.9 ± 12.1	-19.0, -2.7	-4.9 ± 11.6	-13.2, 3.4	-5.7 ± 11.3	-13.3, 1.9	-7.9 ± 11.5	-15.6, -0.2
OKC-JPS	Sham	-5.2 ± 11.9	-13.2, 2.9	-4.2 ± 11.3	-12.4, 2.8	-7.0 ± 9.6	-13.4, -0.6	-6.7 ± 8.3	-12.3, -1.1
(degree)	CON	-8.4 ± 11.7	-16.3, -0.6	-4.1 ± 10.4	-11.0, 2.9	-8.7 ± 9.6	-15.2, -2.3	-7.4 ± 11.3	-15.0, 0.2
AAE	KT	20.3 ± 8.5	14.6, 26.0	14.6 ± 9.0**	8.1, 21.0	12.7 ± 7.2**	7.9, 17.6	12.1 ± 7.9**	6.8, 17.4
CKC-JPS	Sham	18.2 ± 8.1	12.8, 23.6	13.5 ± 9.1**	7.5, 19.6	13.3 ± 8.0**	8.0, 18.7	13.4 ± 6.4**	9.1, 17.7
(degree)	CON	26.6 ± 11.7	18.7, 34.5	19.6 ± 10.3**	12.7, 26.5	18.6 ± 10.1**	11.8, 25.3	13.8 ± 7.1**	9.1, 18.6
RAE	KT	-20.3 ± 8.5	-26.0, -14.6	-14.6 ± 9.0**	-21.0, -8.1	-11.5 ± 9.0**	-17.6, -5.5	-12.0 ± 8.0**	-17.4, -6.6
CKC-JPS	Sham	-18.0 ± 8.4	-23.7, -12.4	-13.4 ± 9.3**	-19.6, -7.2	-13.3 ± 8.1**	-18.7, -7.8	-12.5 ± 8.7**	-18.0, -6.4
(degree)	CON	-26.6 ± 11.7	-34.5, -18.7	-19.0 ± 10.8*	-26.3, -11.8	-18.6 ± 10.1**	-25.3, -11.8	-13.8 ± 7.2**	-18.6, -9.0

*Indicates significant difference from control group at $p < 0.05$

** Indicates significant difference from T0 at $p < 0.05$

BBS= Berg Balance Scale; KT= Kinesio Tape™ Group; CON= Control Group; AAE= Absolute Angular Error; RAE= Relative Angular Error; SD= Standard Deviation; CI= Confidence Interval; OKC-JPS= Open-Kinetic Chain Joint Position Sense; CKC-JPS= Closed-Kinetic Chain Joint Position Sense

3.3 Open-Kinetic Chain Joint Position Sense

Both Relative Angular Error (RAE) and Absolute Angular Error (AAE) of OKC-JPS did violate the assumption of homogeneity of variance (RAE: Mauchly's W=0.553, p=0.006; AAE: Mauchly's W=0.503, p=0.002), therefore, Huynh-Feldt correction was used. (Table 4) Post-hoc pairwise comparison showed no significant KT effects with OKC-JPS for either RAE (p=0.655, ηp^2=0.044) or AAE (p=0.805, ηp^2=0.030), as is shown in Table 3 and Figures 3 and 4.

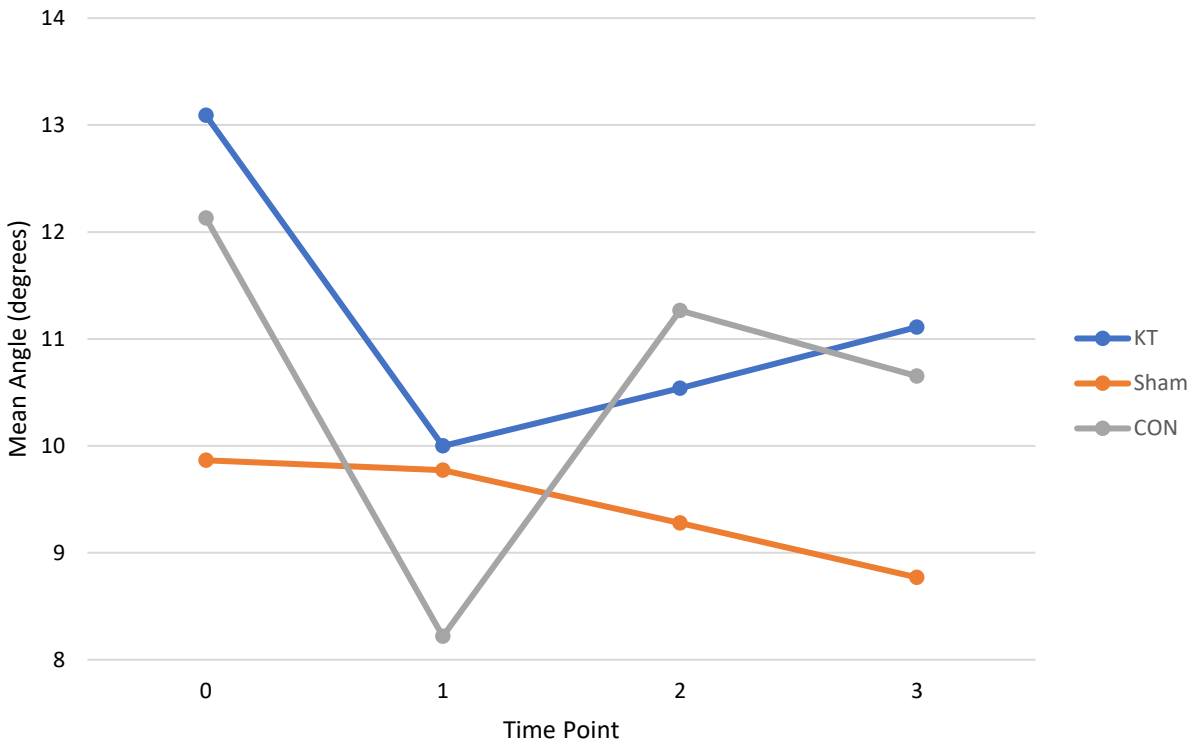

Figure 3. Group by Time Changes in Absolute Angular Error in Open-Kinetic Chain Joint Position Sense
AAE= Absolute Angular Error; OKC-JPS= Open-Kinetic Chain Joint Position Sense; CON= Control group; KT= Kinesio Tape™ group; Sham= Sham Kinesio Tape™ group

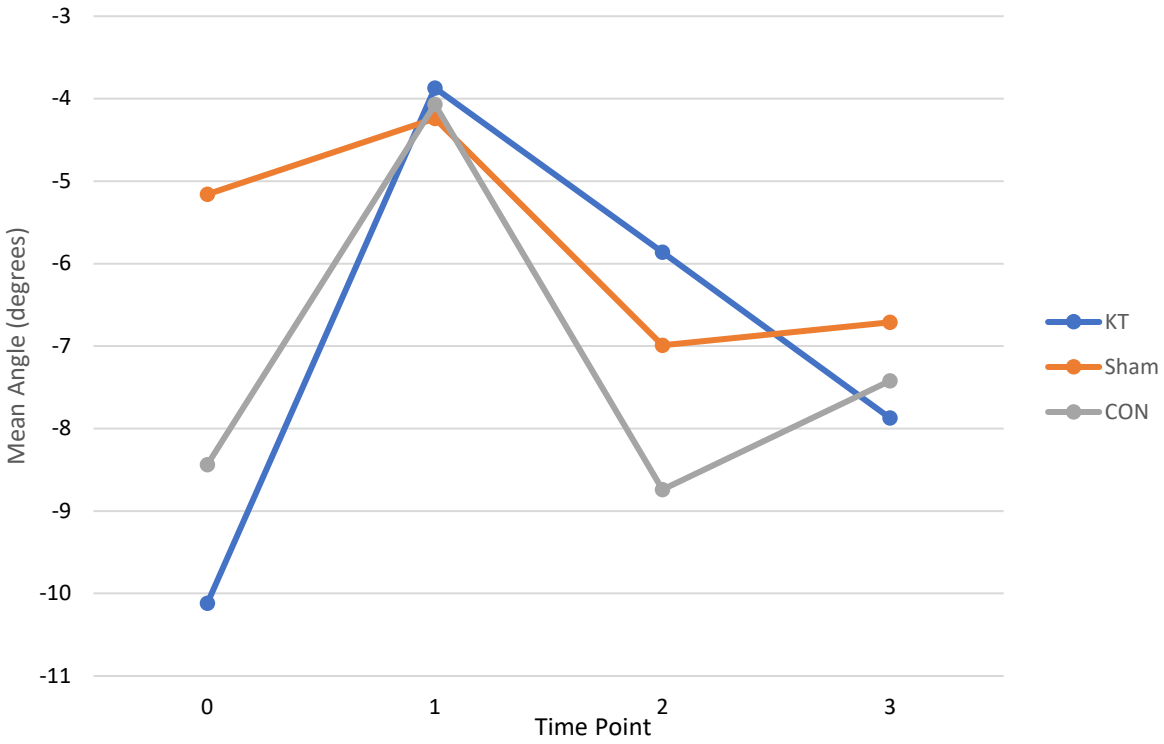

Figure 4. Group by Time Changes in Relative Angular Error in Open-Kinetic Chain Joint Position Sense

