PROTOCOL TITLE: The Effects of Core Activation and Stabilization Training on Gait Kinetics, Kinematics, and Speed, and Self-Perceived Function in Patients with Knee Osteoarthritis

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The Effects of Core Activation and Stabilization Training on Gait Kinetics, Kinematics, and Speed, and Self-Perceived Function in Patients with Knee Osteoarthritis

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1.0 Objectives*

1.1 The purpose of this investigation is to determine the effect, if any, core activation and stabilization training may have on the gait and function of patients diagnosed with knee osteoarthritis (KOA).

The specific aims of this investigation include:

Specific Aim 1: Determine if kinetic (time to first peak ground reaction force [T_1] and second peak ground reaction force [F_2], both in the sagittal plane, and external knee adduction moment [KAM]) and kinematic (peak stance knee flexion angle [KFA]) gait variables, and speed, differ between patients with KOA and age and gender matched controls during self-selected paced ambulation, and determine which ones have predictive relationships with Knee Injury and Osteoarthritis Outcome Score (KOOS) scores in the patients with KOA.

Specific Aim 2: Determine if volitional core activation alters gait kinetics (T_1, F_2, and KAM), kinematics (KFA), and speed in patients with and without KOA during self-selected paced ambulation when compared to ambulating without volitional core activation, and whether the subjective pain complaints are significantly changed in the group with KOA. Determine whether there are baseline differences in core activation between those with and without KOA.

Specific Aim 3: Determine if a six-week core stabilization program alters KOOS score, and the kinetics (T_1, F_2, and KAM), kinematics (KFA), and speed of gait in patients with KOA during self-selected paced ambulation as compared to their pre-intervention baselines. Determine if there is a predictive relationship between the number of completed intervention sessions performed and these observed changes.

1.2 The alternate hypotheses for each specific aim include the following:

Specific Aim 1:

H_1: Participants with KOA will have significant differences in lower extremity kinetics (T_1, F_2, and KAM) and kinematics (KFA), and gait speed, as compared to healthy controls during self-selected paced ambulation.

H_2: The significant kinetic (T_1, F_2, and KAM), kinematic (KFA), and gait speed differences observed in participants with KOA will have a significant predictive relationship to their scores on the KOOS.

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Specific Aim 2:

H_1: Gait speed, kinetics (T_1, F_2, and KAM) and kinematics (KFA) will significantly differ with volitional activation of the core during self-selected paced ambulation within the KOA group and between the KOA and control groups.

H_2: Pain, as assessed via a Numeric Pain Rating Scale (NPRS), will significantly differ from baseline with volitional activation of the core during self-selected paced ambulation for patients with KOA.

H_3: There will be a significant difference in the baseline transversus abdominis (TA) activation observed via electromyography (EMG) analysis between and within the control and KOA groups, without and with volitional activation during ambulation.

Specific Aim 3:

H_1: Gait speed, kinetics (T_1, F_2, and KAM), and kinematics (KFA) will significantly differ in participants with KOA during self-selected paced ambulation after a six-week core stabilization program when compared to their baseline.

H_2: Functional ability, as assessed via the KOOS, will significantly differ in participants with KOA from baseline after a six-week core stabilization program.

H_3: The total number of supervised and home exercise sessions in a six-week intervention program will significantly predict changes in gait speed, kinetics (T_1, F_2, and KAM), and kinematics (KFA) in participants with KOA during self-selected paced ambulation.

2.0 Background*

2.1 This will be the second investigation by the PI and sub-investigator on this topic, following the promising results of a pilot study on a small sample size (N=5) completed last year. Whether or not core stabilization influences gait impairments in patients with KOA remains to be seen. Core stabilization has been shown to have positive effects, including increased stride velocity and scores on functional tests like the Functional Reach Test and Timed Up and Go, in older adults.[1] Older adults were also shown to have high compliance with a core stability training program.[1] A systematic

review indicated that core training is important to consider when treating older individuals to improve functional use of the extremities, improving participation in activities of daily living, and as part of a fall prevention program.[2] Additionally, it has been shown to benefit young, active individuals in preventing anterior cruciate ligament injury[3] and greater duration of improved outcomes in patients with patellofemoral pain syndrome.[4] Athletes with decreased core control have been shown to be at an increased risk of knee injury as well.[5] One potential cause for this is the ability of the core to improve lower extremity kinematics when activated during challenging single leg weight bearing activity.[6] A recent publication by Azuma, et al. did indicate that paraspinal and anterior abdominal thinning had a negative predictive relationship to the presence of KOA;[7] however, no investigation has explored a cause and effect relationship between core stability/stabilization training and the presence or severity of KOA, nor the gait and functional ability of patients with KOA. This later concept is the focus of this investigation.

