EFEECTS OF PNF INTERVENTION ON PAIN, JOINT PROPRIOCEPTION AND KNEE MOMENTS IN THE ELDERLY WITH KNEE OSTEOARTHRITIS DURING STAIR ASCENDING

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This study aims to explore the effects of a 6-week proprioceptive neuromuscular facilitation (PNF) intervention on stair pain, joint proprioception, and external knee moments in the elderly with knee osteoarthritis (KOA) during stair ascending. A total of 27 elderly with KOA participated in our study. Fourteen of the patients were included in the PNF group, and 13 were included in the control group. Self-reported pain and disabilities of the WOMAC were assessed, and joint proprioception was measured, and gait test were performed at weeks 0 and 6. After a 6-week PNF intervention, the PNF group showed a decreased “using stair” pain score, decreased difficulty with “climbing stairs” score, decreased knee joint proprioception threshold, increased knee extension moment (KEM), and decreased knee adduction moment (KAM) during stair ascending. We suggest the use of PNF intervention, which relieves joint pain, recover proprioception, reduce the knee joint loading by changing KAM and KEM, and lessen difficulty during stair ascent of elderly with KOA.

KEYWORDS: pain, proprioception, knee adduction moment, knee flexion moment

INTRODUCTION: Knee osteoarthritis (KOA) is the most common form of osteoarthritis and characterized by the chronic degeneration of the articular cartilage; the disease has been related to mechanical overload, which results in pain and disfunction in elderly individuals (Vanwanseele et al., 2010). Stair climbing is the most complaint physical activity for KOA patients that require higher functional ability than level walking. Patients with KOA use different movements when they climb stairs, and these movements are possibly related to pain(Hurwitz et al., 2000). Kinematics alterations could influence force distribution in the knee by changing the external knee flexion moments (KFM)(Novak & Brouwer, 2011). Individuals with KOA present smaller KFM and larger peak knee adduction moments (KAM) compared with the healthy control. Greater KAM value indicates increased force across the medial knee joint and the severe progression of osteoarthritis(Michael et al., 2004). Moreover, KOA is associated with proprioceptive deficits. Knee proprioception is poor in patients with KOA, which may be caused by osteoarthritic pathologic processes destroying or disrupting the functions of mechanoreceptors(Sharma, Pai, Holtkamp, & Rymer, 1997).
Proprioceptive neuromuscular facilitation technique (PNF) moves joints in sagittal, frontal, and horizontal planes with a spiral and diagonal motion(Knott & Voss, 1957). PNF relieves pain, improves the ROM, restores proprioception as confirmed by clinical research. It can also enhance the gait ability among the elderly with fall experience(Song, Park, & Kim, 2014). Besides, the related muscle reaction time was promoted through the PNF integration movement that stimulates proprioceptors in muscles and tendons to facilitate joint sensitivity(Etnyre & Abraham, 1986). Although the positive effects of PNF are suitable to treat KOA symptoms, such as joint pain, reduced proprioception, and asymmetric force in the knee, only a few studies directly observed the effects of PNF on this condition. It is not clear if the spiral and diagonal movements of PNF are beneficial for the redistribution of joint pressure, and if PNF can effectively restore the proprioception of the knee joint.

METHODS: Seventy-six participants (>65 years) diagnosed with KOA were recruited, and thirty-six of them who were assessed for eligibility were randomly divided into two groups: the PNF group that practiced PNF stretch, the control group participated in a health education lecture series, for one-hour per time, three times per week, for 6 weeks. The participants were excluded when their attendance rate was less than 80% during the 6-week intervention. Finally, twenty-seven of these participants data were be analysed, which 14 in the PNF group and 13 in the control group. Independent t-tests showed no significant difference in age, height, or body mass between the two groups (p=0.05).

