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Research Article

The Effects of PNF Stretching on Range of Motion, Strength, Balance and Postural Adaptations in Older Women with Osteoarthritis

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Abstract

Approximately 30% of the elderly population (> 65 years) experience frequent falls which negatively impacts their physical well-being. This problem is even more pronounced in elderly women who exhibit chronic conditions such as osteoarthritis. As a result, there is a continuous need for non-invasive programs aimed at the improvement of balance, flexibility and strength. The purpose of this research was to examine if proprioceptive neuromuscular facilitated (PNF) stretching exercises enhanced flexibility, sstrength, static balance, and postural adaptations in three elderly women with osteoarthritis in their lower extremities. Three females (M = 64.3, SD = 3.85) completed a pre-test, 12 stretching sessions (3 per week for four weeks), a post-test, and a retention test. Static balance in standing was measured on a force place and was inferred from center of pressure (COP) path length (cm) whereas COP sway area (cm^2) was used to examine changes in postural adaptations. The flexibility was inferred from range of motion of the hip, knee, and ankle joints measured with a goniometer, whereas a sit to stand test was used to capture the changes in strength. Descriptive results showed that all three participants experienced an increase in strength, but even more importantly clinically relevant changes in ROM were evident in the majority of the muscle groups targeted. Static balance remained unaffected, but as expected, the ability to generate dynamic postural adaptations was enhanced, which may have an important impact on overall prevention of falling and staggering. Although the sample size was small, the findings appear to be robust across the participants thus confirming the usefulness of PNF stretching on different aspects of gross motor function in women with osteoarthritis.

Keywords: PNF; Osteoarthritis; Motor abilities

Introduction

Osteoarthritis (OA) is the most common form of arthritis and one of the leading causes of disability in aging Canadians [1]. The term is derived from Latin, roughly translating into inflammation of the bone joint, thus, OA is a disease of the joint where articulating (hyaline) cartilage on the bone wears down over time causing pain, stiffness, and swelling to occur. This disease most commonly affects weight-bearing joints, such as the knees and hips, as well as lower quadrant in the pelvis. Thus, many individuals exhibiting these issues remain inactive as prolonged physical activity adds to their discomfort, which in turns further jeopardizes other aspects of their functioning such as in strength, balance, and range of motion. Currently, no cure has been found for OA, however, multiple treatments have been developed to help delay the progression of the disease and relieve pain. These treatments include resting the affected limb, medications, non-weight bearing exercise, joint protection techniques, and surgery in severe cases (ref). It has been found that early intervention can reduce the deterioration of the affected joint(s) [2], which is of critical importance as there is a significant association between moderate to severe knee and hip osteoarthritis and the incidence of falls in elderly men and women [3-5].

Previous research has found that increasing one's flexibility, strength and balance will reduce the risk of experiencing a fall [6-9]. This is particularly true for the positive role of flexibility within the main joints affording effective ambulation, such as the knees and hips. Recent studies have also found strong evidence that Proprioceptive Neuromuscular Facilitation (PNF) stretching techniques may be the most effective flexibility exercise to use within fall prevention [10,11]. The PNF technique is based upon physical therapy principles and follows spiral-diagonal movements using contractions prior to the stretch to gain a greater range of motion [10-12]. PNF stretches can be passive as well as isometric, which can be done with the assistance of a therapist, or against an object. Older adults who have reduced activity levels may be more inclined to participate in and adhere to simplified exercise programs, such as PNF stretching. The exercises can be performed independently or with assistance, and have minimal physical demands that may lead to a fall or injury [1]. As a result, this approach may be feasible for individuals with osteoarthritis as they are often encouraged to participate in low impact activities to reduce the associated pain and deterioration of the joint(s). A simple PNF stretching routine, once it has been properly learned, will allow participants the freedom to choose when and where they can perform the exercises, such as within their homes, or in a gym. The apparent simplicity will reduce barriers, allow for greater adherence, and will motivate the participants to engage in order to enhance their quality of life and sense of autonomy. This technique has been found to be more effective than static stretching [11-16]. Collectively, the results emerging from these studies showed a robust pattern indicating that PNF stretching exercises resulted in increased flexibility as strength.