2.2 Unpublished pilot data (see 2.1) collected by the same PI and sub-investigator shows that volitional activation of the TA during self-selected paced ambulation significantly decreases the time to first peak ground reaction force (T_1) in the sagittal plane in participants with KOA (D.W. Flowers, C. Frilot, unpublished data, May 2018). This same kinetic gait variable is included in this investigation as one of the dependent variables in all three parts of the investigation.

2.3 Nearly four percent of the global population has KOA, with the global female percentage nearing five percent. Additionally, the years lived with disability (YLDs) resulting from the disorder increased by 64.8% from 1990 to 2010.[8] The picture is not much better in the United States, where osteoarthritis ranks eighth highest in YLDs compared to other pathologies.[9] The rate of KOA has continued to climb here in the U.S., doubling in the past half-century even when accounting for increased life expectancy and higher average BMI,[10] both of which are considered risk factors in the development of KOA.[11]

Patients with KOA have been shown to have gait abnormalities when compared to healthy controls, including alterations in trunk and pelvic kinematics,[12] lower extremity kinematics[13,14] and kinetics,[14-18] gait speed,[13-17,19] and functional outcome measure scores.[19] Some of these differences, like an increased external knee adduction moment (KAM)[20,21] and a decreased peak stance knee

flexion angle (KFA),[14] have been shown to correlate with the advancement of KOA and may be causative in nature. Others, like an increased T_1[16] and reduced freely chosen gait speed,[22] may be compensatory.[23] The same has been found in regard to the reduced second peak ground reaction force in the sagittal plane (F_2) observed in this population.[18]

Reduced gait speed alone is predictive of increased fall risk in older adults, without any need to consider additional activities performed during walking tasks.[24] Additionally, the gait impairments observed in this population can be so extreme that they can be more limiting than those observed in patients with diagnoses typically considered more severe, like congestive heart failure, diabetes, heart disease, and stroke.[25] Therefore, improving function via improving gait speed via novel approaches is indicated, but not at the expense of increasing wear and tear on osteoarthritic joints. This investigation aims to show that core stabilization, which has been shown beneficially influence the kinetics and kinematics of lower extremity movements in younger, more active populations, can serve the same purpose in a population with KOA. The investigators are specifically trying to improve self-perceived function and gait speed, via improving the kinetics and kinematics observed in self-selected ambulation.

3.0 Inclusion and Exclusion Criteria*

3.1 Potential participants will be screened for eligibility by the PI once they have expressed interest either by contacting the PI themselves, or upon being referred by someone familiar with the investigation. Assurance of meeting the inclusion and exclusion criteria will be ensured during the informed consent process.

3.2 The inclusion and exclusion criteria for this investigation are as follows:

Inclusion criteria:
English-speaking men and women, 40 years old and older, of any race or ethnic group, with a documented diagnosis from a medical provider (i.e., physician, physician assistant, or nurse practitioner, etc.) of KOA, unilaterally or bilaterally. Previous or current physical therapy patients may be included (see exclusion criteria for exceptions). *Healthy controls* will meet the same requirements, but without a medical diagnosis of KOA and have the ability to ambulate on a level surface without any report of pain in their knees at the time of gait assessment.

Exclusion criteria: those with other lower extremity injuries (orthopaedic, cardiovascular, neurologic, etc.) which are currently hindering their ability to ambulate, those with current complaints of low back pain, those who have undergone bilateral total knee arthroplasty, those with concomitant diagnosis of rheumatoid arthritis, those persons not able to ambulate independently with or without an assistive device, those who have received a corticosteroid injection within the past two months, those who have received a hyaluronic acid injection in the past six months, and those persons currently enrolled in a core training program as part of formal physical therapy or physical fitness.

3.3 Special populations will not be included in this investigation for the following reasons:

Adults unable to consent, individuals who are not yet adults, pregnant women, and prisoners will not be included in this investigation. Adults unable to consent will not be included since following directions and participating in an intervention program with active participation will be required. Minors will not be included since they do not meet the inclusion criterion for age (>/= 40 years old). Pregnant women will not be included since many of the core exercises would need to be adapted in order to safely prescribe exercises tailored to that population, in addition to certain core contractions being contraindicated. Prisoners will not be included since they would not be able to attend all the intervention sessions.

4.0 Study-Wide Number of Subjects*

4.1 NA.

5.0 Study-Wide Recruitment Methods*

5.1 NA.

5.2 NA.

5.3 NA.

6.0 Multi-Site Research*

6.1 NA.

6.2 NA.

6.3 NA.

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7.0 Study Timelines*

7.1 Each participant with KOA will actively participate in the study eight weeks, depending on the participants scheduling abilities. This will require 10-12 hours total of participation. Participants in the control group are the exception, as they will only be required to attend one session for full participation. This single session will last about 1-2 hours. It is anticipated that it will take approximately 12-18 months to enroll all study participants, with completion of data collection/analyses within this same timeline.