Every session of PNF stretching was one hour consisting of a 5-minute warm-up, 45-minute stretching, and a 10-minute cool down. There are included four techniques and four spiral-diagonal movement patterns in PNF stretching.
All the participants were asked to undergo tests at weeks 0 and 6. Each test included three parts, as follows: 1) measurement of self-report items “using stair pain” and “climbing stair function” of the Western Ontario and McMaster Universities Arthritis Index (WOMAC); 2) knee joint proprioception test, which using a customized proprioception test device; and 3) ascent stair gait test, where in the participants were asked to undergo ascending trials on a customized staircase with six steps. Kinematic data and kinetic data were collected using an eight-camera motion capture system (Vicon, Oxford Metrics Ltd., UK) and a force platform (Kistler, 9287BAs Switzerland) with sampling at 100 and 1000 Hz, respectively.
The WOMAC items and proprioception test data were imported to Microsoft Excel 2007, and the average values were calculated. Cut off frequency for the motion data and ground reaction force data were 6 and 30 Hz, respectively, using a fourth-order low pass Butterworth filter. All moment variables were described for the changes of the more affected leg in a single support phase. The external moments were the moments created about the joint center from the ground reaction forces and inertial force, which were calculated using inverse dynamics via Visual3D and normalized to the individual’s body weight and height (%BW*Ht). Kinematics were computed using a joint coordinate system approach.
Two-way ANOVA with repeated measures was used to determine the effects of time and group on each of variable. Partial eta squared (η^2_p) was used to represent the effect size of the main effect and interaction of two-way ANOVA. Cohen’s *d* was used to represent the effect size of the post hoc comparison(Cohen et al., 1988).

RESULTS: Table 1 presents the descriptive statistics and subgroup comparisons of the WOMAC items for stair pain and climbing stairs and joint proprioception. Significant time*group interactions are shown in the items “using stairs” and “climbing stairs,” as well as the knee flexion and extension proprioception threshold, which significantly decreased from week 0 to week 6 in the PNF group.

Table 1.Items of stair pain and climbing stairs of WOMAC and joint proprioception threshold, as presented by mean ± standard deviation

		PNF group (*n*=14)	Control group (*n*=13)	Post hoc p	Post hoc Cohen’s *d*	Time×group *P*	Time×group η^2_p
WOMAC item: stair pain	$Week_0$	5.71±2.05[a]	7.00±1.78	a<0.001	a=1.47	Interaction <0.001	0.638
	$Week_6$	2.64±2.13[b]	6.85±1.68	b<0.001	b=2.19		
WOMAC item: climbing stairs	$Week_0$	4.43±1.91[a]	5.77±2.09	a<0.001	a=1.09	Interaction =0.009	0.241
	$Week_6$	2.29±2.02[b]	5.77±1.64	b<0.001	b=1.89		
Knee flexion threshold(°)	$Week_0$	5.62±4.19[a,]	5.50±3.21	a=0.002	a=0.76	Interaction =0.006	0.267
	$Week_6$	2.83±1.66[b]	6.12±4.13	b=0.011	b=1.05		
Knee extension threshold(o)	$Week_0$	6.32±4.88[a,]	4.72±3.13	a=0.049	a=0.54	Interaction =0.016	0.212
	$Week_6$	3.99±3.31[b]	6.59±2.72	b=0.035	b=0.86		

[a] Denotes significant difference compared with week 6 in PNF group.
[b] Denotes significant difference compared with the control group at the same week.

As shown in Figure 1 and 2, significant time*group interactions were shown in the external knee moment (p=0.004,0.024;η^2_p=0.288,0.187for KEM and KAM, respectively), which increased KFM(p=0.011,Cohen’s *d*=0.64) and decreased KAM (p=0.026, Cohen’s *d*=0.27)from week 0 to week 6 in the PNF group.

DISCUSSION: Climbing stairs is one of the most highly recommended tests to assess physical function in patients with KOAs because of its sensitivity in detecting alterations. Pain would influence the stair climbing performance by changing movement patterns in patients with KOA(Bennell et al., 2003). Our results showed significant decreases in the two items in the PNF group at week6, indicating KOA symptom reduction. The hold–relax stretching of PNF may benefit pain relief because it requires the antagonist muscle to implement isometric contraction in the maximum ROM, thereby inducing the inhibitory effect of Golgi tendon

organs (GTOs) when the force exceeds the safety threshold as body perception. The gate control theory(Melzack & Wall, 1965), one of the well-known theories about pain, states that pressure signals suppress the expression of pain signals, and thus moderately decrease pain(Hindle, Whitcomb, Briggs, & Hong, 2012a).

