SHORTCOMMUNICATION

The Influence of Pole Exercise on the Range of Motion of Thoracic Spine

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ABSTRACT

Background: The stability of the spine and flexibility of the thoracic cage have been in discussion for long. Authors have continued clinical practice and rehabilitation for various subjects. Among them, we have developed the application of pole exercise for various subjects, leading to the improved flexibility of thoracic spine. **Subjects and Methods:** Enrolled subjects were 18 adults with an average age of 27.8 ± 2.9 years old. Methods included the continuation of pole exercise by two ways, which are performed on the shoulder and at the armpit. The range of motion (ROM) of thoracic upper/lower (U/L groups) thoracic cage was analyzed using the measurement apparatus, spinal mouse. **Results:** For the main effect between U/L groups, there was a significant difference in the range of the total ROM. For alternating effect between intervention condition and time, there was a significant difference in ROM (total, flexion, and extension). U-group showed larger ROM compared to the L-group. **Discussion and Conclusion:** There would be probable some reasons for the difference, which are (i) bucket-handle rotation about a dorsoventral axis, (ii) caliper rotation about a craniocaudal axis, and (iii) pump-handle rotation about a mediolateral axis. These results would become reference data, leading to further research in the future.

Key words: Flexibility of the thoracic cage, pole exercise, spinal mouse, stability of the spine, upper and lower rib cages

INTRODUCTION

As for the stability of the spine, there has been a lot of continuing discussion. Among them, the fundamental concept would be that there are three subsystems during various postures and movements.[1] They are a passive, an active, and a neural control subsystem.[1,2] The spine has been deeply involved in our various movements. Each movement has action and reaction, which is influenced from the flexibility and motor function of the spine.[2] When there exists the force action, the spine has the function of absorbing and buffering the returning reaction force.

In our usual activity, the movement of the spine is influenced by the surrounded thoracic spine. The smooth mobility and flexibility of thoracic cage and vertebra have been easily restricted by various situations.[2,3] When some physical dysfunctions are found due to diseases or aging, the fixation changes stronger than the mobility, leading to the restriction of flexibility of the thoracic cage.[4] These conditions may influence smooth gait or other movements. When the range of extensibility of the vertebrae changes, the lumbar frontal curvature can be influenced.[2,5] As the thoracic vertebral curve is decreased, the movement of the center of foot pressure can become smooth. Consequently, walking or gait balance becomes also improved due to increased stability of spine.

On the other hand, authors and colleagues have continued our clinical rehabilitation and research concerning the spinal flexibility associated with actual practice of pole exercise in various situations.[6] Pole exercise has been simple and effective, including physical therapy, manual therapy,

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gymnastics therapy, and so on. Its characteristic points seem to be with low cost practically for maintaining and improving physical function in a short time.[7]

Regarding the application of the pole exercise in standing position and sitting position, we had shown clinical efficacy in the light of several examinations such as finger floor distance, shoulder extension test, body warp prone position, and others.[8] These findings would indicate the improved function of flexibility and motor function in thorax and spine.

In general, exercise therapy includes all types of procedures. There are different approaches in the fields of rehabilitation, sports medicine, orthopedics, and integrated medicine. Among them, a common goal seems to be present that the development for the spinal range of motion (ROM) would be important by stretching and other procedures.[6,8]

In this case, however, it has not been clarified yet by what kind of operation for a certain segment of the spinal column can be stimulated, stretched, and improved in flexibility. There have been few reports concerning the attempts for effective exercise for the upper thoracic spine.[9]

The authors have various experiences so far including rehabilitation for the patients with medical and health problems, lecture and workshop for the various staffs, advice for athletes on several kinds of sports, and so on.[6,10,11] Among them, we have continued developing "Be healthy by pole exercise." It can become an effective aid for everyone that can be easily understood and performed using the convenient Moriyasu pole.[8]

We have presented our research results and achievements in various conferences and meetings.[12] In particular, Moriyasu pole seemed to improve and broaden the range of movement in upper thoracic vertebra.[6,8] It is probably due to the performance posture holding a pole on the shoulder and twisting some motion to the upper thorax. From these situations, we investigated the effect of pole exercise on the upper thorax and thoracic vertebral and report certain findings in this article.

SUBJECTS AND METHODS

The enrolled subjects were 18 adults (male/female 7/11) with the age at 27.8 ± 2.9 years old. As a method, the practitioner performs a certain exercise therapy on the subjects. The exercise therapy has two types. One is holding Moriyasu pole on the shoulder (upper position as Group U) and another is holding the pole below the armpit (lower position as Group L). Each project was performed in 1 day and did it twice in random order. The movement range of the thoracic spine before and after exercise therapy was measured and compared.