RAE= Relative Angular Error; OKC-JPS= Open-Kinetic Chain Joint Position Sense; CON= Control group; KT= Kinesio Tape™ group; Sham= Sham Kinesio Tape™ group

Table 4. Huynh-Feldt Correction Values for AAE and RAE of OKC-JPS and CKC-JPS

	Time			Time x Tape		
OKC-JPS	F	p	ηp^2	F	p	ηp^2
AAE	1.062	0.360	0.035	0.447	0.805	0.030
RAE	1.174	0.322	0.039	0.667	0.655	0.044
CKC-JPS						
AAE	13.476	<0.001	0.317	0.988	0.438	0.064
RAE	13.024	<0.001	0.310	0.863	0.525	0.056

OKC-JPS= Open-Kinetic Chain Joint Position Sense; CKC-JPS= Closed-Kinetic Chain Joint Position Sense; AAE= Absolute Angular Error; RAE= Relative Angular Error

3.4 Closed-Kinetic Chain Joint Position Sense

The assumption of homogeneity of variance was violated by both AAE (Mauchly's W=0.660, p=0.042) and RAE (Mauchly's W=0.675, p=0.054) for CKC-JPS, therefore, Huynh-

Feldt corrections were used when examining univariate tests (Table 4). Post-hoc pairwise comparison showed no significant KT effects with CKC-JPS for either RAE ($p=0.525$, $\eta p^2=0.056$) or AAE ($p=0.438$, $\eta p^2=0.064$), as shown in Table 3 and Figures 5 and 6. Significantly lower angular error for all participants were seen over time with CKC-JPS regardless of the group (AAE: $p<0.001$, $\eta p^2=0.317$; RAE: $p<0.001$, $\eta p^2=0.310$) (Table 3).

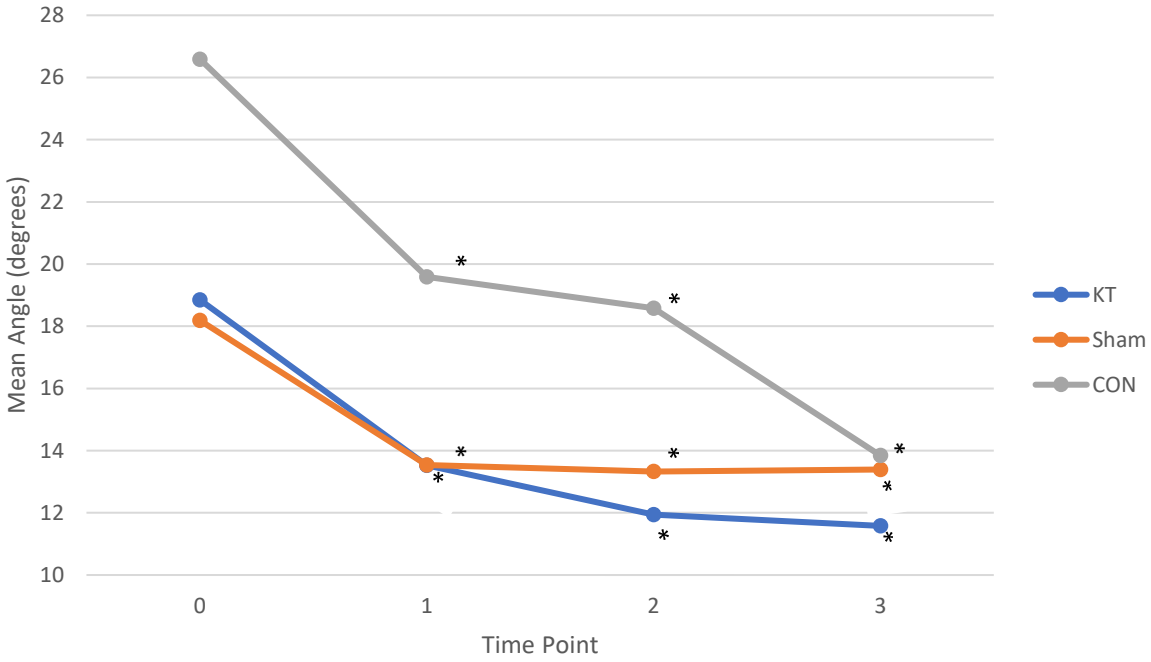

Figure 5. Group by Time Changes in Absolute Angular Error in Closed-Kinetic Chain Joint Position Sense
*= Indicates significance from T0 at $p<0.05$
CKC-JPS= Closed-Kinetic Chain Joint Position Sense; AAE= Absolute Angular Error; CON= Control group; KT= Kinesio Tape™ group; Sham= Sham Kinesio Tape™ group

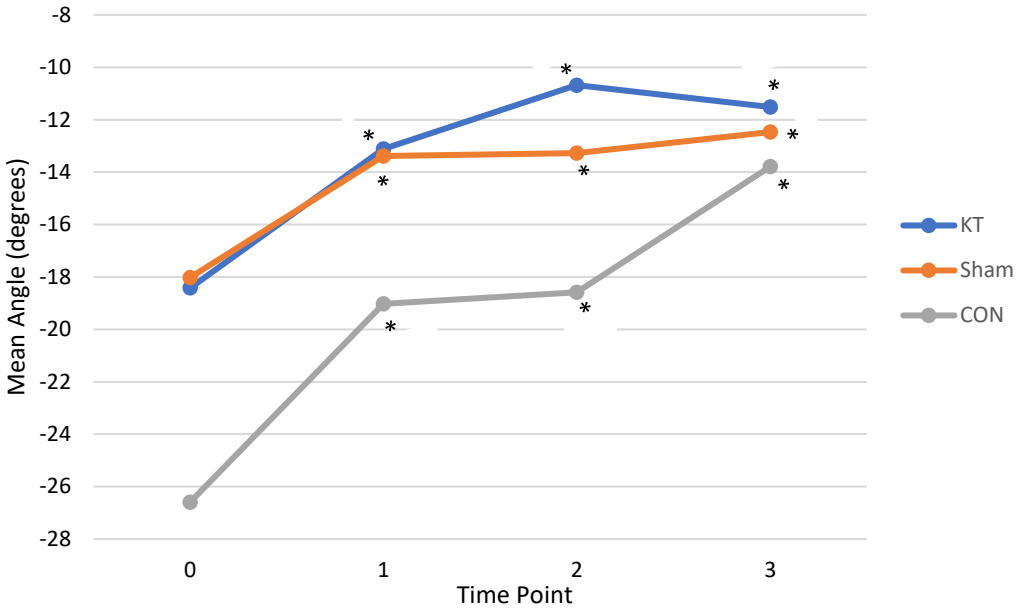

Figure 6. Group by Time Changes in Relative Angular Error in Closed-Kinetic Chain Joint Position Sense

*= Indicates significance from T0 at $p<0.05$

CKC-JPS= Closed-Kinetic Chain Joint Position Sense; RAE= Relative Angular Error; CON= Control group; KT= Kinesio Tape™ group; Sham= Sham Kinesio Tape™ group

CHAPTER 4. DISCUSSION

The purpose of this study was to compare a quadriceps femoris activation KT application to a sham KT application, and their effects on JPS, balance, pain, and functionality. To our knowledge, this study is the first to examine the effects of KT on pain, proprioception, and balance, while also examining a possible residual effect on these variables from the KT application. Our main findings were that KT does improve balance ability in individuals with knee pain, while having no significant influence on pain levels or JPS.

