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Effects of Posterior-Anterior Mobilization of Lumbar Spine on Muscle Tone and Stiffness of Superficial Back Muscles and Lumbar Mobility

Background: Previous researchers have investigated the mechanical and neurophysiological effects of manual mobilization, however little research has been done on muscle tone and muscle stiffness.
Objective: To compare the effects of posterior-anterior (PA) mobilization with weight bearing on sling and conventional PA mobilization on the bed.
Design: Randomized controlled trial (single blind)
Methods: The subjects were 16 male university students and randomized to sling mobilization group (SMG, n=8) or conventional mobilization group (CMG, n=8). SMG received PA mobilization using a sling and CMG received traditional mobilization on the bed during lumbar mobilization.
Results: Both left and right muscle tones of SMG increased, but left muscle tone of SMG were increased and right muscle tone was decreased after intervention. In addition, both left and right muscle stiffness of SMG were also increased, however left muscle stiffness of SMG was increased and right muscle stiffness was decreased. The muscle tone and muscle stiffness of SMG were higher than those of DMG, especially the right side was statistically significantly higher. Extension of SMG, extension and flexion of CMG were increased statistically significantly except for Flexion of SMG ($p<.05$). There were no significant differences between the groups in Extension and Flexion.
Conclusions: This study suggests that lumbar spine PA mobilization using sling is beneficial in improving muscle tone, muscle stiffness, and trunk movement.

Key words: *Sling Mobilization; Muscle Tone; Muscle Stiffness; Lumbar Mobility*

Jisung Kim, Ph,D., Prof.

Suwon Women's University, Suwon, Republic of Korea

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Address for correspondence
Ji Sung Kim, PT, Ph.D
Department of Physical Therapy, Suwon Women's University,
Juseok-ro 1098, Bongdam-eup
Hwaseong-si, Gyeonggi-do, Korea
Tel: 82-31-290-8977
E-mail: sparkler7@swc.ac.kr

INTRODUCTION

The joint mobility is generally assessed by the range of motion(ROM) [1]. The active ROM is smaller than the passive one and has strong relationship with effort, muscle strength and motivation of the subject [2]. In patients with joint dysfunction such as joint malalignment, the efforts to move joint cause pain, muscle cramp, and restrict ROM because a normal movement in joint capsule is limited [3]. As a therapy for spinal joint dysfunction, one of such musculoskeletal dysfunction, the joint mobilization and manual therapy have long been used [4].

The purposes of manual therapy are reduction of spine or terminal joint, functionality enhancement [5], mobility maintenance, improvement in low mobility, and retardation of progressive joint stiffness [6]. The Maitland concept, one of various manual therapy techniques, has been widely used in clinical settings [5], and compared to conventional ones, is more effective in improving ROM and balance ability and is also applied for restoration of vertebral function [7, 8].

The most of manual therapies used in conventional clinic settings, however, were applied under gravity state and physical therapies were inactive ones in general [9]. These pose excessive tense on soft tissue and the resultant pain restricts ROM which have numerous negative effects on treatment outcomes. The sling may be an effective alternative to avoid these problems accompanied by manual therapy.

The sling exercise reduces body weight loads significantly by hauling the treatment site using suspension device. This allows training for improvement of muscle and joint mobility with more dynamic posture without almost no loads to joint [10-12]. These sling exercises have been applied to various forms such as relaxation, mobilization, muscle stabilization, sensory integration training, muscle strengthening exercise, stretching exercise and endurance exercise [9, 13, 14]. The sling also has a therapeutic advantage that allows early initiation of treatment and exercise under removed gravity [10].

The clinical studies up to now using, the sling have focused on the effectiveness of training for muscle functionality such as cervical stabilization, lumbar stabilization, gait training, and trunk stabilization [15], and the recent trend is that many studies have been reported on the effects of joint mobilization and frequency of treatment using the sling [16]. The previous studies on objective indicators for the effects of applying manual mobilization such as changes in muscle tone and mobility of joints, however, have been limited [5].

The purpose of this study, accordingly, was to investigate the clinical effectiveness of manual therapy using the sling by comparing between the outcomes of applying mobilization under removed gravity and conventional mobilization applied on the bed without removing gravity in university students in their 20's.