8.0 Study Endpoints*

8.1 The primary endpoint of this investigation will be the completion of all data collection, with all participants in both the control and experimental groups having concluded their participation.

The secondary endpoint will be the completion of all data analysis, and preparation for dissemination of the research findings.

8.2 NA.

9.0 Procedures Involved*

9.1 This investigation will be divided into three parts, each associated with one of the specific aims detailed in Section 1. All procedures will be performed in the School of Allied Health Professions, either in the Motion Analysis Laboratory (Gait Lab) or the Rehabilitation Faculty Practice (RFP) Clinic.

Part 1: Compare age and gender matched healthy controls and KOA groups on kinetics, kinematics, and gait speed during self-selected speed via a between groups analysis across the dependent variables, and determine if those differences in the KOA group have a predictive relationship with their KOOS scores.

Part 2: Within-group comparison of both groups (with and without volitional TA activation) and between-groups (control group versus KOA group). Compare pain levels during both conditions via NPRS for the KOA group. Participants will wear biofeedback under both conditions, and all condition trials will be randomized. Alarm or verbal cue will be provided at 30% MVIC, and two electrodes placed over TA/obliquus internus (OI) just medial to anterior superior iliac spine (ASIS). A comparison of TA activation will be performed both within and between groups.

Part 3: Within-groups comparison of KOA group (pre-treatment and post-treatment; six-week training program) on kinetics, kinematics,

and gait speed during self-selected paced ambulation. A comparison of KOOS scores before and after treatment with be performed as well.

9.2 Once recruitment (see 22.0) and informed consent (see 27.0 and 28.0) are completed:

Part 1: All participants will undergo anthropometric data collection first, including weight, height, leg length, knee joint width, and ankle joint width. Age matching will be done within +/- 5 years between the two groups. Reflective markers will then be placed on bilateral lower extremities following the Plug in Gait Model. EMG electrodes will be placed bilaterally just medial to the ASIS, over the TA/OI. The Gait Lab will undergo calibration, and the participant will undergo a static trial. In participants with bilateral KOA, the most painful limb, identified by subjective report, will be used in the data collection procedures. Healthy controls will undergo analysis of their dominant limb by indicating with which leg they would kick a ball.

Once the set-up and calibration are completed, the data collection will begin. The participant will be allowed a brief warm-up of 1-2 minutes, walking in the Gait Lab prior to data collection commences. The participant will then be asked to walk at a self-selected pace across the capture area until three trials with good force plate contact are obtained. Good force plate contact is defined as initial contact at the heel and pre-swing/toe off occurring on the force plate, and the absence of any evidence of distraction via the video cameras, such as the participant talking or looking around the lab. These three trials will be used in the kinetic, kinematic, and gait speed data analysis.

See Part 2 for additional trials that will be performed concurrently for both groups. Participants in the experimental group will also be asked to complete a KOOS questionnaire at the same time.

Part 2: Participants will undergo the same procedures described in Part 1 above. While the three trials are obtained for Part 1, three additional walking trials will be concurrently collected for the both groups. These will include the participant volitionally activating their TA during the walking trials, performed and screened exactly the same as in Part 1. These trials will be performed with and without audible biofeedback (via an alarm or verbal cueing), indicating the TA meeting the threshold subsequently discussed below. Investigators will randomly determine whether the trials with or without volitional TA activation are performed first (i.e., Part 1 versus Part 2 trials). The randomization done for Part 2 to determine

whether or not the without (Part 1) or with (Part 2) volitional TA activation trials are performed first will be determined via random number generation between 0 and 1 in Excel. Those with 0 will perform the without volitional TA (Part 1) trials first, while those with 1 will perform the with volitional TA activation trials (Part 2) first.

The patient will lie supine on the mat in the lab and will be taught how to perform a TA contraction. Please see the attached script with the instructions that will be used in this education. A baseline maximal contraction will be performed supine, and the amplitude of contraction will be considered maximal voluntary isometric contraction (MVIC). The device will be set to provide audible feedback, or the participant will receive a verbal cue from the investigator, at 30% MVIC. This feedback will be randomized throughout the trials with TA activation via random number generation in Excel, with 0 signifying no cue and 1 indicating a cue. The task will be repeated seated, then standing, prior to data collection.

The experimental group, during both sets of trials, will be asked to subjectively rate their perceived pain in the lower extremity being used in data collection via a 10-point scale, typically used on the NPRS, although no visual will be used. Please see the supplemental script document attached to this protocol for the instructions used.