The impact of these changes in the ability to maintain static balance or perform dynamic postural adaptions remains unknown. This is particularly true when balance is measured via accurate and precise measures of postuography, involving the analysis of changes in Center of Pressure measures such as path length and area of sway [17-20]. In the case of postural adaptions, this type of tasks although implemented in research involving typically and atypically functioning individuals [21], has not been examined in individuals with osteoarthritis. As a result, the purpose of this research was to examine the effects of a PNF stretching routine, implemented for 12 sessions, on flexibility, strength, and balance scores of women diagnosed with Osteoarthritis (OA). It was hypothesized that there will be a positive change in scores following the intervention, and that these positive findings would persist as inferred from the retention test.

Methods

Participants

Three female participants (M = 64.3, SD = 3.85), recruited via purposive type of sampling, had osteoarthritis of the lower limbs, as diagnosed by a healthcare professional, the ability to walk independently without the assistance of any supporting equipment such as a cane, live independently within the community, and gained doctor's consent to exercise, participated in this study. Participants completed all of the 12 sessions implemented. These participants did not have a neurological condition(s) that affect balance abilities, such as Parkinson's disease, dementia, or multiple sclerosis, and they were not taking balance jeopardizing drugs such as anti-depressants. In addition, none of the participants had any sensory impairments, such as vestibular dysfunction or vision problems. All procedures were approved by the Lakehead University School of Kinesiology Research Ethics Committee and were in line with ethical requirements from the Declaration of Helsinki.

Participants were recruited locally from an aquafit classes as well from an older adult fitness centre (55 Plus Fit Center). The researcher personally contacted the appropriate instructors to gain permission to advertise this study within their classes through a verbal presentation as well as providing access to recruitment packages. Prior to being accepted to the study, participants were made aware of the potential risks and benefits that may occur during the study and that their participation was completely voluntary, however it was stressed that the expectation was that they were available for the proposed length of the study.

Experimental Protocol

The pre-test, the training sessions, the post- and the retention tests took place in the biomechanics lab at the academic unit. The pre-, post- and retention tests consisted of the same protocol (Figure 1). The retention test was administered a week after the post-test.

In regards to the intervention, the sessions occurred three times a week for four consecutive weeks. Each session lasted approximately 30-45 minutes in duration and involved the participants performing a routine consisting of 12 active-assisted PNF stretches, as well as a warm up and cool down. The PNF stretching exercise plan was designed by the researcher who is a certified advanced flexibility practitioner, with a focus on the PNF technique. The researcher stretched all three participants, but individually. The exercises involved placing the respective muscle group into a stretched position and holding it there for 5 seconds. In line with the assumptions of PNF, participants were encouraged to stretch a muscle group to its limit, and then push that same muscle group against a therapist. After providing the resistance for 10 seconds, the participant was asked to take in a deep breath while relaxing the muscles, and subsequently the therapist pushed the muscle group further as the person was exhaling. The muscle groups of primary interest were muscles around the hip, knee and ankle, with 4 exercises being performed for each muscle group that generally targeted flexors and extensors.

Measures

Flexibility measurements (in degrees) were taken for range of motion in the hip, knee, and ankle joints using a goniometer. To assure consistency, the respective body landmarks were identified with markers, recorded, and maintained between test sessions. A trained physiotherapist performed all the measurements. The pilot data examining the reliability of the measurement process indicated that the expected measurement error was low (+/- 2 degrees). Each recording was done twice.

Strength was assessed with a sit to stand test where participants were asked to complete as many repetitions from a chair until they were unable to continue physically or safely. For consistency, the participants were instructed to have their hands placed on their knees when moving from a sitting to a standing position. Once an upright standing position was achieved, the participants sat back down and repeated this until they were unable to continue due to fatigue or pain/discomfort.