METHODS

Subjects

The subjects of this study were 16 healthy university students who had no noticeable pain on the lumbar part and were enrolled in H university located in Jeollabuk-do. The exclusion criteria were injury on lumbar part within six months, history of surgery treatment on lumbar part, current treatment in medical institution for lumbar damage, and being diagnosed with rheumatism. The subjects participated in this study voluntarily after being informed of and understand the purpose of this study.

The subjects were randomly assigned to sling mobilization group (SMG; n=8) and conventional mobilization group (CMG; n=8). The average (±SD) age, height, and weight were 24.25±0.46 years, 174.38±4.66cm, and 71.00±3.78kg, respectively and for CMG, these were 25.25±0.71 years, 177.63±8.12cm, and 73.50±8.25kg.

Materials and outcome measures

Muscle tone & stiffness

The muscle tone and stiffness were measured by using the myotonometer (Myoton®PRO, MyotonAS, Estonia) with high reliability [17]. The subjects were positioned in a prone on the bed. The Myoton®PRO probe was positioned vertically on the most sensitive parts of superficial erector spinalis (1cm away from both L1 and L4 spinous processes) [18]. The average of duplicate measurements were used in analysis. All measurements were performed by a single physical therapist.

Trunk Flexion & Extension

The trunk flexion was measured, using a tape (Stanly, USA) as a distance between floor and fingertip under bending the body in straight posture. The trunk extension was measured, using GoniometerPro (5fuf5, USA), a joint mobility measurement application, installed to a iPhone (Apple 6, USA), as a trunk extension angle in straight posture. The subjects were informed of being cautious of restricting lateral flexion and rotation during both measurements.

Procedure

In SMG, a 3D Sling exercise device (3D NEWTON Sliding Box, EASYSTEP, Korea) was used to decrease gravity during mobilization. The subjects on the electric bed were, after being supported on ankle, knee, pelvis, chest and head by using a sling suspension device and a strap in prone position to remove gravity, and were kept the head and body horizontal by adjusting the length of sling line. The pelvic area strap was connected to the sling suspension device using an elastic hook to assist the mobilization of the lumbar. After completing the support of the subject's body, the electric bed was lowered by 10cm to make the subject's body to be in air so that the mobilization is allowed under removed gravity.

The subjects of CMG, similarly to those of SMG, the mobilization using conventional method was performed on the lumbar part with position of prone on the electric bed without decreasing gravity.

In the mobilization, the therapist standing at the right side of subject applied the posterior-anterior (PA) mobilization technique 20 times with Maitland grade III and positioning right hand pisiform on the L1 spinous process of the subject and covering the right hand with left hand (pisiform grip). The period of a PA mobilization technique application was set as 1 sec. The PA mobilization technique was applied on

from L1 to L5 in a row. Two sets of PA mobilization technique was administered the pause time between sets were 1 minute. The muscle tone and stiffness of superficial back muscles, trunk extension, and trunk flexion mobility were measured before and after mobilization on all the subjects.

Data and statistical analysis

The data collected in this study was analyzed using SPSS WIN (ver. 20.0). The Kolmogorov-Smirnov test was conducted to verify normal distribution in each group and the independent t-test was employed to verify homogeneity. The paired t-test was conducted to analyze differences in measured after mobilization in each group. The independent t-test was used to analyze inter-group differences. The significance levels in this study were set at α=.05.

RESULTS

Change of muscle tone and stiffness on the superficial back muscles

The muscle tone and stiffness increased after mobilization in both group and there were no statistically significant difference between pre- and post-measurement excepting for the muscle tone of right superficial back muscles in SMG($p<.05$). The statistically significant inter-group difference was observed only in the right superficial back muscles in SMG($p<.05$) 〈Table 1〉.

Change of trunk flexion and extension

The trunk extension in SMG and trunk flexion and extension in CMG increased statistically significantly after mobilization ($p<.05$) and there was no statistically significant inter-group difference〈Table 2〉.

