STRETCH IMPROVES PAIN AND DESCENT MECHANICS

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This study aims to examine the effects of a12-week Proprioceptive neuromuscular facilitation (PNF) intervention on pain relief, passive and active joint ROM, external knee adduction moment (KAM) and hip adduction moment (HAM) in the elderly with Knee osteoarthritis (KOA) during stair descent. Seventy-six elderly who were diagnosed with KOA were recruited and randomly divided into two groups: the twelve-week PNF intervention group and the control group. Pain score was measured by the Western Ontario and McMaster Universities Arthritis Index (WOMAC). KAM, and HAM during stair descent were measured using a motion analysis system with a force platform. All the data were recorded at weeks 0, 6, and 12. Compared to the control group, the PNF group showed a decreased pain score, increased HAM during stair descent. PNF intervention is a successful method to relieve symptoms of KOA. It relieves pain without increasing KAM, and increases HAM during stair descent in the elderly with KOA.

KEYWORDS: Proprioceptive neuromuscular facilitation,Joint moment, motion range

INTRODUCTION: Knee osteoarthritis (KOA) is a common, chronic joint disease that results in knee pain and disability. The prevalence of KOA is associated with aging; over 40% of adults 65 and older are symptomatic (Dawson et al., 2004). Increased pain leads to reduced dynamic balance (Takacs, Carpenter, Garland, & Hunt, 2015) and postural control (Hirata, Arendt-Nielsen, Shiozawa, & Graven-Nielsen, 2012) during gait. Stair walking is the first task to be affected among individuals with KOA. It requires greater functional ability than level walking, and is easily influenced by the knee pain (Whitchelo, McClelland, & Webster, 2014).
In addition to kinematic changes, KOA is also accompanied by increased and redistributed joint stress. Mechanical loading is a probable contributor to cartilage degradation (Beaupre, Stevens, & Carter, 2000), and the susceptibility of KOA development might be related to increased load distribution (approximately 60%–80%) and to the medial rather than the lateral compartment (A. Chang et al., 2005). The external knee adduction moment (KAM) during the stance phase of gait has been characterized both as a determinant and a surrogate for dynamic medial knee load (A. H. Chang et al., 2015), and even a reliable biomechanical marker of OA progression associated with the loss of cartilage thickness (A. H. Chang et al., 2015). Furthermore, a potentially protective kinetic parameter to reduce medial load is the external hip adduction moment (HAM), and an increased HAM during stance phase is associated with reduced likelihood of KOA progression (A. Chang et al., 2005).
KOA results in pain, increase of KAM (Duffell, Southgate, Gulati, & McGregor, 2014), and decrease of HAM (A. Chang et al., 2005) in the elderly. Stair descent is challenged by KOA more than level walking with greater KAM (Paquette, Zhang, Milner, & Klipple, 2014), greater demands on lower limb joint ROM (Protopapadaki, Drechsler, Cramp, Coutts, & Scott, 2007), and greater knee pain (Whitchelo et al., 2014). PNF intervention, as a multiple-phase practice, may decrease KAM and relieve pain (Sharman, Cresswell, & Riek, 2006). Therefore, the aim of this study was to examine the effects of a 12-week PNF intervention on pain relief, range of motion, and frontal plane knee moments in the elderly with knee osteoarthritis during stair descent. We hypothesized that after PNF intervention, the elderly with KOA would experience the following: reduced pain without increased KAM, increased passive and active joint ROM, and increased HAM during stair descent.

METHODS:A total of 36 elderly participants satisfied the following inclusion criteria in this study: aged 65 years old or older and diagnosed medial knee osteoarthritis (Kellgren/Lawrence radiographic grade≥1) in one or both legs (Qingguang et al., 2015).The participants were divided into two groups. Participants in the PNF group experienced 12-week PNF stretching. Five qualified physical therapists performed the intervention during one-hour sessions three times a week. Participants in the control group watched television or read magazines at the same time. Data from thirteen participants from the PNF group (8 females, age: 68.5±4.3 years, height: 162.3±7.4 cm, and body mass: 68.2±6.6 kg) and 16 participants from the control group (10 females, age: 67.4±3.4 years, height: 161.9±6.4 cm, and body mass: 68.1±7.2 kg) were included in the final analysis.