In terms of balance control, once the height, weight, foot width and length were recorded, participants carried out two different conditions on the force platform. To examine static balance, the participants were asked to stand motionless on an Advanced Mechanical Technologies Incorporated (AMTI) force platform with their feet approximately shoulder width apart, and arms resting comfortably at the sides. Three, 10 second trials were performed. To examine dynamic postural adaptations, once the participant assumed a comfortable standing position, as per previous task, on the "GO" command they were instructed to lean as far as possible in the anterior and then posterior direction, without taking a step or falling. This type of leaning task has been used in previous research to infer dynamic postural adaptions. Again, participants completed 3 trials in total, each lasting 10 seconds. All testing was completed on an AMTI force plate with an amplifier gain set at 4000 times, and a low pass filter of 10.5 Hz. The force platform data were collected at a sampling rate of 100 Hz and stored offline for analysis. The AMTI BioDaq analysis package was used to compute balance measures. From the center of pressure (COP) measures, the mean was derived for area of sway (Ao). For the postural adaptations task, and path length (L) was used to examine potential changes in static balance. The Ao allows inferences to be made regarding the area of COP excursions during the performance of each balance condition (cm2), whereas the path length (cm) measures the total distance travelled by the COP.

Figure 1: The testing protocol administered during the pre-, post, and retention tests, involving measures of Strength (sit to stand) (two upper panels), Range of Motion (lower left panel) and Balance protocol on the force platform (lower right panel).

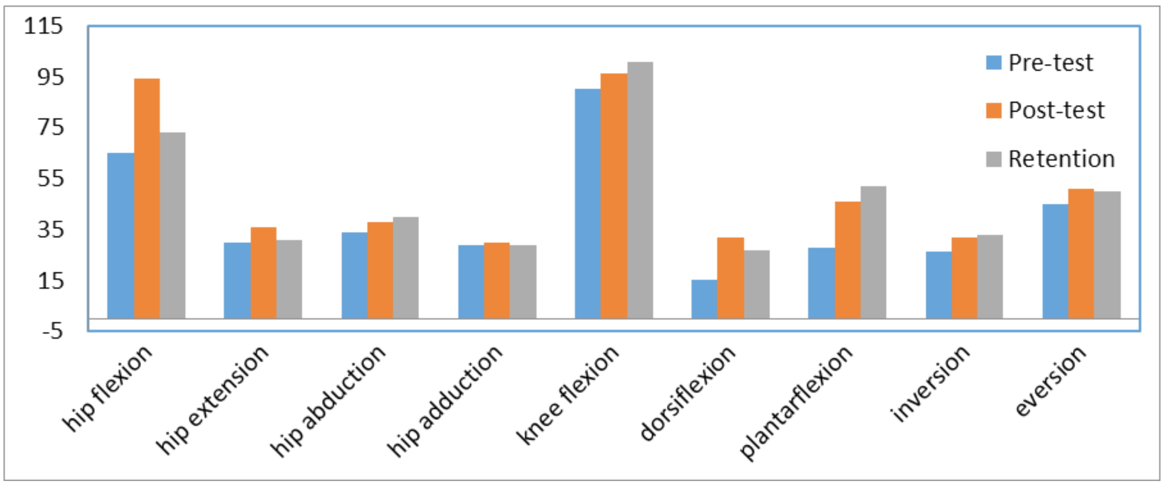
Design / Analysis

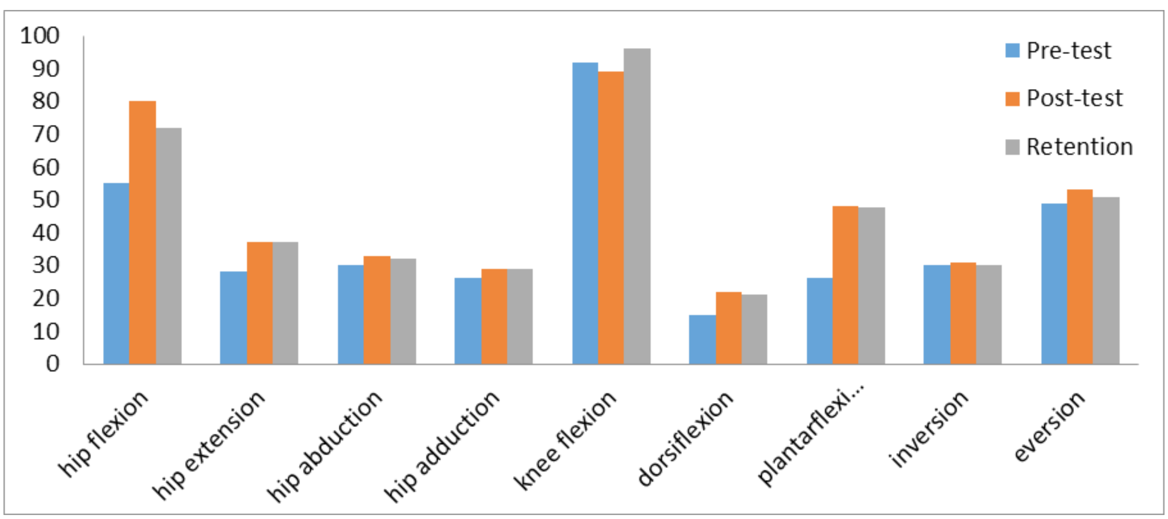
The study implemented a repeated measures design with time as a factor, with three levels (pre-test *vs* post-test *vs* retention test). Given the small sample sizes only descriptive statistics of central tendency (mean) and variability (standard deviation) were implemented. The mean of the group, as well as the individual data were considered when making the inferences regarding the potential effectiveness of the approach implemented.