Part 3: Participants in the experimental group will participate in a six-week core stabilization intervention program. Please see the attached intervention program. This program will commence as soon as possible after Parts 1 and 2 of the investigation are completed. Participants will participate in two scheduled intervention sessions each week. Additionally, there will be a home exercise program, consisting of exercises from each week to be performed at home independently. Participants will be provided education and a handout on these exercises by the PI, which will include directions, photographs of the exercises, and a completion check-off for each session. These will be performed three times per week, every other day. The PI will be coordinator of the scheduling and performance of these interventions. These intervention sessions will be performed in the RFP Clinic in the SAHP, either in the open gym or in a private treatment room. This decision will be left up to the participant. More than one participant may or may not undergo intervention with the PI simultaneously, but only with the participants' consent. No more

than three participants will undergo the training simultaneously. Training sessions will not be performed on consecutive days in an effort to reduce the chances of delayed onset muscle soreness being present during treatment sessions. Additionally, the core training program includes predetermined guidelines on exercise progressions in order to ensure that the exercises are not progressed too rapidly. The PI will be present and will lead all sessions, ensuring that the exercises and their progressions are done correctly.

After the completion of the intervention program, each participant will undergo gait analysis in the same manner mentioned in Part 1, with the exception of no anthropometric data being collected. Participants will then complete a second, post-intervention KOOS questionnaire, and turn in their home exercise program sheet with tallies from completed sessions. Please see Part 1 for completion of the pre-intervention KOOS questionnaire.

9.3 The table below details the procedures and occurrence of those procedures throughout a single participant's participation in the investigation:

Procedures	Occurrence
Education/Informed Consent	1 all participants
Anthropometric Data Collection	1 all participants
Baseline (Part 1) Without & With Core Activation (Part 2) Pre 6-Week Intervention Gait & EMG Assessment (Part 3)	1 all participants (except no part 3 for controls)
Pain NPRS Assessment	2 for KOA group
Core Stability Intervention Program	12 sessions, plus 18 home program sessions (KOA group only)
Post 6-Week Intervention Gait & EMG Assessment	1 (KOA group only)
Pre and Post 6-Week Intervention KOOS Assessment	2 (KOA group only)

9.4 The exclusion criteria serve to prevent participation of those who require assistance or assistive devices for ambulation, so safety during the ambulation activities is minimized. The adhesive tape used in reflective marker placement is intended for placement on the skin. Regarding PHI, the PI will be the only investigator involved in the recruitment and consent process and will be charged with

protecting the PHI in his office. The motion analysis data and PHI will be protected in the manner discussed in sections 11.3.

A tape measure, body weight scale, EMG biofeedback with electrodes, and Vicon Vero 2.2 Motion Analysis System, and reflective markers with tape will be used. Exercise equipment will include exercise mats/high-low exercise tables, ankle weights, hand weights, BOSU balls, and resistance bands.

Please see the attached Excel file that will be used for data collection, in addition to the script for instructions to patients and KOOS questionnaire.

9.5 There is no long-term follow-up for this study apart from the final data collection session for the experimental group after completing the six-week intervention. This session will include another motion analysis session and post-treatment KOOS questionnaire completion.

9.6 NA.

10.0 Data and Specimen Banking*

10.1 A repository will be used to store all of the gait kinetic, kinematic, and speed data collected during the motion analysis sessions. This data will be stored on the computer system in the Gait Lab which is password protected, in addition to the lab itself being key access. The Data Collection Form (see attached), in addition to completed Core Program Tracker for Investigator Use and KOOS forms (see attached) will be included in the repository. This data will be kept in the PI's office which is key access, with the Data Collection Form staying on the PI's password protected personal laptop or state desktop computer, with the hardcopy KOOS and Core Program Tracker for Investigator Use forms will remain in the hardcopy compliance binders. The data will be stored for a period of seven years. Persons using the Gait Lab will have access to this data but will require IRB approval for use in research activities.

10.2 The repository data will include all force plate data and that collected from the infrared cameras, including pelvis, hip, knee, and ankle joint moments, range of motion in all three planes, and spatiotemporal gait characteristics, in addition to anthropometric data, KOOS scores, pain NPRS ratings, and exercise data from the Core Program Tracker for Investigator Use form.

10.3 In order for the data to be accessed for research purposes, a new approved IRB protocol will be required. Additionally, if the author

of said protocol is not the PI or the sub-investigator, they will need to request permission from one of these investigators prior to including this request in their proposed research protocol.

11.0 Data Management* and Confidentiality

11.1 Data analysis will be performed by the PI, with the assistance of the sub-investigator. The PI will use the latest version of SPSS available to the PI on his personal laptop computer (see 11.3 for security details). The kinetic, kinematic, and speed data will be analyzed together, either by a MANOVA (if assumptions are met) or separate ANOVA/mean comparison analyses with Bonferroni corrections, while the pain NPRS and KOOS scores will be analyzed each individually via means comparisons. The EMG data will be analyzed via a 2x2 ANOVA or separate means comparisons. If the groups have significantly different mean BMIs, then it will be included in the kinetic and kinematic analysis as a covariate. The predictive relationship between the number of exercise sessions and the change observed within the KOA group for each variable will be analyzed via regression analysis.