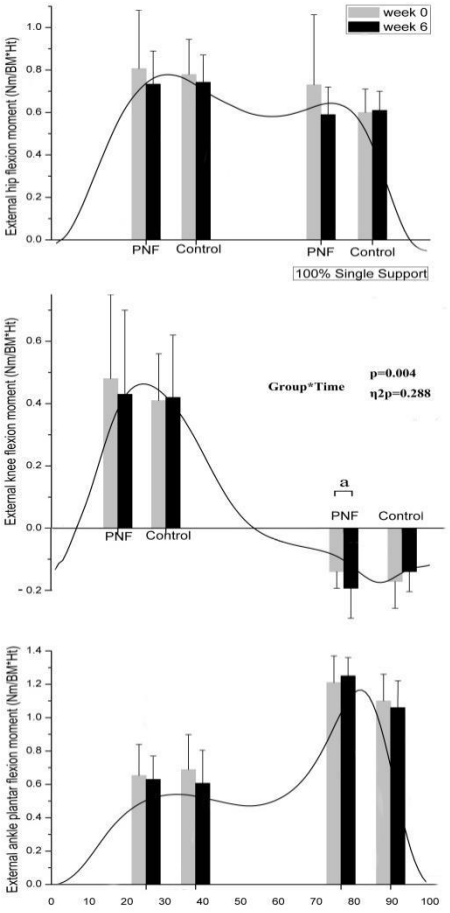

Figure1 Joint moments in the sagittal plane

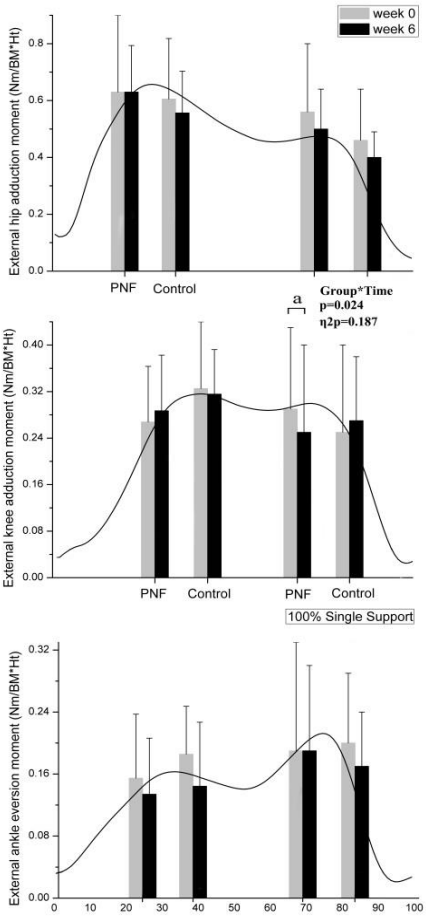

Figure2 Joint moments in the frontal plane

The black line presents group moments across the single support phase from the affected foot contact on the third step until it left the step. The bar-group with error bars represents the mean and standard deviation of the peak values in PNF and control groups at week0 and week6.

The mechanoreceptors in the muscles, ligaments, capsules of patient with KOA were degraded and damaged(Bennell et al., 2003). Our results showed significant improvements in two directions of knee joint proprioception in the PNF group. The possible explanation is that a stretch reflex was observed at the beginning, and an isometric contraction that lasted for few seconds was at the end of PNF stretching; these effects activate muscle spindles(Etnyre & Abraham, 1986). Signals from muscle spindles are important not only to the midrange perception of the joint angle and mechanoreceptors but also to the detection of stretching at the extreme ranges of joint motion. (Hindle, Whitcomb, Briggs, & Hong, 2012b). Hence, joint motion perception improves after PNF intervention.

KAM is an indicator for estimating mechanical load distribution in knee joints, and a low KAM indicates reduced KOA severity and good KOA treatment outcome(Novak & Brouwer, 2011). The decreased KAM in our study may benefit from the PNF intervention that improves joint force distribution. The spiral- and diagonal-patterned movements are vital elements in PNF, which against resistance several times through a full ROM, including movements in three dimensions with sequential, and at times, simultaneous movement at several joints(Knott & Voss, 1957). Thus, the joint motions in the frontal plane were repeated, resulting in the symmetry loading of the knee joint.

Although KFM did not differ between the two groups, we observed an increasing knee extension moment (KEM) in the PNF group at week6. KEM is regarded as a surrogate

measure for net muscle contraction, playing the same role maintaining joint stability. Compared with that in healthy people, the knee flexor strength was reduced in patients with KOA. The strength imbalance may cause joint instability, and long-term development can easily lead to joint laxity(Brenneman, Kuntz, Wiebenga, & Maly, 2016). Flexor muscles participate in co-contraction to jointly maintain the stability of knee joints(Michael et al., 2004). In particular, lateral knee flexors can be used to balance KAM dynamically. Therefore, an increasing KEM might result in a gait adaptation that reduces the adduction moment and therefore improves joint force distribution in the elderly with KOA.

CONCLUSION: This study confirmed that a 6-week PNF intervention positively affects KOA treatment by relieving pain, recovering proprioception, and improving joint force distribution in the elderly with KOA. The overall climbing stair function level was enhanced.

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