Previous research has been conducted to examine the effects of KT on pain and proprioception of people with knee OA, while other studies have examined the proprioceptive effects of KT on healthy individuals[10], stroke patients[11], and people with PFPS.[12]

4.1 Knee Injury and Osteoarthritis Outcome Scores

The results of the current study did not support our hypothesis as KOOS score did not improve overtime; however, they did verify differences in KOOS pain scores between the KT and Sham groups compared to controls at all time points. These significant differences are most likely due to the control group being healthy individuals with no self-reported knee pain, whereas the KT and Sham groups reported symptomatic knee pain. These findings were similar between KOOS score categories of symptoms, sports and recreations, and ADLs. Comparably, Castrogiovanni et al.[1] used the WOMAC and VAS to measure their participants levels of pain and limitations and saw improvements in all three groups (Exercise alone group, tension KT + exercise group, non-tension KT + exercise group) by the end of three months, however, the tension KT group + exercise showed the greatest decrease in WOMAC and VAS scores from the exercise alone and the non-tension KT + exercise groups, with significant differences observed between the latter two groups by the end of the study. Despite differences in data collections, a similarity was seen between the current study and Castrogiovanni et al.[1], that the KT application

group saw the most improvements. Differences between the current study and previous research[1,] may be due to the length of time of tape applications (multiple times across three months vs one time for three days) and due to the participants following an exercise protocol while being taped. Previous research also suggests that greater improvements might be seen in the experimental groups of the current study if the participants had received more than one tape application[16,20].

4.2 Balance

Balance was assessed using the BBS, which has been shown to have high reliability.[22] The significant time-contrast indicates linear changes over time, as well as a linear interaction for Time x Group. At baseline, there was a significant difference observed between the KT group and the Sham group, compared to the controls. When examined across time, there was only a significant difference between the Sham group and the controls at the final data collection. All three groups showed linear changes in BBS, but the effect of KT was apparent in the interaction when examining the KT and Sham groups, while controls remained the same. Despite the noted increases in scores post-taping, one could argue that the changes in the KT group might not be considered clinically relevant. Conradsson et al.[20] demonstrated that within a population of elderly people living in three residential care facilities, a change of at least 8 points in BBS score is needed in order to show any significant changes in function, while the current study had a change of 0.63 from baseline to the final data collection (Mean score of all three groups at: Baseline= 53.70 ± 2.34; at T3= 54.33 ± 1.88). In the current study, while performing the BBS, participants scored relatively high in comparison to Conradsson et al. (Mean score: 30.1 ± 15.9 for the first test, Mean score: 30.6 ± 15.6 for the re-test). Moreover, our participants' BBS mean score is in the average normative ranges[23,24] for healthy, community dwelling individuals (60+ years old), indicating that BBS may not have been challenging enough to adequately assess change in balance ability.

4.3 Proprioception

Though there were small improvements seen with the application of KT in BBS, no KT effects were seen in either JPS test. After conducting both OKC- and CKC-JPS tests on healthy individuals and those with symptomatic knee pain, our results do not support previous research that states KT improves proprioception in individuals with knee pain. We did not see any immediate significant improvements in the healthy control group after KT application, which supports findings by Halseth et al.[10] who found no immediate proprioceptive improvement in healthy ankles after KT application. No significance was seen between groups at any time point, indicating that there was no difference in proprioceptive ability between healthy and knee pain groups; however, there was a significant improvement in all three groups across time for CKC-JPS, perhaps suggesting a learning effect for this test. The results of the current study contradict Cho et al[25], who found that KT, when applied with tension along the rectus femoris, does improve proprioception in individuals with radiographic knee OA. According to the classification of "good proprioception" as <5° from the target angle described by Cho et al., the groups in the current study went from "bad proprioception" to "good proprioception" at the second data collection, in regards to OKC-JPS RAE. Subjects then went back to "bad proprioception" for the last two data collections, possibly indicating clinical relevance of a short-term KT effect. Kurt et al[12] applied KT tape for two days and saw significant differences in proprioception between the KT group and placebo KT group, in patients with PFPS. The differences between the current study's results and previous research[12, 25] may be due to different tape applications, length of the application, the pathology the tape was applied for, and what defines "good" vs "bad" proprioception.

4.4 Limitations

Several limitations are present in the current study. A total 33 individuals, who met the criteria, were recruited from the community during the given time frame. A post-hoc power analysis using SPSS indicated that statistical power ranged from 0.16-0.37 for AAE and RAE for both OCK- and CKC-JPS Time x Group effect with an effect size of 0.030-0.064, suggesting that non-significant findings could be due to small sample size. A larger sample size might be needed to minimize the chance of committing type II error. The length and number of tape applications in this study was limited to one tape application lasting for 3 days. Multiple tape applications and a longer study period may influence the pain and joint position sense differently, as well as trying to maintain the tape application better, without altering the participants lifestyles. Also, the lack of randomization in order of procedures might have influenced possible learning effects, as seen by the improvements in all three groups with CKC-JPS across time. The lack of randomization might have also affected pain levels and changed the participants' ability to perform the tasks. Lastly, although KOOS confirmed increased pain level and decreased functionality in the knee pain groups (KT and sham) compared to healthy control, the participants with knee pain in the current study were relatively functional evident in high BBS score and no difference in proprioceptive ability compared to control. Although the aim of this study was to recruit individuals with knee OA, the current study did not restrict inclusion to those who were diagnosed with by physician using radiograph in order to increase the sample size. The findings of this study are only generalizable to individuals with symptomatic knee pain, rather than knee OA. Further investigation is warranted in individuals with symptomatic, radiographic knee OA.

CHAPTER 5. CONCLUSION

The goal of our study was to examine if applying KT to people with self-reported knee pain would improve not only their pain but also their proprioception and balance. Our results showed that KT improved the balance of those who have knee pain; however, KT did not influence the pain level and proprioceptive ability. While the current results do not support our research hypothesis, further research is warranted to examine the long-term effects of KT on proprioception and balance, particularly in pathologic populations.

CHAPTER 6. REVIEW OF LITERATURE

The primary focus of research in treating knee osteoarthritis (OA) has been aimed at finding new ways to reduce the cost associated with economic burdens and to increase the benefits from treatment. As the popularity of KT continues to grow, it is starting to become a new treatment for knee OA by helping reduce pain, increase quadricep muscle activation, and decrease functional limitations. Most research regarding the application of KT in patients with knee OA assesses the effects of the tape being applied to the quadricep muscle and if that helps increase the patient's ability to perform activities-of-daily-living. Limitations exist in current literature regarding therapeutic effects of KT when treating knee OA, despite positive results being reported. Several studies examine the effects of KT on proprioception, but most are either in healthy patients or in stroke patients, which then leads to the question of how do the results apply to other diseases and injuries.

6.1 Kinesio Tape™ Effects on Activation of Quadricep Muscles

It is understood that the quadriceps femoris muscle group helps eccentrically control the knee as it flexes during weight bearing movements, allowing it to affect one's ability to perform daily activities. Quadriceps weakness has been found to be a cause for many functional limitations, pain, and continuing degeneration of articular tissue in knee OA. Patients with knee OA are seen to have weakened quadriceps, which is the number one cause for changes in walking pace[1]. Studies have been designed to investigate the effects that KT has on quadriceps weakness, with the goal of addressing functional limitations and pain associated with knee OA progression.

Castrogiovanni et al.[1] conducted a study examining KT application, along with an exercise program, on physical limitations in patients with knee OA. 66 patients (35 males, 31 females) with comparable height and weight, aged 63 ± 9 years, and duration of disease of 5.5 ±

4.32 years, were randomly, equally, and blindly allocated into one of three groups: 1) exercise group, 2) exercise KT with tension application (stabilizing effect) group, and 3) exercise KT without tension application (draining effect) group. Outcome measures included: the Western Ontario and McMaster Universities Arthritis Index (WOMAC) to assess pain, stiffness, and functional limitations, the Visual Analogue Scaling Score for Pain (VAS), used to assess level of pain, the Timed Up and Go test (TUG), used to assess Kinesio taping and exercise effect on disability, and analgesic consumption. The authors' results demonstrated that after 15 days and three months, the use of tension KT application concurrently with exercise protocols not only relieves knee pain, but also greatly improved knee function, supporting that the activation of the quadricep muscle with KT improves knee function.