11.2 An *a priori* power analysis was performed to determine the number of participants required to achieve significance for the variables of highest interest in the investigation. Data from previous publications on these variables were used in the power analysis. These include the following: T_1 between[16] and within (D.W. Flowers, C. Frilot, unpublished data, May 2018) groups, F_2 between and within groups,[18] KAM between and within groups,[17] KFA between[14] and within[26] groups, and gait speed between[16] and within[27] groups for the kinetic and kinematic analyses. Additionally, the KOOS[28] was examined for within-group means comparison. The PI used G*Power (Heinrich-Heine-University Düsseldorf, Düsseldorf, Germany) for the purposes of these analyses. It was determined that 45 participants would be required, except for the KFA which would require a larger sample size. Since this variable will be collected concurrently along with the other kinetic and kinematic data, and all the other variables of interest are appropriately powered at a much lower sample size, we felt confident proceeding regardless of being underpowered for one of these five dependent kinetic/kinematic variables of interest.

Since this study involves a six-week intervention, an attrition rate of 10% was assumed, so a total of 50 participants (25 healthy controls and 25 with KOA) will be recruited. Data analysis will be completed

intermittently throughout data collection, and if significance is achieved prior to 50 participants completing their participation, recruitment will be discontinued, and only those in the study will be allowed to complete the study. This will be done in an effort to reduce the number of people undergoing this less than minimal risk investigation.

11.3 The kinetic and kinematic data will be stored on the computer system in the Gait Lab. This lab is key accessible by the faculty of the SAHP. The computer system is password protected, with the PI and the sub-investigator being the only two individuals who currently know that password. Other faculty members would need to get the password from these two investigators for their own research activities unrelated to this investigation. The data will be backed up on an external hard drive belonging to the two investigators. No personal identifying information will be included in this data, as the participants will be identified by their participant identification numbers. The key to these identifiers will be the signed consent forms maintained by the PI that have both the participants' names and identification number on them. These forms will be maintained in the PI's office (SAHP Rm 2-234) which is key access, in a compliance binder. The data collection forms and KOOS questionnaires will also be located in this binder, with only the identification number on them. All of the deidentified raw data, including kinetic, kinematic, gait speed, NPRS ratings, and KOOS scores will also be maintained on the PI's personal laptop and work desktop computers for the purposes of data analysis, and preparations for dissemination after the completion of the data collection and analysis. Both of these computers are password protected. This de-identified data will be backed-up on the PI's personal flash drives.

11.4 The PI and/or the sub-investigator will be performing a calibration of the motion analysis system prior to each data collection session, thereby reducing the risk of errors in the data from loss of calibration over time. EMG calibration and set-up will be completed by the sub-investigator. Additionally, the PI will be providing the same instructions on the core activations and pain NPRS reporting performed during Part 2 of the investigation.

11.5 See 11.3 regarding the mode and length of data storage, and who will have access to the data.

12.0 Provisions to Monitor the Data to Ensure the Safety of Subjects*

12.1 NA; pending the IRB agreeing with the PI that there is no more than minimal risk to participants in this investigation.

13.0 Withdrawal of Subjects*

13.1 Participants in the experimental group will be withdrawn from participation without their consent if they miss more than four of the total 12 sessions throughout the entire intervention program. They will also be removed if they do not perform the home exercise program at least once a week.

13.2 Immediately upon meeting the criteria for termination from participation, the participant will be informed in-person or by phone by the PI.

13.3 If participants withdraw from the research, including partial withdrawal with some data collection having already been completed, data already collected will be used in data analysis, unless the participant specifically requests otherwise. Additionally, they will not participate in any further aspects of the investigation, after following the procedures from 13.1 and 13.2. The same will be done for participants who withdraw of their own volition.

14.0 Risks to Subjects*

14.1 The only foreseeable risk/discomfort a participant may have is some muscle soreness within 48 hours from the ambulation and TA muscle contractions involved in Part 2, or the same after participation in the core stability exercises included in Part 3. This soreness is considered a normal effect of muscular exercise. Also, there is a possibility of the adhesive tape, used during marker placement in the motion analysis data collection, pulling any hair present on the skin when removed.

14.2 NA.

14.3 NA.

14.4 NA.

15.0 Potential Benefits to Subjects*

15.1 There is a possibility of direct benefits to half of the participants (group with KOA) in Part 3 of the investigation, but no guarantee. This investigation focuses on a novel intervention to improve the gait and function of patients with KOA. Therefore, the purpose of

this investigation is whether or not this intervention will have direct beneficial effects.