The detail procedures of the exercise therapy are described as follows. First, the task protocol of method included forward and backward spiral movements for 30 times in each upper and lower position.

Second, a series of the measurement procedures are summarized in the following:

1) For measuring the ROM of the thoracic spine, "spinal mouse" was used.[13,14] It is an analyzing apparatus manufactured by INDEX Co. Ltd.[15] The upper thoracic kyphosis angle is the sum total of the angles from Th1/2 to Th6/7, while the lower thoracic kyphosis angle is the sum of the angles from Th7/8 to Th11/12
2) The positions of spine and lower extremities were measured in three different situations including (i) sitting position, (ii) maximum flexion (bending as possible), and (iii) maximum extension of spine (stretching the back as possible).[16]
3) Regarding these three positions (i, ii, and iii), there are two technical medical terms defined. The bending ROM is defined as the space between (i) and (ii). Furthermore, the extension ROM is defined as the space between (i) and (iii)
4) Similarly, the total ROM is defined as the space between (ii) and (iii)
5) The difference between flexion and extension was defined as the total ROM
6) As to several biomarkers mentioned above, they were calculated by measuring the area of the upper thoracic spine (Th1-6) and also the lower thoracic spine (Th7-12).

Statistical analysis

Dependent and independent variables were set and analyzed for each value of thoracic spine movement range. At that time, analysis was performed using by two-way ANOVA under two conditions. One was intervention time (pre-exercise and post-exercise) and another was intervention condition (Group U and Group L). In addition, when an interaction was observed, the method of the simple main effect test was adopted. $P < 0.05$ was considered statistically significant.

RESULTS

The results of changes in the ROM (total, flexion, and extension) of the upper thoracic vertebra are shown in Table 1. This comparison of pole exercise was conducted by two positions of upper (U) and lower (L) groups, which are on the shoulder and at the armpit.

Regarding the main effect (P1) between the U and L groups, there was a significant difference in the range of the total ROM. There was no significant difference in the main effect (P2) between before and after the intervention. As to the alternating effect (P3) between intervention condition and time, there was a significant difference in the three ROM (total, flexion, and extension).

The results of changes in the ROM (total, flexion, and extension) of the lower thoracic vertebra are shown in Table 2. This comparison of pole exercise was conducted by two positions similarly.

For the main effect (P1) between the U and L groups, there was a significant difference in the range of flexion. The difference between U and L groups was 2.1 cm before the intervention and 1.2 cm after the intervention, showing a significant difference between the two groups. There was no significant difference in the main effect (P2) between before and after the intervention. There was no significant difference in the alternating effect between groups and before and after (P3).

Table 1: Movable degree of upper thoracic vertebrae

Range	Group	Before	After	Difference
Total degree	Up	19.6±3.7	28.2±3.6	P1*
	Low	23.7±3.7	22.1±3.5	P2 ns
				P3*
Flexion degree	Up	15.4±1.9	19.3±1.2	P1 ns
	Low	15.7±1.7	15.4±2.3	P2 ns
				P3*
Extension degree	Up	4.2±2.3	8.2±2.6	P1 ns
	Low	7.6±2.8	6.9±2.6	P2 ns
				P3*

P1: Significant difference in main effects of different intervention conditions, P2: Significant difference in main effects before and after intervention, P3: Significant difference in interaction between intervention condition and time, $^{*}P<0.05$, ns: No significant. Values express mean±SEM

Table 2: Movable degree of lower thoracic vertebrae

Range	Group	Before	After	Difference
Total degree	Up	33.2±2.5	35.1±2.3	P1 ns
	Low	31.7±2.5	34.5±2.2	P2 ns
				P3 ns
Flexion degree	Up	17.6±1.6	19.8±1.9	P1*
	Low	15.5±1.5	18.6±1.2	P2 ns
				P3 ns
Extension degree	Up	16.1±2.9	15.2±2.7	P1 ns
	Low	17.2±2.7	17.9±3.0	P2 ns
				P3 ns

P1: Significant difference in main effects of different intervention conditions, P2: Significant difference in main effects before and after intervention, P3: Significant difference in interaction between intervention condition and time, $^{*}P<0.05$, ns: No significant. Values express mean±SEM

DISCUSSION

In this research, we held a research using a pole for a spiral motion. We examined the location of the pole in two cases: On the shoulder and at the armpit. As a result, the former showed larger ROM of the upper thoracic vertebra compared to the latter.