Tani et al.[2] similarly conducted a study that examined the effect of KT on gait speed in patients with knee OA. A control group (n=73, mean age 59.4) composed of randomly chosen patients that were not diagnosed with knee OA, was compared to the patients group (n= 102, mean age 63.2), which was composed of consecutive out-patients with a clinical diagnosis, by a rheumatologist, of primary unilateral knee OA . The patient group had KT applied with a tonus regulation technique on the quadriceps femoris muscle. The authors observed the change of time it took the patients to walk 10 meters at their respective normal speed at the following points: before, one day after and three days after KT application on the quadriceps muscle. The time needed to perform the 10-meter walk on the third day after application of KT changed significantly in both groups with $p<0.0001$ for both the control group and patients group. The authors inferred that the application of KT to facilitate muscle activation of the quadriceps femoris muscle leads to improved walking speed, which agrees with the results of other studies.

Anandkumar et al.[17] examined the effects of KT on isokinetic quadricep torque in knee OA. Their results supported other studies in that when KT is applied to facilitate the quadriceps femoris muscle, there are immediate effects on improving peak concentric and eccentric quadriceps torque production in patients with knee OA. A limitation of their study is that they looked at the immediate results (1 hour after application) and not the effects of KT after a long-term application. Outcome measures included: effects of KT on peak quadriceps torque production both concentrically and eccentrically at 90°/second and 120°/second, the effect of the participants' ability to climb up and down stairs through the Standardized Stair Climbing Task (SSCT), and its effects on pain experienced with SSCT through VAS as secondary outcomes. The authors' study was different because they examined how KT effects the process of climbing up and down stairs, compared to other studies[1,2] that looked at the effects of KT in the quadriceps while walking in a straight line.

The research designs of many studies were done with the purpose of examining the effects of KT on the activation of quadricep femoris muscle in patients with knee OA and how it affects a patient's functionality and pain levels. Though many looked at straight line walking and found KT to improve walking pace, there are still limitations from these studies. One study included a 3-month long program and was performed alongside an exercise program. One examined the effects after a 1-hour application, while another examined effects immediately after application, 3 days, and 6 days post application. Despite all studies supporting the application of KT for quadriceps activation, there was no consistency regarding the length of application.

6.2 Kinesio Tape™ Effects on Proprioception

Kinesio Tape™ has 5 proposed therapeutic mechanisms, with muscle activation being one and proprioception being another.[7,9] Though there is much research on KT application for

quadricep muscle activation in patients with knee OA, studies on proprioception are limited. Proprioception has primarily been studied in this manner when examining healthy individuals or in stroke patients. These types of studies have provided a basis for examining the application of KT to influence proprioception, despite not having examined a population with OA.

Halseth et al.[10] designed a study to examine the effects of KT on proprioception on subjects with healthy ankles. The authors tested 30 subjects (15 male, 15 female) between the ages of 18-30 on their ability to reproduce joint position in both plantarflexion and inversion with 20° of plantarflexion. The subjects were randomly tested pre-taping and post-taping through a completion of 5 trials in each position for each circumstance. The authors looked at constant and absolute error which were determined from the difference between the target angle and the trial angle produced by the subject. Halseth et al.'s results showed no significant difference in constant error for either plantar flexion or inversion with 20° of plantar flexion between the taped and no-tape conditions. The authors concluded that KT had no significant effect on proprioception in a healthy ankle which is inconsistent with the results of Murray's findings.[9] Halseth et al.'s conclusions could be inconsistent with Murray's[9] results due to the lack of studying the cutaneous effects of KT on proprioception during JPS; therefore, one cannot rule out the effects of KT on cutaneous stimulation and whether or not it has a role in JPS.

Choi et al.[13] examined the effects of KT, alongside proprioceptive neuromuscular facilitation (PNF) in hemiplegic stroke patients. Choi et al. compared an experimental group (PNF patterns plus KT) to a control group (neurodevelopmental treatment). The subjects in the experimental group received a combination of patella inferior gliding taping, patella medial gliding taping, and quadricep femoris muscle taping. Data was collected before and after the 4-week treatment period and the subjects' dynamic balance ability was assessed by the Berg

Balance Scale (BBS). Gait speed was measured by having the subjects perform a 10-m walk. The experimental group showed statistically significant differences between pre- and post-test for the BBS and 10-m walking test. Significant differences were also seen between the groups in ankle dorsiflexion, BBS, and 10-m walk. The authors concluded that the application of KT around the knee joint prior to rehabilitation treatment can positively influence the functional improvement of patients with nervous system damage.

Kurt et al.[12] examined the short-term effects of KT on joint position sense, isokinetic measurements, and clinical parameters in PFPS. Their KT application consisted of a VMO facilitation and patellar correction strips, with their placebo tape consisting of two strips of KT equidistant above and below the inferior and superior patellar borders. Kurt et al. used VAS to determine pain intensity, Kujala Pain Scale (KPS) to assess the severity of symptoms and physical limitations of the participants, the Tampa Scale (TSK) to evaluate kinesiophobia and an isokinetic dynamometer to evaluate quadriceps strength and knee joint proprioception. The authors applied the KT for 2 days and noted significant improvement in joint position sense, kinesiophobia, pain, symptoms, and functional limitations in the KT group.[12] The authors concluded that short-term application of KT on the patella and VMO may improve joint position sense, pain, kinesiophobia, symptoms, and functional limitations.

Cho et al.[25] examined the short-term effects of KT on the different types of pain, active range of motion, and proprioception in knee OA patients. Forty-six participants, over the age of 50 and with symptomatic, radiographic knee OA for more than a year, were randomly assigned to either a KT group (taping with tension) or a placebo KT group (taping without tension). The authors used a single “I” strip that started at the origin of the rectus femoris and ended in a “Y” strip that started at the superior border of the patella and went around the patella. Outcome

measures for this study were: VAS scores taken at rest and during walking, pressure pain threshold (the point at which pressure elicited pain) of OA at the midpoint of the quadriceps and midpoint of the anteromedial aspect of the tibia, active range of motion (AROM) through the use of a digital inclinometer, and proprioception acuity with an OKC-JPS at three angles (15°, 30°, and 45°). Cho et al. classified "good proprioception" as being 5° or less from the target angle and "bad proprioception" as being greater than 5° from the target angle. The authors saw significant improvement in both resting and walking VAS scores after KT application, but none in the placebo KT group, and no significant differences were noted between groups. Pressure pain threshold increased in the KT group after tape application with there also being a significant difference between groups. Pain-free AROM increased significantly for the KT group as well as proprioception for all three test angles. Cho et al.'s results supported the idea that KT application can improve pain, proprioception, and AROM of those with knee OA with a short-term application of tape.

Studies have been conducted that examine the effects of KT on proprioception. Even though only one of these studies looked at the effects on KT on knee OA patients, their results support the use of KT for decreasing pain and increasing proprioception in knee OA patients. These studies support the need for further research that examine the cutaneous effects of KT and how that affects proprioception.

6.3 Functional Tests

6.3a Proprioception Tests

Knee joint position sense (KJPS) tests are frequently used as assessments in clinics and research to assess changes in proprioception in knee OA patients. Since the change of proprioception needs to be accurate to help track the degeneration of the disease and help design treatment for patients, the inter- and intra-rater reliability of KJPS tests needed to be examined.

Baert et al.[5] saw this need and compared the inter- and intra-rater reliability of KJPS tests and knee force sense (KFS) tests between subjects both with and without knee OA. The subjects performed the tests in an open kinetic chain (OKC) position while sitting on a table with their eyes closed. Measurements were taken using an analogue inclinometer and handheld dynamometer. KJPS for each subject was tested twice in each of the three test angles. Even with few trials, Baert et al. concluded that measuring KJPS with an analogue inclinometer in different test positions and calculating the mean repositioning error is a reliable method to test proprioception in clinical practices.

Arvin et al.[18] further studied the reproducibility of joint position sense of the hip and knee in healthy older adults, by having 19 healthy older adults participate in an active-active joint position test. The subjects were blindfolded and standing, single legged, on a 10cm high block, allowing the other leg to have free range of movement. The assessors had the subjects then move at their own pace until the target angle was reached, as instructed by the assessor. After holding the target angle for 4 s, the subjects slowly moved back to starting position. The subjects then completed four trials for each of the three test positions on each limb. The outcome measures examined were: intraclass correlation coefficient (ICC), standard error of measurement (SEM), and limits of agreement (LOA), which were analyzed for relative angular error (RAE), absolute angular error (AAE) and variable angular error (VAE). Arvin et al. concluded that after assessing the relative and absolute error of an active-active joint position sense test, in a standing position, that this method is a reliable way to assess proprioceptive acuity of the knee and hip of older healthy adults.