15.2 There is no possibility of a direct benefit, besides knowledge of current gait and functional ability for Parts 1 and 2 of this investigation; however, there is a possibility of direct benefit after participation in the core stability intervention program included in Part 3 if the program is found to improve gait and function in participants with KOA.

16.0 Vulnerable Populations*

16.1 NA.

17.0 Community-Based Participatory Research*

17.1 NA.

18.0 Sharing of Results with Subjects*

18.1 No individual participant results will be provided. Participants will be provided with the PI's contact information if they wish to know the results of the investigation after their participation is completed, and data analysis is completed.

19.0 Setting

19.1 All recruitment, informed consent, data collection, and data analysis will be completed in the SAHP at LSU Health-Shreveport. Data collection will be performed in the Gait Lab in the SAHP. The intervention program will take place in the RFP Clinic in the SAHP.

20.0 Resources Available

20.1 The PI is a licensed physical therapist, with board-certification in orthopaedic physical therapy, and is a PhD candidate at Texas Woman's University in the School of Physical Therapy. The PI has training in motion analysis. The sub-investigator has a PhD in Biomedical Engineering and is licensed as a Professional Engineer in Electrical Engineering. He also runs the Gait Lab in the SAHP. Both investigators are full-time faculty in the SAHP, the first as Assistant Professor and the later as Professor with tenure.

20.2 Participants will be recruited from within the University and from outside sources in the greater Shreveport area. With KOA being so prevalent, the PI does not foresee any difficulty in recruiting the necessary sample size. Additionally, the recruitment methods

include assistance from other clinicians and departments, in addition to public advertising, enabling the PI to broaden the opportunities for recruitment (see 22.0).

The PI has an FTE percentage of 30% dedicated to research in the LSU-Health Shreveport system, therefore up to 12 hours a week will be available for completing this project. This will be the only research project the PI is lead investigator on during the duration of this investigation. Additionally, the sub-investigator's research FTE percentage is 40%, so he has up to 16 hours per week to devote to this project, among others.

The Gait Lab is located on the second floor (room 2-217) in the SAHP. The lab is 700 square feet, and has a Vicon Vero 2.2 (12 camera) motion analysis system with 2 AMTI force plates embedded in the raised platform (8 x 24 ft). The Gait Lab has an EMG system which is integrated with the motion analysis system, and will be used to collect the EMG data during the walking trials. There are two desktop monitors connected to the computers used for data collection and analysis for viewing of output and processing. The RFP Clinic is located on the ground floor of the SAHP and is a 27,000 square foot facility with a large open gym area and private treatment rooms.

The PI has designed the investigation, completed all of the IRB submission requirements, and pursued avenues for recruitment of participants; therefore, he is familiar with the protocol. The sub-investigator has been informed and consulted throughout the process, and therefore has a good understanding of the purpose and specific aims of the study. He will be provided a copy of the protocol to review prior to commencement of the investigation.

21.0 Prior Approvals

21.1 Prior to commencing the research, approval of the study via an Institutional Authorization Agreement (IAA) with Texas Woman's University in Houston (TWU) will be required since this investigation is being used in partial fulfillment of the PI's PhD degree as the dissertation research. No data collection or recruitment will be done at this site.

22.0 Recruitment Methods

22.1 Participant recruitment will start immediately after IRB approval is obtained, and the IAA is signed by TWU. All recruitment will be managed through LSU Health-Shreveport and will be focused in the Shreveport area. No recruitment will be done through TWU.

Potential participants will be recruitment in multiple ways, including word of mouth, e-mailed flyers through the LSU Health-Shreveport Public Relations Department's Friday flyer, e-flyer postings on the announcement TVs in the SAHP, e-flyers posted on social media (including Facebook), flyer placements in the RFP Clinic in the SAHP, hard-copy and EHR (TherapySource, Advanced MD, and EPIC) chart reviews in through the RFP Clinic in the SAHP, flyer postings throughout the community (ex. gyms, churches, etc.), and through coordination with departments in the Medical School and area physical therapy clinicians/clinics. The PI will request assistance from the Departments of Family Medicine, Rheumatology, and Orthopaedic Surgery, among any others identified, to identify potential participants, in addition to posting flyers. This will also include the Rehabilitation Sciences Department in Ochsner-LSU Hospital. This cooperation with other departments may also include chart reviews for each respective clinic in the EPIC system to screen for potential participants who may quality for the study prior to approaching them while in their clinic visits. The PI will also contact area therapists and therapy clinics asking them to do the same. If the PI does not recruit the participant in person, they will be contacted via telephone using the script attached to this protocol (see Telephone Script.v1.docx).

22.2 Participants will be primarily those living in the Shreveport area, and may also include previous/current patients in the RFP Clinic.

22.3 Once a potential participant expresses interest and contacts the PI, or once the PI contacts them, the PI will ensure they meet the inclusion/exclusion criteria.