The one-hour PNF stretching sessions included a 5-minute warm up, 45-minute stretching, and 10-minute cool down. The participants were laying supine during the stretch sessions without side-bending or rotation. Starting with the hip in the neutral rotation, the extremity was moved into the elongated range of the pattern with the proper rotation beginning with the foot and ankle.

The overall pain score from the affected leg (the leg with the higher Kellgren/Lawrence score) was self-assessed at the end of weeks 0, 6, and 12 by completing the Western Ontario and McMaster Universities Arthritis Index.

Three-dimensional data for calculating frontal plane joint moments were collected while the participants descended a cast iron simulating staircase with six steps with a self-selected velocity. One force platform (Kistler, 9287BAs Switzerland), embedded in the 4th step from the bottom of the staircase, was used to collect ground reaction force data at a sample rate of 1,000 Hz. The stair descent test was recorded by an eight-camera motion analysis system (Vicon, Oxford Metrics, Ltd., England) at 100 Hz.

A two-way analysis of variance with repeated measures was used to determine the effects of time and group on pain score and joint moments. Partial eta squared (η2p) was used to represent the effect size of main effect and interaction of two-way analysis of variance. The Cohen' d was used to represent the effect size of post hoc comparison.

RESULTS: Table 1 presents the descriptive statistics and subgroup comparisons of the pain scores. Significant time*group interactions were shown in pain scores (p<0.001,η2p=0.789), which significantly decreased from week 0 to weeks 6 (p<0.001, Cohen' d =1.19) and 12(p<0.001, Cohen' d =2.03), and from week 6 to week 12 (p=0.008, Cohen' d =0.81) in the PNF group, and were significantly lower in the PNF group compared with that in the control group at week 6 (p=0.001, Cohen' d =1.38) and 12 (p<0.001, Cohen' d =2.13).

Table1.Pain score from WOMAC, presented by mean ± standard deviation

	PNF Group (*n*=13)	Control Group (*n*=16)	Post Hoc p	Post Hoc Cohen's *d*	time*group p	time*group η^2_p
$Week_0$	3.19±1.47[a,b]	3.16±1.10	a<0.001; b<0.001	a=1.19; b=2.03	<0.001	0.789
$Week_6$	1.61±1.08[b,c]	3.24±1.47	b=0.008; c=0.001	b=0.81; c=1.38		
$Week_{12}$	0.55±0.48[a,c]	3.21±1.18	a=0.008; c<0.001	a=0.81; c=2.13		

[a] Denotes significant difference compared with week 6 in PNF group.
[b] Denotes significant difference compared with week 12 in PNF group.
[c] Denotes significant difference compared with the control group at the same week.

As shown in Figure 1, the black line presents the average hip, knee and ankle moments in the frontal plane during a single suppose phase from the affected foot touch down on the 4th step to the same foot as it left the step, and the bars present the peak values (two peak values in the bimodal curve and one peak value in the unimodal curve) in the PNF and control groups at weeks 0, 6 and 12, respectively. Significant time*group interactions were shown in the first peak values of the external hip adduction moment(p=0.026,η2p=0.486), which increased from week 0 to weeks 6 (p=0.029, Cohen' d =0.59) and 12 (p=0.002, Cohen' d =0.81) in the PNF group.

DISCUSSION: Many kinds of interventions, such as total knee replacement surgery (Liao et al., 2015), gait-training (Hunt, Charlton, Krowchuk, Tse, & Hatfield, 2018), and Chinese