There would be some reasons for this results in the following: (1) Motor stimuli are input to the joints of the upper rib cage such as intervertebral joints, costovertebral joint, sternocostal joint, and costotransverse joint and (2) the tension of the muscles attached to the upper ribcage is reduced to the normal range, such as middle trapezius muscle fibers, rhomboid muscles, and upper posterior saw muscles.[17-19]

From these mechanisms, the flexibility of upper thoracic cage seemed to be improved with smooth movement of various operations.

There are some characteristic points concerning thoracic spinal ROM.[9] Compared with cervical and lumbar spine, thoracic spine has distinctly smaller segmental ROM. Further, thoracic motion pattern in several planes has been decided due to the thoracic cage and the orientation of the facets. In general, ROM and neutral zone seemed to be decreased in the inferior direction for the equal bending moments.[20] On the other hand, ROM ranges were higher in the lower segments.[19] Consequently, thoracic cage has been present for the significant decrease of ROM in all kinds of motion planes, especially in the axial aspect.[17] In contrast, it is the intervertebral disc that can determine the thoracic spinal ROM.[18]

In this study, the ROM of the upper thoracic vertebra was significantly wider in upper group than lower group. Among our continuous studies for years, the upper thoracic ROM was related to elbow push test (EPT), suggesting the presence of a functional connection between the upper thoracic vertebrae and the scapula. EPT is a test method for judging the function of the scapula and has been used in the fields of sports medicine and rehabilitation.[21] There are three factors involved in this evaluation method. They are (i) muscle strength of the front saw muscle, (ii) muscle strength of the oblique muscle strength, and (iii) the inner/outer function of the shoulder.[22,23]

The current research method is a torsional motion with the straight pole held on the shoulder. By this movement, there was the movement of the thoracic ribs, vertebrae, and facet joints in the rib cage, associated with the motion stimulation for the shoulder blade. Therefore, it seemed to contribute to the improvement of the movable range of the upper thoracic vertebra. From these results above, it was more effective to hold the pole on the shoulder than at the armpit. These results suggested that the exercise of the pole exercise on the upper thoracic vertebra may be useful for the treatment of the related neck, shoulder joint, and lumbar region.

Conventionally, it is thought that the movement of the rib cage is not involved when moving the lumbar spine or cervical spine. However, in fact, it is related to respiratory diseases and back pain. In other words, the movement and flexibility of the rib cage are also related to back pain.[4,24]

The movement of the thorax involves the facet joint and the spinal joint. Further, it is influenced by the direction of the movement axis of the spine joint.[25] The upper and lower rib cages are different in the movement way. The upper rib cage is characterized by pump-handle motion, in which the rib cage expands back and forth. In contrast, the lower rib cage is characterized by bucket-handle motion, in which the rib cage spreads left and right.[26]

Concerning costal kinematics and anatomy, rib motions can be explained as some rotations including three anatomical axes.[27] They are (i) bucket-handle rotation about a dorsoventral axis, (ii) caliper rotation about a craniocaudal axis, and (iii) pump-handle rotation about a mediolateral axis. Further, additional mechanisms are also involved in these motions such as (iv) anatomy of the thorax with flexibility and (v) the sternal ribs articulate with the sternum.

Ribs 1–7 are vertebrocostal ribs, connecting directly to the sternum. Ribs 8–10 are vertebrochondral ribs, where the cartilage of each rib attaches to the cartilage of the rib above it. Ribs 11–12 are floating ribs which terminate in the posterior abdominal musculature without attaching to the sternum. Costal cartilage 1–10 can facilitate the elastic recoil of the thoracic wall contributing to various passive movement.[27]

Concerning the movement of thoracic cage and rib, there is recently new computational mechanics model according to the motions of the ribs, diaphragm, and muscle contractions.[25] Furthermore, a validated thoracolumbar spine model was used with a flexible thorax (T1–T12), a completely rigid one or rigid with thoracic posture updated at each analysis step. This study indicates that the lumbar spine models with a rigid thorax definition can be used for loading investigations at the lower-most spinal levels. For predictions of upper lumbar spine loading, using models with an articulated thorax are advised.[28]

CONCLUSION

This study investigated the effect of torsional motion on the upper rib cage on the ROM of the thoracic spine. As a result, there was a tendency for increasing ROM in upper thoracic spine. This can be involved in body flexibility and respiratory function. These results would become reference data and further development of research would be expected in the future.

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