22.4 Both printed and e-versions of the same flyer will be used to recruit participants. Please see attached.

22.5 NA.

23.0 Local Number of Subjects

23.1 Fifty participants (N = 50), 25 healthy controls and 25 with a diagnosis of KOA will be recruited for the purposes of this investigation.

23.2 Refer to the *a priori* power analysis provided in section 11.2.

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24.0 Provisions to Protect the Privacy Interests of Subjects

24.1 During data collection procedures in the Gait Lab, no one other than the two investigators will be present without the participant's consent. Additionally, during both the informed consent process and six-week intervention program, if the participant wishes to complete these activities in a private treatment room, this will be provided upon request. Participants will be required to inform the front desk they are present for research upon entering the RFP Clinic in the SAHP in order to be allowed into the clinic space during informed consent and intervention procedures but will not be required to provide additional information.

24.2 See 24.1 regarding private treatment rooms, and limiting the number of persons present during data collection.

24.3 If the participant is a previous/current patient in the RFP Clinic or University Health Clinics/Hospital, the PI will be able to access their medical record to obtain contact information during the recruitment process.

25.0 Compensation for Research-Related Injury

25.1 NA. This investigation does not involve any procedures greater than minimal risk to the participants.

25.2 NA. See 25.1above.

26.0 Economic Burden to Subjects

26.1 Participants will be responsible for the cost of their own transportation to and from all research related activities. Otherwise, all aspects of the investigation will be provided at no cost to the participants, including the six-week core stabilization program including in Part 3 of the investigation.

27.0 Consent Process

27.1 All participants enrolled in this investigation will undergo informed consent following SOP: Informed Consent Process for Research (HRP-090). Informed consent will be performed in the RFP Clinic in the SAHP. Consent will typically be obtained immediately after informing the potential participant of all the procedures; however, they will have the option of a waiting period if they feel they need more time to make an informed decision prior to signature/consent.

28.0 Process to Document Consent in Writing

28.1 This investigation will be following SOP: Written Documentation of Consent (HRP-091).

28.2 The investigators plan on obtaining informed consent (see 28.3 below), unless the IRB feels this investigation is exempt from such procedures.

28.3 Informed consent will be documented in writing. Please see the attached informed consent document.

29.0 Drugs or Devices

29.1 NA.

29.2 NA.

References

1. Granacher U, Lacroix A, Muehlbauer T, Roettger K, Gollhofer A. Effects of core instability strength training on trunk muscle strength, spinal mobility, dynamic balance and functional mobility in older adults. *Gerontology*. 2013;59(2):105-113. doi: 10.1159/000343152 [doi].

2. Granacher U, Gollhofer A, Hortobágyi T, Kressig RW, Muehlbauer T. The importance of trunk muscle strength for balance, functional performance, and fall prevention in seniors: A systematic review. *Sports Med*. 2013;43(7):627-641. Accessed Oct 24, 2017. doi: 10.1007/s40279-013-0041-1.

3. Whyte EF, Richter C, O'Connor S, Moran KA. Effects of a dynamic core stability program on the biomechanics of cutting maneuvers: A randomized controlled trial. *Scand J Med Sci Sports*. 2018;28(2):452-462. Accessed Mar 27, 2018. doi: 10.1111/sms.12931.

4. Ferber R, Bolgla L, Earl-Boehm JE, Emery C, Hamstra-Wright K. Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: A multicenter randomized controlled trial. *J Athl Train*. 2015;50(4):366-377. Accessed Oct 24, 2017. doi: 10.4085/1062-6050-49.3.70.

5. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J. Deficits in neuromuscular control of the trunk predict knee injury risk: A prospective biomechanical-epidemiologic study. *Am J Sports Med*. 2007;35(7):1123-1130. Accessed Oct 24, 2017. doi: 10.1177/0363546507301585.

6. Shirey M, Hurlbutt M, Johansen N, King GW, Wilkinson SG, Hoover DL. The influence of core musculature engagement on hip and knee kinematics in women during a single leg squat. *Int J Sports Phys Ther*. 2012;7(1):1-12. Accessed Oct 24, 2017.

7. Azuma K, Sera Y, Shinjo T, et al. Maintenance of the paraspinal muscles may protect against radiographic knee osteoarthritis. *Open access rheumatology: research and reviews*. 2017;9:151-158.

8. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: A systematic analysis for the global burden of disease study 2010. *The Lancet*. 2012;380(9859):2163-2196. http://www.sciencedirect.com/science/article/pii/S0140673612617292. Accessed Feb 20, 2018. doi: 10.1016/S0140-6736(12)61729-2.

9. Murray CJL, Abraham J, Ali MK, et al. The state of US health, 1990-2010: Burden of diseases, injuries, and risk factors. *JAMA*. 2013;310(6):591-608. http://dx.doi.org/10.1001/jama.2013.13805. doi: 10.1001/jama.2013.13805.