Table 1. Change of muscle tone and stiffness on the superficial back line muscles

Variable		SMG		CMG	
		Pre	Post	Pre	Post
Muscle tone(Hz)	Lt	15.98±1.50	16.55±1.72	15.98±1.50	16.55±1.72
	Rt†	15.89±1.50	17.08±1.96*	15.89±1.50	17.08±1.96*
Muscle Stiffness(N/m)	Lt	315.06±64.74	328.56±76.35	315.06±64.74	328.56±76.35
	Rt†	315.13±73.97	347.63±80.40	315.13±73.97	347.63±80.40

SMG : sling mobilization group, CMG : conventional mobilization group, Lt: left, Rt: right
Values are means ± standard deviation
* $p<.05$
† Independent t-test for inter-group differences($p<.05$)

Table 2. Change of trunk flexion and extension

Variable	SMG		CMG	
	Pre	Post	Pre	Post
Extension(°)	35.00±15.03	47.50±18.37*	48.28±8.26	56.25±13.50*
Flexion(cm)	3.88±13.36	4.50±14.84	-.63±8.02	-3.25±8.081*

SMG : sling mobilization group, CMG : conventional mobilization group
Values are means ± standard deviation
* $p<.05$

DISCUSSION

This study investigated the effects of the mobilization under decreased gravity using sling and conventional mobilization applied on the bed on muscle tone and stiffness and trunk mobility.

The rehabilitation interventions such as manual therapy is commonly used in managing chronic back pain. According to Maitland's classification, I and II grades of Maitland mobilization technique is mainly used in treating painful joint and III and IV grades are mainly used in tissue stretching [19]. These techniques aid in change in muscle tone and stiffness by reducing the muscle activity of paraspinal muscle [20-22]. The mechanical characteristics including muscle tone and stiffness are the essential element of muscle activity and contribute to maintaining energy efficiency of muscular contraction [23]. The muscle tone and stiffness increase or decrease depending on the type of exercise [18, 24].

The sling device is helpful in decreasing gravity and weight using hanging during application of mobilization technique. This is used to enhance the effect of mobilization therapy by induce relaxation on the treated part. Though there is difficulty in direct comparison due to lack of similar previous studies, was reported to improve flexibility of spine and enhance the response time of vertebral muscle [25]. The sling exercise is also improve the flexion, extension, and rotation movement of vertebral joint [14], and the mechanical vibration of low frequency from sling recovers the proprioceptive sensation [26].

Although the mobilization increased muscle tone and stiffness in both groups in this study, the increase did not reached statistical significance except for muscle tone of right superficial back muscles in SMG. The inter-group comparison showed statistically significant difference also only in muscle tone of right superficial back muscles ($p<.05$). In the assessment of mobility of lumbar part, the trunk extension in SMG and trunk flexion and extension in CMG increased statistically significantly ($p<.05$) and there was no statistically significant inter-group difference, a result consistent with those of previous studies. These results indicate that the application of mobilization on unstable surface by sling rather than the reduction in paraspinal muscle activity due to mobilization [20-22] or decreasing of weight or gravity by sling had effects on motor control system, thus the muscle tone and stiffness of superficial back muscles by improving muscle activity [27-33]. The fact that the active relaxation by subjects was inhibited by sling suspension device may be another reason. The result that the increase in SMG was observed only in trunk extension indicates that the application of posterior-anterior mobilization using sling and resultant flexibility of suspension device facilitated lumbar extension and increased ventral gliding of facet joint in the spine.

Considering these results, it is necessary, in patients with pain due to increase muscle tone and restricted mobility, to consider the use of sling for therapeutic relaxation in applying mobilization. The decision on the mobilization methods, sling or conventional one, should be dependent on the aim of treatment. It is also considered that further studies are necessary to recruit more subject and investigate change in muscle tone, using EMG, during mobilization application.

CONCLUSION

This study provides evidence that the lumbar spine posterior-anterior mobilization using sling under decreased gravity improves muscle tone of superficial back muscles and trunk extension mobility. Such differences, however, were not observed in muscle stiffness, trunk flexion, and trunk extension except for muscle tone between lumbar spine mobilization using sling under removed gravity and conventional mobilization applied on the bed.

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