Results

Range of Motion

The analysis of individual profiles (Figure 2), revealed that all three individuals improved their range of motion from the pre- to the post-test, and those positive changes were generally evident at the retention test. In terms of the different muscle groups involved, the changes in the hip flexion were most pronounced, whereas hip adduction and abduction revealed only subtle changes. These data corresponding to changes in knee flexion also showed a consistent improvement at the intra-group level, across the testing times, including at the retention test. This was evident from the fact that at retention test all three participants performed better as compared to their initial abilities. In regards to the ankle, the most pronounced and consistent differences emerged when dorsi- and plantar-flexion were examined. This was evident from the magnitude of change as well as from the consistency across the participants. The analysis of inversion and eversion was most equivocal, as the differences were very subtle, if any at all.





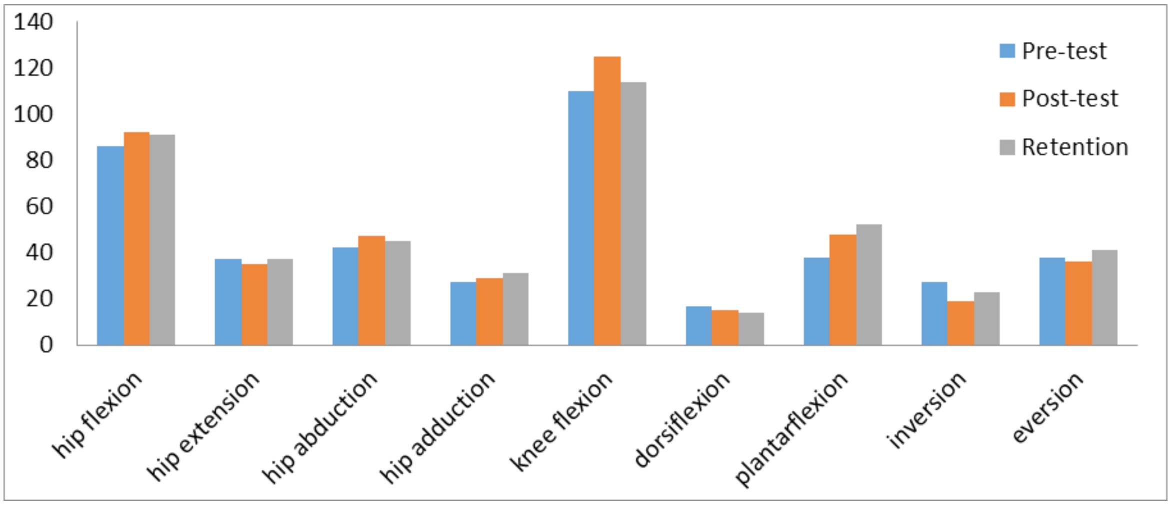


Figure 2: Individual data for Range of Motion, for the three participants, across the different joints (in degrees).

Strength

As evident from (Figure 3), the differences between the pre- and retention tests were substantial in two out of three participants, while participant B exhibited less pronounced, yet still clinically relevant changes. Thus these data, which captured the total maximum number of sit-to stand repetitions, as performed to the maximum, showed robust and consistent changes across the three participants.