10. Wallace IJ, Worthington S, Felson DT, et al. Knee osteoarthritis has doubled in prevalence since the mid-20th century. *PNAS*. 2017;114(35):9332-9336. Accessed Feb 20, 2018.

11. Felson DT, Lawrence RC, Dieppe PA, et al. Osteoarthritis: New insights. part 1: The disease and its risk factors. *Ann Intern Med*. 2000;133(8):635-646. Accessed Mar 21, 2018.

12. Linley HS, Sled EA, Culham EG, Deluzio KJ. A biomechanical analysis of trunk and pelvis motion during gait in subjects with knee osteoarthritis compared to control subjects. *Clin Biomech*. 2010;25(10):1003-1010.

13. Al-Zahrani KS, Bakheit A. A study of the gait characteristics of patients with chronic osteoarthritis of the knee. *Disabil Rehabil*. 2002;24(5):275-280.

14. Astephen JL, Deluzio KJ, Caldwell GE, Dunbar MJ. Biomechanical changes at the hip, knee, and ankle joints during gait are associated with knee osteoarthritis severity. *Journal of orthopaedic research*. 2008;26(3):332-341.

15. Kumar D, Manal KT, Rudolph KS. Knee joint loading during gait in healthy controls and individuals with knee osteoarthritis. *Osteoarthritis and cartilage*. 2013;21(2):298-305.

16. Chen CPC, Chen MJL, Pei Y, Lew HL, Wong P, Tang SFT. Sagittal plane loading response during gait in different age groups and in people with knee osteoarthritis. *Am J Phys Med Rehabil*. 2003;82(4):307-312. Accessed Jan 24, 2018. doi: 10.1097/01.PHM.0000056987.33630.56.

17. Duffell LD, Jordan SJ, Cobb JP, McGregor AH. Gait adaptations with aging in healthy participants and people with knee-joint osteoarthritis. *Gait Posture*. 2017;57:246-251.

18. Messier SP, Loeser RF, Hoover JL, Semble EL, Wise CM. Osteoarthritis of the knee: Effects on gait, strength, and flexibility. *Archives of physical medicine and rehabilitation*. 1992;73(1):29. http://www.ncbi.nlm.nih.gov/pubmed/1729969.

19. Huang S, Wei I, Chien H, et al. Effects of severity of degeneration on gait patterns in patients with medial knee osteoarthritis. *Med Eng Phys*. 2008;30(8):997-1003.

20. Zeni Jr JA, Higginson JS. Differences in gait parameters between healthy subjects and persons with moderate and severe knee osteoarthritis: A result of altered walking speed? *Clin Biomech*. 2009;24(4):372-378.

21. Miyazaki T, Wada M, Kawahara H, Sato M, Baba H, Shimada S. Dynamic load at baseline can predict radiographic disease progression in medial compartment knee osteoarthritis. *Ann Rheum Dis*. 2002;61(7):617-622.

22. Favre J, Erhart-Hledik JC, Chehab EF, Andriacchi TP. Baseline ambulatory knee kinematics are associated with changes in cartilage thickness in osteoarthritic patients over 5 years. *J Biomech*. 2016;49(9):1859-1864.

23. Messier SP. Osteoarthritis of the knee and associated factors of age and obesity: Effects on gait. *Med Sci Sports Exerc*. 1994;26(12):1446-1452. http://europepmc.org/abstract/med/7869877. Accessed Jan 29, 2018.

24. Menant JC, Schoene D, Sarofim M, Lord SR. Single and dual task tests of gait speed are equivalent in the prediction of falls in older people: A systematic review and meta-analysis. *Ageing research reviews*. 2014;16:83-104.

25. Guccione AA, Felson DT, Anderson JJ, et al. The effects of specific medical conditions on the functional limitations of elders in the framingham study. *American Journal of Public Health*. 1994;84(3):351-358. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=9406150680&site=ehost-live. Accessed Apr 16, 2018.

26. Shi H, Huang H, Yu Y, et al. Effect of dual task on gait asymmetry in patients after anterior cruciate ligament reconstruction. *Scientific reports*. 2018;8(1):12057.

27. Tang SF, Chen CP, Chen MJ, Pei Y, Lau Y, Leong C. Changes in sagittal ground reaction forces after intra-articular hyaluronate injections for knee osteoarthritis. *Arch Phys Med Rehabil*. 2004;85(6):951-955. Accessed Jan 24, 2018.

28. Rue JH, Yanke AB, Busam ML, McNickle AG, Cole BJ. Prospective evaluation of concurrent meniscus transplantation and articular cartilage repair: Minimum 2-year follow-up. *Am J Sports Med*. 2008;36(9):1770-1778.