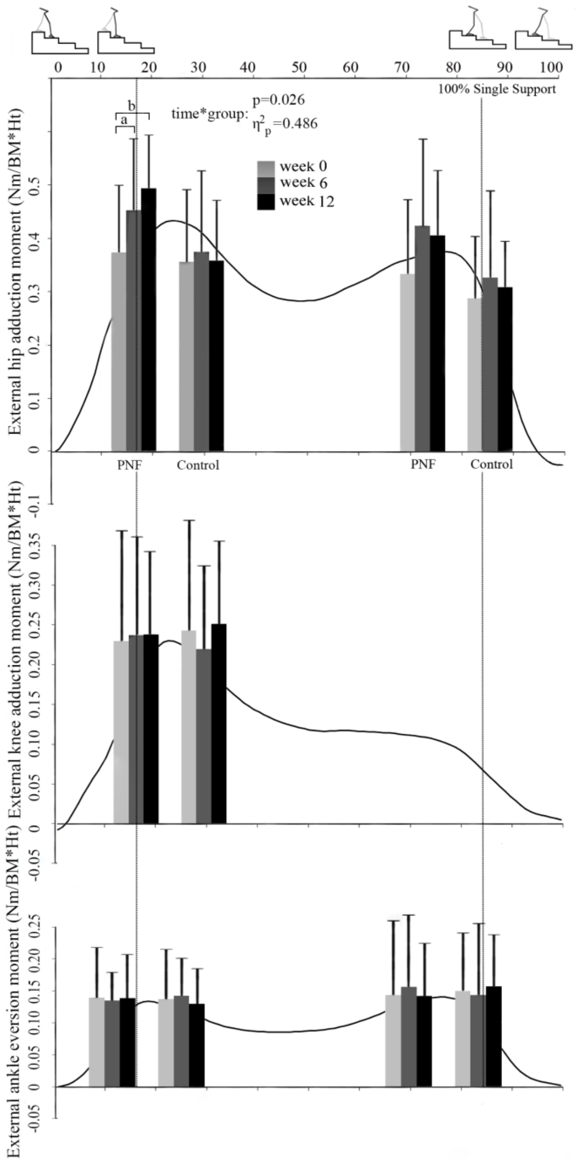

Figure 1. Joint moments of hip, knee and ankle

massage (Qingguang et al., 2015), could relieve pain in patients with KOA. PNF intervention may also have a pain relief effect, as a contract-relax-antagonist-contract stretching method. The gate control theory (Nathan, 1976) is a possible mechanism to reduce pain. In contract-relax and hold-relax techniques, large force and stretch are produced in elongated muscle when the participants resist the stretch; this large force is sensed as noxious stimuli and is seen as potentially damaging, which triggers the activation of Golgi tendon organs (GTOs) to inhibit the force and prevent injury, and the pain was also been inhibited by the sensory inputs form

At present, knee load cannot be directly measured noninvasively in vivo (A. H. Chang et al., 2015). The KAM, which represents loading on the medial compartment, is positively related with the increase in KOA severity (A. H. Chang et al., 2015). A study was done to examine whether a custom-designed Yoga strengthening program, which also contains foot external rotation practice, could reduce KAM in people with KNA. Just like our results, no KAM reduction was observed (Brenneman, Kuntz, Wiebenga, & Maly, 2015). Hence, reducing KAM through exercise or stretching is difficult. In this study, PNF intervention improved pain without increasing KAM, while pain relief drugs or injection increased KAM. From this viewpoint, PNF showed a better effect than the pain relief drugs or injection.

HAM is a potentially protective kinetic parameter that delays medial KOA progression (A. Chang et al., 2005), and weak hip abductor muscles in the stance limb cause excessive pelvic drop in the contralateral limb (MacKinnon & Winter, 1993). This drop shifts the body’s center of mass toward the swing limb, thereby increasing the force across the medial compartment cartilage of the stance limb (A. Chang et al., 2005). Hence, a high HAM during gait may prevent excessive medial compartment loading and potentially prevent ipsilateral KOA progression. From another perspective, a few knee muscles specifically provide knee frontal plane stability, and hip frontal plane muscles with a large cross-sectional area may play an important role in regulating medial-lateral knee load distribution and providing frontal stability (A. Chang et al., 2005). In this study, HAM increased after PNF intervention, indicating that PNF is an effective positional intervention for slowing the progression of KOA.

This work has limitations. After the 12-weeks of intervention, no further tests were done. Hence, we could not determine how long the effect of PNF intervention on pain relief, ROM, and gait would be sustained after the PNF practice.

Conclusion: This study confirmed that a 12-week PNF intervention could relieve pain without increasing KAM, enhance passive ROM, increase active knee flexion ROM, and increase HAM in the elderly with KOA during stair descent. These findings support that PNF practice is an effective intervention to relieve the symptoms and slow down the progression of KOA.

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