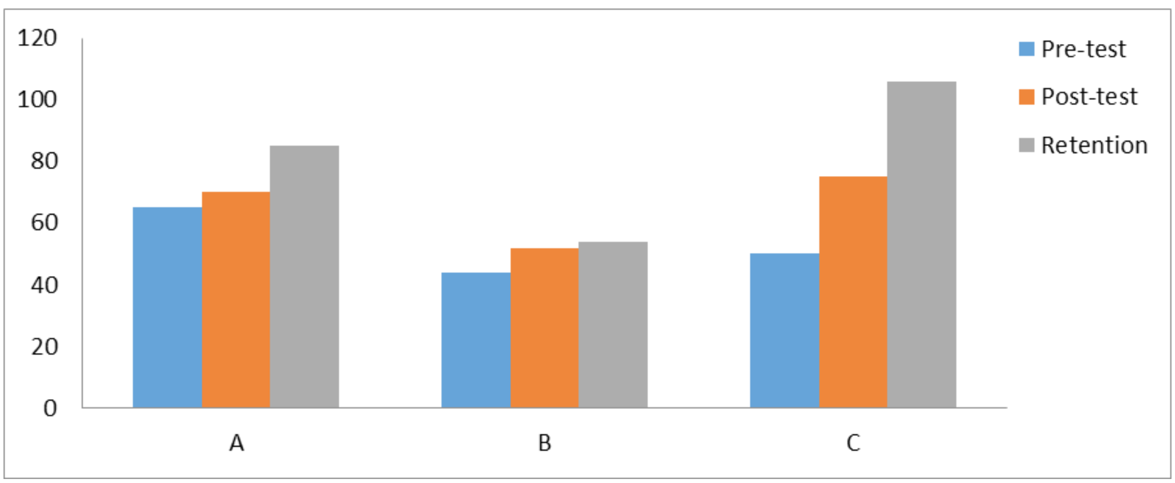


Figure 3: Individual data for Strength, for the three participants, as captured by the number of sit-to-stand attempts to fatigue.

Balance

Balance control was examined in two domains, static and dynamic, as both are important to the ability to perform the activities of daily living. The analysis of static balance (Figure 4), showed that path length remained approximately the same before and after training, with subtle increase in the retention test. From the standpoint of intra-group variability, which was small, it appears that this pattern was consistent across the three participants. Given, that in static balance the expectation is that the amount of sway decreases, with training (ref), this indicates that overall, no changes were evident. The analysis of sway area for the postural adaption task revealed a different scenario. There was a positive trend evident, as the participants were able to lean further away from the vertical, without losing their balance. In this case, since the task involved active leaning from the vertical, larger values coincided with positive change in behavior.