Marks et al.[19] also examined the test-retest reliability and the construct validity of the measurement of knee joint position sense in women with knee OA. Joint position sense was

tested by having retroreflective markers placed on the greater trochanter, lateral femoral epicondyle, and lateral malleolus of the effected limb. The subject then stood on the affected leg and bent their knee to the test angle, held that position for 5s while a photograph was taken, and then returned to the resting position. The subjects completed 4 additional trials with a different target angle (20°-40°) used each time. Measurements were taken by drawing lines on the photographs between the retroreflective markers, and then the absolute error was calculated for each trial. Based on the results, good measurement reliability and a comparable mean angular error with repeated tests in joint position sense tests were demonstrated. A link between joint position sense and an individual with knee OA's functional ability in walking was found, supporting the use of proprioceptive tests in the assessment on those with knee OA.

6.3b Number of Trials Needed to Assess Knee Proprioception

Although there are multiple studies[5,18,19] that support the use of KJPS tests in clinical practices, there are conflicting methods as to how the KJPS should be conducted and the number of trials needed to be performed in order to get accurate results. Most studies vary from using 3-10 trials per test and found that their chosen number of trials could be used to show inter- and intra-rater reliability of the tests; however, it is important to have a valid and reliable number of trials to obtain accurate information without fatiguing the patients.

Piriyaprasarth et al.[26] conducted a study to examine the number of trials needed to identify significant impairments in knee joint position and movement sense for those who had recently had a stroke. The authors used the two most common techniques of verbal responses and contralateral limb matching to assess joint position sense and tested the subjects in a sitting position and supine position. They then compared the differences between 3 trials and 5 trials, and between 5 trials and 10 trials. After ten trials, the authors were able to identify 46% of participants to have a proprioceptive deficit, with less than 10% detected after 1 trial.

Piriyaprasarth et al. estimated that 9.4% of patients with a deficit would be missed during seated KJPS testing if only 3 trials were used instead of 5. That percentage was then estimated to jump to 18.8% of patients being missed if clinicians conducted 3 trials instead of 10; therefore, the authors concluded that at least 10 trials should be performed to quantify joint position sense and movement sense of the knee in stroke patients.

6.3c Balance

Balance is linked to an individual's functionality, posture, and ability to respond to outside forces. [4] The elderly population sees declines in balance leading to an increased fear of falling and risk of falling. Individuals with knee OA have poor balance control, due to loss of eccentric strength, leading these individuals to have a significantly higher risk of falling than healthy elderly individuals. [4]

Conclusive and comprehensive evidence exists regarding the effects of exercise programs on the overall function of knee OA patients; however, studies examining the effect of balance training are limited. Takacs et al.[4] conducted a study to examine the effects of a 10-week dynamic balance training program on dynamic balance and overall function in individuals with knee OA. The 10-week long dynamic balance training program was progressive over 3 phases and focused on dynamic balance control, eccentric lower limb muscle strength, and core stability. Outcomes measures were obtained through the use of the Community Balance and Mobility Scale (CB&M) to assess dynamic balance, WOMAC was used for self-reported physical function while pain was quantified on an 11-point NRS. Participants completed the Brief Fear of Movement Scale to self-report their feelings of fear towards pain, movement, and reinjury. And finally, muscle strength was assessed using an "isokinetic dynamometer with 3 trials of maximal effort at 90°/s". [4] Based on their results, the authors concluded that a 10-week dynamic balance training program will improve self-reported knee pain, physical function, and

fear of movement in individuals with knee OA, but no significant difference was seen in dynamic balance.

Lopes et al.[22] conducted a study looking at the prevalence of fear of falling in elderly individuals and how it correlates with mobility, dynamic balance, and risk and history of falls. Lopes used a population of 147 older adults to assess the fear of falling, mobility, risk of falls, and dynamic balance. Outcome measurements were collected using FES-I-BRAZIL, the "timed up and go", the "functional reach test", and "tandem gait test." The results of this study showed significant correlations between fear of falling and mobility, dynamic balance, and risk and history of falls. Fear of falling was very prevalent among older adults in the community, independent of their history of falls. Lopes et al.'s conclusions support the correlation of dynamic balance with the risk of falls in healthy older adults and suggest that this correlation is applicable to knee OA patients.

With there being many dynamic balance tests used throughout residential care facilities and clinics, Conradsson et al.[20] conducted a study to examine the intra-rater reliability of the Berg Balance Scale (BBS). The participants of this study were 45 elderly people, aged 82.3 ± 6.6, who lived in 3 residential care facilities and had an average score of 17.5 on the Mini Mental State Examination. To test the intra-rater reliability, the authors had the BBS assessed by the same assessor twice, with 1-3 days between assessments. The mean score for the first BBS test was 30.1 with the mean score being 30.6 points for the BBS retest. Based off the mean absolute difference being 2.8 points between the tests, absolute reliability was calculated to be 7.7 points and the intraclass correlation coefficient (ICC) to be .97. The authors concluded that even with a high ICC value, absolute reliability showed a necessary change of at least 8 points in order to show any significant change in function in older people who live in a residential care facility.

This is important in the clinical setting, not only for elderly people in residential care facilities, but also in those who have degenerative diseases, such as OA, because it can help evaluate an individual's change in balance function over time.

APPENDICES

Appendix A.

RESEARCH SUBJECT INFORMATION AND CONSENT FORM

TITLE: The Effects of Kinesio Tape™ on Proprioception and Balance in Elderly Patients with Knee Pain

PROTOCOL NO.: 2019-00287

PRIMARY INVESTIGATOR: Kaori Tamura, PhD, ATC
1337 Lower Campus Rd
Honolulu, Hawaii 96822
United States

STUDENT INVESTIGATOR: Adriana Trost, BS, ATC & Jingyu Hu, BS
1337 Lower Campus Rd
Honolulu, Hawaii 96822
United States

SITE(S): University of Hawaii at Manoa
Biomechanics and Gait Laboratory
Stan Sheriff Center Room 100
Honolulu, Hawaii 96822
United States

STUDY-RELATED PHONE NUMBER(S): Adriana Trost, BS, ATC
303-457-3332

Jingyu Hu, BS
812-391-0594

Kaori Tamura, PhD, ATC
808-956-3801

This consent form may contain words that you do not understand. Please ask the study doctor or the study staff to explain any words or information that you do not clearly understand. You may take home an unsigned copy of this consent form to think about or discuss with family or friends before making your decision.

SUMMARY

You are being asked to be a participant in a research pilot study. The purpose of this consent form is to help you decide if you want to be in the research study. Please read this consent form carefully. To be in a research study you must give your informed consent. "Informed consent" includes:

- Reading this consent form
- Receiving a thorough explanation of the research study from study staff
- Asking questions about anything that is not clear, and
- Taking home an unsigned copy of this consent form. This gives you time to think about it and to talk to family or friends before you make your decision.

You should not join this research study until all of your questions are answered.

Things to know before deciding to take part in a research study:

- The main goal of a research study is to learn in order to help patients in the future.
- The main goal of regular medical care is to help each patient.
- No one can promise that a research study will help you.
- Taking part in a research study is entirely voluntary. No one can make you take part.
- If you decide to take part, you can change your mind later on and withdraw from the research study at any time.
- The decision to join or not join the research study will not cause you to lose any medical benefits. If you decide not to take part in this study, your doctor will continue to treat you.
- Parts of this study may involve standard medical care. Standard care is the treatment normally given for a certain condition or illness.
- After reading the consent form and having a discussion with the research staff, you should know which parts of the study are experimental (investigational) and which are standard medical care.
- Your medical records may become part of the research record. If that happens, your medical records may be looked at and/or copied by the sponsor of this study and government agencies or other groups associated with the study.

After reading and discussing the information in this consent form you should know:

- Why this research study is being done;
- What will happen during the research;
- Any possible benefits to you;
- The possible risks to you;
- How problems will be treated during the study and after the study is over.

If you take part in this research study, you will be given a copy of this signed and dated consent form.

PURPOSE OF THE STUDY

The purpose of this study is to compare the effects of Kinesio Tape™ on: 1) proprioception examined through joint position sense tests, 2) balance ability through completion of series of balance tests, and 3) the patients' perceived pain and limitations as obtained through a survey.

RESEARCH SUBJECT CRITERIA

Test subjects will meet one or more of the following criteria:

- Pain with rest in the affected knee(s)
- Pain with normal movements/activities of daily living
- Pain and/or limitations with going up and down stairs
- And/or stiffness in your affected knee(s)

Exclusion criteria include:

- Current lower limb injury
- Currently a candidate for knee replacement surgery
- Open wounds around knee or thigh area
- Require assistance during walking
- Skin sensitivity to tape
- Any neurological conditions
- Current back pain
- And/or rheumatoid arthritis of the lower body

PROCEDURES

If you decide to participate in this study, you will be asked to report to the University of Hawaii at Manoa, Kinesiology and Rehabilitation Science Laboratory (Biomechanics and Gait Lab, Stan Sheriff 100) for three data collection procedures.

Upon arrival to the Biomechanics and Gait Lab, you will be asked to fill out one brief survey in reference to your current health and function. When you arrive at the Biomechanics and Gait Lab, measurements about your height and body weight will be taken, as well as a measurement of your thigh length. After 31 reflective markers are placed on your legs, hips, and upper body, you will be asked to perform the following tasks, in the specified order:

(1) A standing calibration of the motion capture system, followed by three (3) successful walking trials at a self-selected pace.

(2) A familiarization trial, followed by ten (10) single leg, seated knee extension repetitions to the test angle of 30 degrees of knee flexion, to be completed on the affected limb (total of 10 knee extension repetitions). Each repetition will be held for 5 seconds prior to returning to the starting position

(3) Completion of a series of balance ability tests, where you will be asked to perform tasks similar to those done in everyday life such as picking up something from the ground, balancing on two feet, and transferring yourself from one chair to another.

(4) A familiarization trial, followed by ten (10) double leg squat repetitions to the test angle of 30 degrees of knee flexion. Each repetition will be held for 5 seconds prior to returning to the starting position

Prior to Kinesio Tape™ application, you may be asked to shave the front of your thigh to which the Kinesio Tape™ is being applied.

The entire visit will take approximately 60 minutes.

RISKS AND DISCOMFORTS

There are minimal risks associated with your participation in this study. These include but are not limited to:

- Soreness and/or pain during and/or after participation
- Lower leg injury
- Stiffness after participation
- Falling during balance tests and walking examination

Due to the level of physical activity involved, there is a risk of injury. You may have pain in your legs during testing. You may also have some fatigue, discomfort, muscle cramping or soreness during or after test sessions. Although we have people to assist you and a chair for balance in place, there is a chance of falling during the test. There is a very remote chance of a medical emergencies such as: cardiac arrest, stroke, and/or death. These risks are comparable to your activities of daily living.

NEW INFORMATION

You will be told about anything new that might change your decision to be in this study. You may be asked to sign a revised consent form if this occurs.

BENEFITS

You may not receive direct/immediate benefits. However, you may obtain information regarding your joint position sense tests, as well as information for the biomechanics of walking and the balancing tests. Results of this study may assist physicians, physical therapists, strength and conditioning specialists, and athletic trainers to ensure the optimal clinical outcomes when considering the effects of Kinesio Tape™ on joint position sense, balance, and walking mechanics.

PAYMENT FOR PARTICIPATION

There is no compensation provided for your participation in this four-time data collection. No medical insurance is collected. There is no charge to your insurance company for your participation in this study.

COSTS

There are no additional costs related to the procedures and visit. Any costs for transportation to/from the UH Biomechanics and Gait Lab are your responsibility.

ALTERNATIVE TREATMENT

Your alternative is not to participate in this study. There is no treatment associated with this study beyond the potentially beneficial effect of Kinesio Tape™.

USE AND DISCLOSURE OF YOUR HEALTH INFORMATION:

By signing this form, you are authorizing the use and disclosure of individually identifiable information. Your information will only be used/disclosed as described in this consent form and as permitted by state and federal laws. If you refuse to give permission, you will not be able to be in this research.

This consent covers all information about you that is used or collected for this study. It includes

- Research records
- Records about your study visit
- Self-reported medical questionnaire documentation

Your authorization to use your identifiable health information will not expire even if you terminate your participation in this study or you are removed from this study by the study staff. However,

you may revoke your authorization to use your identifiable information at any time by submitting a written notification to the principal investigator, Dr. Kaori Tamura, University of Hawaii at Manoa, Honolulu, HI 96822. If you decide to revoke (withdraw or "take back") your authorization, your identifiable health information collected or created for this study shall not be used or disclosed by the study staff after the date of receipt of the written revocation except to the extent that the law allows us to continue using your information. The investigators in this study are not required to destroy or retrieve any of your health information that was created, used or disclosed for this study prior to receiving your written revocation.

By signing this consent form you authorize the following parties to use and or disclose your identifiable health information collected or created for this study:

- Kaori Tamura and her research staff for the purposes of conducting this research study.
- University of Hawaii at Manoa.

The individuals named above may disclose this consent form and the information about you created by this study to:

- The sponsor of this study and their designees (if applicable)
- Federal, state and local agencies having oversight over this research, such as the Office for Human Research Protections in the U.S. Department of Health and Human Services, Food and Drug Administration, the National Institutes of Health, etc.
- The University of Hawai'i for purposes of overseeing the research study and making sure that your ethical rights are being protected.

Some of the persons or groups that receive your study information may not be required to comply with federal privacy regulations, and your information may lose its federal privacy protection and your information may be disclosed without your permission

COMPENSATION FOR INJURY

In the event of any physical injury from the research, only immediate and essential medical treatment is available. First Aid/CPR and a referral to a medical emergency room will be provided. In the event of any emergency incidence outside the lab as a result of this research, contact your medical doctor and inform the study coordinator: Kaori Tamura Ph.D., ATC, at 808-956-3801. You should understand that if you are injured in the course of this research process that you or your medical insurance will be billed for the costs of treating your injuries.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Your participation in this study is voluntary. You may decide not to participate or you may leave the study at any time. Your decision will not result in any penalty or loss of benefits to which you are entitled.

Your participation in this study may be stopped at any time by the study doctor or the sponsor without your consent for any of the following reasons:

- it is in your best interest;
- you do not consent to continue in the study after being told of changes in the research that may affect you;
- you become pregnant;
- or for any other reason.

If you leave the study before the planned final visit, you may be asked by the study doctor to have some of the end of study procedures done.

SOURCE OF FUNDING FOR THE STUDY

This research study is sponsored by the University of Hawaii, Manoa.

QUESTIONS

Contact Kaori Tamura, Ph.D., ATC at 808-956-3801, Adriana Trost, BS, ATC at 303-457-3332, or Jingyu Hu, BS at (812)-391-0594 for any of the following reasons:

- if you have any questions about this study or your part in it
- if you feel you have had a research-related injury or
- if you have questions, concerns or complaints about the research

If you have questions about your rights as a research subject or if you have questions, concerns or complaints about the research, you may contact:

Office of Research Compliance
Institutional Review Board
University of Hawaii at Manoa
2425 Campus Road, Sinclair 10
Honolulu, HI 96822
Email: ORC@hawaii.edu

The Office of Research Compliance is a group of people who perform independent review of research.

The Office of Research Compliance will not be able to answer some study-specific questions, such as questions about appointment times. However, you may contact them if the research staff cannot be reached or if you wish to talk to someone other than the research staff.

Do not sign this consent form unless you have had a chance to ask questions and have gotten satisfactory answers.

If you agree to be in this study, you will receive a signed and dated copy of this consent form for your records.

CONSENT

I have read this consent form. All my questions about the study and my part in it have been answered. I freely consent to be in this research study.

I authorize the use and disclosure of my health information to the parties listed in the authorization section of this consent for the purposes described above.

By signing this consent form, I have not given up any of my legal rights.

_____

Subject Name (printed)

CONSENT SIGNATURE:

_____

Signature of Subject Date

_____

Signature of Person Conducting Informed Consent Discussion Date

Appendix B.