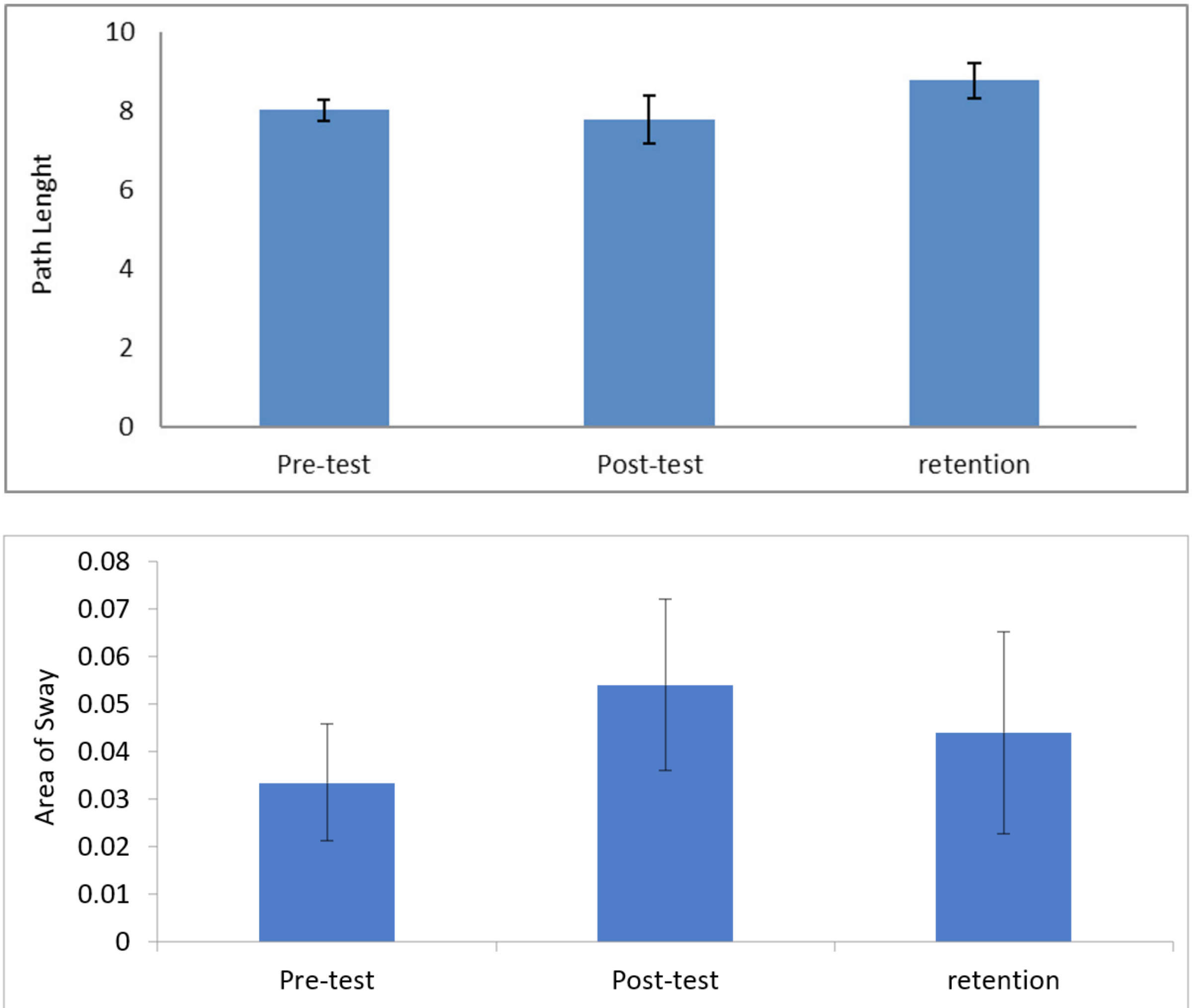


Figure 4: Group data for Balance Control (upper panel) and Postural Adaptations (lower panel).

Discussion

Proprioceptive Neuromuscular Facilitation (PNF) was implemented here to enhance various aspects of motor abilities in women exhibiting osteoarthritis. Although, the exact nature of the underlying control mechanisms remains unclear, from the behavioral perspective studies have shown that PNF exercises helped in development of muscle strength and endurance, joint stability, balance, mobility, as well as neuromuscular control in various populations, with [26] and without deficits [29]. The amount of research examining these issues in individuals with osteoarthritis is much more narrow and we have extended these observations here by showing the positive benefit of PNF stretching on range of motion, strength and balance.

The analyses of range of motion showed that overall PNF had a positive effect on this aspect of motor ability, in the women with osteoarthritis involved in the study. It is important to note that although inferential analysis was not implemented here, due to the small sample size, the notion of significant or important changes remain valid. Given a relatively small measurement error, the differences that emerged here before and after the treatment should be considered as clinically meaningful. For example, when the ROM for the different aspects of hip range of motion were examined in a population of stroke patients, the difference between the affected and unaffected side was approximately 3°.Thus even though the difference was relatively small, from the descriptive standpoint, it confirmed that even such subtle changes could aid clinical practitioners to assess the effectiveness of interventions administered to patients, and to interpret the significance of improvements in the selected parameters of range of motion [22]. Across the different joints, the evidence shown here, particularly related to the knee joint, are consistent with most recent investigations which showed that even short proprioceptive neuromuscular facilitation (PNF) stretching can improve proprioception, joint range of motion (ROM), and joint moments during stair ascending among older adults with knee osteoarthritis [23-31]. Furthermore, it has been shown that PNF stretching may be more beneficial to conventional physiotherapy when treating knee osteoarthritis in older adults [24]. Also, in regards to hip flexion / extension the current data is in line with the overall consensus put forward in a systematic review examining the impact of PNF and static stretching on hip range of motion [27]. The substantial differences emerging here in regards to plantar flexion are also consistent with previous findings which provided evidence that PNF stretching results in increased ankle dorsiflexion in older adults [24]. Thus, it is evident that the data emerging from the current study are consistent with previous work making it even more robust. However, it should be pointed out that more research involving elderly individuals with osteoarthritis is required, especially women. As it stands, the majority of the available research focus primarily on the knee joint, and involved mixed samples comprised of both genders.

In terms of strength and balance control, those two constructs appear to be complimentary as increases in the former generally result in the improvement of the latter. However, this hypothesis was only partially confirmed by the present data. In terms of static balance it was surprising to note that the amount of sway exhibited by the participants did not decrease, which would indicate an improvement in their stability. This is generally the pattern of results emerging from studies examining the impact of other exercise modalities on individuals with knee osteoarthritis [27-31].This has also been a consistent pattern that is evident in the rehabilitation protocols involving PNF stretching and individuals with stroke [24-26].These data related to older adults, particularly women population with osteoarthritis, is limited to this domain.

In terms of postural adaptations, conceptually speaking a leaning task allows for the examination of the ability of the person to explore their perceptuo-motor workspace that one has at their disposal in order to perform actions that involve self-perturbations to the orientation of the body from the vertical. From the practical/clinical perspective, possessing larger functional work-spaces would allow an individual to perform tasks such as leaning for an object without staggering or falling. Although inevitably the ability to lean in different directions, without falling or staggering, is affected to some extent by visual input, it is predominantly dependent on feedback from muscle spindles (type I and II), golgi tendon organs (GTO), and joint receptors [28].It is well known that these neural mechanisms are impacted by PNF stretching. The actions of muscle spindles and GTOs are essentially a feedback system that aid in the lengthening of a particular muscle through sensory control in response to change in tension and length in muscles [30-32]. In terms of the underlying neural causes of these positive changes, PNF stretching techniques makes use of proprioceptive stimulation for the strengthening (facilitation) of a particular agonist muscle group or for relaxation (inhibition) of the antagonist muscle group. One important principle of PNF streching, that maybe relevant here, is that voluntary muscle contractions can be performed in combination with muscle stretching to promote muscle relaxation [24].Thus, such induced muscle relaxation that overcomes resistance to movement, and subsequently increases joint ROM, may have contributed to the observed improvements in the leaning task. This increase in the ability to project the body in a controlled fashion can be also supported by the fact that plantar flexion was the domain that exhibited one of the most substantial changes among the lower leg muscles. In line with research examining static balance, also very little is known in regards to the possible link between dynamic postural adaptions and PNF among individuals with osteoarthritis. However, research has shown that PNF is effective in enhancing dynamic balance, strength, and overall mobility in older adults with chronic stroke and may mitigate falls risk in this population [26]. A similar pattern of results has also been shown in research examining effect of PNF on postural adaptations in healthy adults [29].

Conclusion

Musculoskeletal deterioration is closely related to balance and gait problems in older adult population, particularly those affected by musculoskeletal disorder such as osteoarthritis (OA) in the hips, knees or ankles .These issues result in reduced participation in physical activities as exercise or movement generally bring on symptoms such as joint swelling, stiffness, fatigue and pain. These symptoms, and the accompanied alterations in joint biomechanics, may have a direct impact on the gait patterns, static and dynamic balance, that eventually lead to an increased risk of falls. Although the current study involved a small sample size, the results were robust in showing that the implementation of a PNF stretching routine for 12 sessions had positive effects on range of motion, strength and postural adaptations, which were clinically relevant. Although there are some drawbacks regarding the implementation of PNF stretching, as a trained facilitator is required, the fact remains that this "treatment" is not physically demanding thus it does not exacerbate the already sore joints. As a result, from the clinical perspective, the use of PNF stretching programs may result in long lasting adherence, which is also one of the issues that individuals with osteoarthritis have to face as their motor system cannot handle or accommodate for frequent participation in physical activities.

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