RESEARCH SUBJECT INFORMATION AND CONSENT FORM
FOR CONTROL GROUP

TITLE: The Effects of Kinesio Tape™ on Proprioception and Balance in Elderly Patients with Knee Pain

PROTOCOL NO.: 2019-00287

PRIMARY INVESTIGATOR:
Kaori Tamura, PhD, ATC
1337 Lower Campus Rd
Honolulu, Hawaii 96822
United States

STUDENT INVESTIGATOR:
Adriana Trost, BS, ATC & Jingyu Hu, BS
1337 Lower Campus Rd
Honolulu, Hawaii 96822
United States

SITE(S):
University of Hawaii at Manoa
Biomechanics and Gait Laboratory
Stan Sheriff Center Room 100
Honolulu, Hawaii 96822
United States

STUDY-RELATED PHONE NUMBER(S):
Adriana Trost, BS, ATC
303-457-3332

Jingyu Hu, BS
812-391-0594

Kaori Tamura, PhD, ATC
808-956-3801

This consent form may contain words that you do not understand. Please ask the study doctor or the study staff to explain any words or information that you do not clearly understand. You may take home an unsigned copy of this consent form to think about or discuss with family or friends before making your decision.

SUMMARY

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- Receiving a thorough explanation of the research study from study staff
- Asking questions about anything that is not clear, and
- Taking home an unsigned copy of this consent form. This gives you time to think about it and to talk to family or friends before you make your decision.

You should not join this research study until all of your questions are answered.

Things to know before deciding to take part in a research study:

- The main goal of a research study is to learn in order to help patients in the future.
- The main goal of regular medical care is to help each patient.
- No one can promise that a research study will help you.
- Taking part in a research study is entirely voluntary. No one can make you take part.
- If you decide to take part, you can change your mind later on and withdraw from the research study at any time.
- The decision to join or not join the research study will not cause you to lose any medical benefits. If you decide not to take part in this study, your doctor will continue to treat you.
- Parts of this study may involve standard medical care. Standard care is the treatment normally given for a certain condition or illness.
- After reading the consent form and having a discussion with the research staff, you should know which parts of the study are experimental (investigational) and which are standard medical care.
- Your medical records may become part of the research record. If that happens, your medical records may be looked at and/or copied by the sponsor of this study and government agencies or other groups associated with the study.

After reading and discussing the information in this consent form you should know:

- Why this research study is being done;
- What will happen during the research;
- Any possible benefits to you;
- The possible risks to you;
- How problems will be treated during the study and after the study is over.

If you take part in this research study, you will be given a copy of this signed and dated consent form.

PURPOSE OF THE STUDY

The purpose of this study is to compare the effects of Kinesio Tape™ on: 1) proprioception examined through joint position sense tests, 2) balance ability through completion of series of balance tests, and 3) the patients' perceived pain and limitations as obtained through a survey.

RESEARCH SUBJECT CRITERIA

Exclusion criteria include:

- Pain with rest in the affected knee(s)
- Pain with normal movements/activities of daily living
- Pain and/or limitations with going up and down stairs
- And/or stiffness in your affected knee(s)

PROCEDURES

If you decide to participate in this study, you will be asked to report to the University of Hawaii at Manoa, Kinesiology and Rehabilitation Science Laboratory (Biomechanics and Gait Lab, Stan Sheriff 100) for three data collection procedures.

Upon arrival to the Biomechanics and Gait Lab, you will be asked to fill out one brief survey in reference to your current health and function. When you arrive at the Biomechanics and Gait Lab, measurements about your height and body weight will be taken, as well as a measurement of your thigh length. After 31 reflective markers are placed on your legs, hips, and upper body, you will be asked to perform the following tasks, in the specified order:

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(2) A familiarization trial, followed by ten (10) single leg, seated knee extension repetitions to the test angle of 30 degrees of knee flexion, to be completed on the affected limb (total of 10 knee extension repetitions). Each repetition will be held for 5 seconds prior to returning to the starting position

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(4) A familiarization trial, followed by ten (10) double leg squat repetitions to the test angle of 30 degrees of knee flexion. Each repetition will be held for 5 seconds prior to returning to the starting position

Prior to Kinesio Tape™ application, you may be asked to shave the front of your thigh to which the Kinesio Tape™ is being applied.

The entire visit will take approximately 60 minutes.

RISKS AND DISCOMFORTS

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- Soreness and/or pain during and/or after participation
- Lower leg injury
- Stiffness after participation
- Falling during balance tests and walking examination

Due to the level of physical activity involved, there is a risk of injury. You may have pain in your legs during testing. You may also have some fatigue, discomfort, muscle cramping or soreness during or after test sessions. Although we have people to assist you and a chair for balance in place, there is a chance of falling during the test. There is a very remote chance of a medical emergencies such as: cardiac arrest, stroke, and/or death. These risks are comparable to your activities of daily living.

NEW INFORMATION

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BENEFITS

You may not receive direct/immediate benefits. However, you may obtain information regarding your joint position sense tests, as well as information for the biomechanics of walking and the balancing tests. Results of this study may assist physicians, physical therapists, strength and conditioning specialists, and athletic trainers to ensure the optimal clinical outcomes when considering the effects of Kinesio Tape™ on joint position sense, balance, and walking mechanics.

PAYMENT FOR PARTICIPATION

There is no compensation provided for your participation in this four-time data collection. No medical insurance is collected. There is no charge to your insurance company for your participation in this study.

COSTS

There are no additional costs related to the procedures and visit. Any costs for transportation to/from the UH Biomechanics and Gait Lab are your responsibility.

ALTERNATIVE TREATMENT

Your alternative is not to participate in this study. There is no treatment associated with this study beyond the potentially beneficial effect of Kinesio Tape™.

USE AND DISCLOSURE OF YOUR HEALTH INFORMATION:

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This consent covers all information about you that is used or collected for this study. It includes

- Research records
- Records about your study visit
- Self-reported medical questionnaire documentation

Your authorization to use your identifiable health information will not expire even if you terminate your participation in this study or you are removed from this study by the study staff. However, you may revoke your authorization to use your identifiable information at any time by submitting a written notification to the principal investigator, Dr. Kaori Tamura, University of Hawaii at Manoa, Honolulu, HI 96822. If you decide to revoke (withdraw or "take back") your authorization, your identifiable health information collected or created for this study shall not be used or disclosed by the study staff after the date of receipt of the written revocation except to the extent that the law allows us to continue using your information. The investigators in this study are not required to destroy or retrieve any of your health information that was created, used or disclosed for this study prior to receiving your written revocation.

By signing this consent form you authorize the following parties to use and or disclose your identifiable health information collected or created for this study:

- Kaori Tamura and her research staff for the purposes of conducting this research study.
- University of Hawaii at Manoa.

The individuals named above may disclose this consent form and the information about you created by this study to:

- The sponsor of this study and their designees (if applicable)
- Federal, state and local agencies having oversight over this research, such as the Office for Human Research Protections in the U.S. Department of Health and Human Services, Food and Drug Administration, the National Institutes of Health, etc.
- The University of Hawai‘i for purposes of overseeing the research study and making sure that your ethical rights are being protected.

Some of the persons or groups that receive your study information may not be required to comply with federal privacy regulations, and your information may lose its federal privacy protection and your information may be disclosed without your permission

COMPENSATION FOR INJURY

In the event of any physical injury from the research, only immediate and essential medical treatment is available. First Aid/CPR and a referral to a medical emergency room will be provided. In the event of any emergency incidence outside the lab as a result of this research, contact your medical doctor and inform the study coordinator: Kaori Tamura Ph.D., ATC, at 808-956-3801. You should understand that if you are injured in the course of this research process that you or your medical insurance will be billed for the costs of treating your injuries.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Your participation in this study is voluntary. You may decide not to participate or you may leave the study at any time. Your decision will not result in any penalty or loss of benefits to which you are entitled.

Your participation in this study may be stopped at any time by the study doctor or the sponsor without your consent for any of the following reasons:

- it is in your best interest;
- you do not consent to continue in the study after being told of changes in the research that may affect you;
- you become pregnant;
- or for any other reason.

If you leave the study before the planned final visit, you may be asked by the study doctor to have some of the end of study procedures done.

SOURCE OF FUNDING FOR THE STUDY

This research study is sponsored by the University of Hawaii, Manoa.

QUESTIONS

Contact Kaori Tamura, Ph.D., ATC at 808-956-3801, Adriana Trost, BS, ATC at 303-457-3332, or Jingyu Hu, BS at (812)-391-0594 for any of the following reasons:

- if you have any questions about this study or your part in it
- if you feel you have had a research-related injury or
- if you have questions, concerns or complaints about the research

If you have questions about your rights as a research subject or if you have questions, concerns or complaints about the research, you may contact:

Office of Research Compliance
Institutional Review Board
University of Hawaii at Manoa
2425 Campus Road, Sinclair 10
Honolulu, HI 96822
Email: ORC@hawaii.edu

The Office of Research Compliance is a group of people who perform independent review of research.

The Office of Research Compliance will not be able to answer some study-specific questions, such as questions about appointment times. However, you may contact them if the research staff cannot be reached or if you wish to talk to someone other than the research staff.

Do not sign this consent form unless you have had a chance to ask questions and have gotten satisfactory answers.

If you agree to be in this study, you will receive a signed and dated copy of this consent form for your records.

CONSENT

I have read this consent form. All my questions about the study and my part in it have been answered. I freely consent to be in this research study.

I authorize the use and disclosure of my health information to the parties listed in the authorization section of this consent for the purposes described above.

By signing this consent form, I have not given up any of my legal rights.

_____

Subject Name (printed)

CONSENT SIGNATURE:

_____

Signature of Subject Date

_____

Signature of Person Conducting Informed Consent Discussion Date

Appendix C.

KT-Proprioception Data Collection Form

Subject ID#: _____ Date_____

Age_____

Gender: F / M Dominant Leg: L / R Affected Leg: L / R

Pain Level: None Mild Moderate Severe Extreme

Pain Medication: Y / N Type:_____

Measurements

Weight (kg)	
Height (m)	
Thigh length (cm)	
Lat. Thigh Length (cm)	
Med. Thigh Length (cm)	

Walking		
Trial	Which foot hit the plate	Time
1	R / L	
2	R / L	
3	R / L	
4	R / L	
5	R / L	
6	R / L	

Single Leg	
Trial	Which leg was tested
1	R / L
2	R / L
3	R / L
4	R / L
5	R / L
6	R / L
7	R / L
8	R / L
9	R / L
10	R / L

Single Leg	
Trial	Which leg was tested
1	R / L
2	R / L
3	R / L
4	R / L
5	R / L
6	R / L
7	R / L
8	R / L
9	R / L
10	R / L

Double Leg	
Trial	Which leg was tested
1	R / L
2	R / L
3	R / L
4	R / L
5	R / L
6	R / L
7	R / L
8	R / L
9	R / L
10	R / L

Appendix D.

Berg Balance Scale

The Berg Balance Scale (BBS) was developed to measure balance among older people with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluation of the effectiveness of interventions and for quantitative descriptions of function in clinical practice and research. The BBS has been evaluated in several reliability studies. A recent study of the BBS, which was completed in Finland, indicates that a change of eight (8) BBS points is required to reveal a genuine change in function between two assessments among older people who are dependent in ADL and living in residential care facilities.

Description:

14-item scale designed to measure balance of the older adult in a clinical setting.

Equipment needed: Ruler, two standard chairs (one with arm rests, one without), footstool or step, stopwatch or wristwatch, 15 ft walkway

Completion:

Time: 15-20 minutes

Scoring: A five-point scale, ranging from 0-4. "0" indicates the lowest level of function and "4" the highest level of function. Total Score = 56

Interpretation: 41-56 = low fall risk
21-40 = medium fall risk
0 –20 = high fall risk

A change of 8 points is required to reveal a genuine change in function between 2 assessments.

Berg Balance Scale

Name: _____ Date: _____

Location: _____ Rater: _____

ITEM DESCRIPTION	SCORE (0-4)
Sitting to standing	_____
Standing unsupported	_____
Sitting unsupported	_____
Standing to sitting	_____
Transfers	_____
Standing with eyes closed	_____
Standing with feet together	_____
Reaching forward with outstretched arm	_____
Retrieving object from floor	_____
Turning to look behind	_____
Turning 360 degrees	_____
Placing alternate foot on stool	_____
Standing with one foot in front	_____
Standing on one foot	_____

Total _____

GENERAL INSTRUCTIONS
Please document each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item.

In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if:

- the time or distance requirements are not met
- the subject's performance warrants supervision
- the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.
Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 12.

Berg Balance Scale

SITTING TO STANDING

INSTRUCTIONS: Please stand up. Try not to use your hand 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 stabilize
( ) 0 needs moderate or maximal assist to stand

STANDING UNSUPPORTED

INSTRUCTIONS: Please stand for two minutes without holding on.

( ) 4 able to stand safely for 2 minutes
( ) 3 able to stand 2 minutes with supervision
( ) 2 able to stand 30 seconds unsupported
( ) 1 needs several tries to stand 30 seconds unsupported
( ) 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

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 2 minutes under supervision
( ) 2 able to able to sit 30 seconds
( ) 1 able to sit 10 seconds
( ) 0 unable to sit without support 10 seconds

STANDING TO SITTING

INSTRUCTIONS: Please sit down.

( ) 4 sits safely with minimal use of hands
( ) 3 controls descent by using hands
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently but has uncontrolled descent
( ) 0 needs assist to sit

TRANSFERS

INSTRUCTIONS: Arrange chair(s) for 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 cuing and/or supervision
( ) 1 needs one person to assist
( ) 0 needs two people to assist or supervise to be safe

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 safely
( ) 0 needs help to keep from falling

STANDING UNSUPPORTED WITH FEET TOGETHER
INSTRUCTIONS: Place your feet together and stand without holding on.
( ) 4 able to place feet together independently and stand 1 minute safely
( ) 3 able to place feet together independently and stand 1 minute with supervision
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs 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

Berg Balance Scale continued…

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach 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 confidently 25 cm (10 inches)
( ) 3 can reach forward 12 cm (5 inches)
( ) 2 can reach forward 5 cm (2 inches)
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up the shoe/slipper, which is 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 but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying
( ) 0 unable to try/needs assist to keep from losing balance or falling

TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING
INSTRUCTIONS: Turn to look directly behind you over toward the 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 other side shows 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

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 4 seconds or less
( ) 2 able to turn 360 degrees safely but slowly
( ) 1 needs close supervision or verbal cuing
( ) 0 needs assistance while turning

PLACE 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 in > 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

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 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

STANDING ON ONE LEG
INSTRUCTIONS: Stand on one leg as long as you can without holding on.
( ) 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
( ) 0 unable to try of needs assist to prevent fall

( ) TOTAL SCORE (Maximum = 56)

Appendix E.

KOOS KNEE SURVEY

Today's date: _____/_____/_____ Date of birth: _____/_____/_____

Name: _____

INSTRUCTIONS: This survey asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to perform your usual activities.
Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms
These questions should be answered thinking of your knee symptoms during the **last week**.

S1. Do you have swelling in your knee?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S2. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S3. Does your knee catch or hang up when moving?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S4. Can you straighten your knee fully?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

S5. Can you bend your knee fully?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

Stiffness
The following questions concern the amount of joint stiffness you have experienced during the **last week** in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

S6. How severe is your knee joint stiffness after first wakening in the morning?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

S7. How severe is your knee stiffness after sitting, lying or resting **later in the day**?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Pain

P1. How often do you experience knee pain?

Never	Monthly	Weekly	Daily	Always
☐	☐	☐	☐	☐

What amount of knee pain have you experienced the **last week** during the following activities?

P2. Twisting/pivoting on your knee

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P3. Straightening knee fully

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P4. Bending knee fully

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P5. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P6. Going up or down stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P7. At night while in bed

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P8. Sitting or lying

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P9. Standing upright

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, daily living

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A1. Descending stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A2. Ascending stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A3. Rising from sitting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A4. Standing

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A5. Bending to floor/pick up an object

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A6. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A7. Getting in/out of car

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A8. Going shopping

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A9. Putting on socks/stockings

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A10. Rising from bed

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A11. Taking off socks/stockings

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A12. Lying in bed (turning over, maintaining knee position)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A13. Getting in/out of bath

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A14. Sitting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A15. Getting on/off toilet

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A17. Light domestic duties (cooking, dusting, etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, sports and recreational activities

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the **last week** due to your knee.

SP1. Squatting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP2. Running

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP3. Jumping

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP4. Twisting/pivoting on your injured knee

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP5. Kneeling

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Quality of Life

Q1. How often are you aware of your knee problem?

Never	Monthly	Weekly	Daily	Constantly
☐	☐	☐	☐	☐

Q2. Have you modified your life style to avoid potentially damaging activities to your knee?

Not at all	Mildly	Moderately	Severely	Totally
☐	☐	☐	☐	☐

Q3. How much are you troubled with lack of confidence in your knee?

Not at all	Mildly	Moderately	Severely	Extremely
☐	☐	☐	☐	☐

Q4. In general, how much difficulty do you have with your knee?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Thank you very much for completing all the questions in this questionnaire.

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