

The Influence of Abdominal Muscles on Shoulder Isometric Muscular Strength

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Abstract

It has been known that core stabilization is associated with the trunk stability and the mobility of limbs. However, studies on the relationships between the core stabilization and the muscle strength of limbs were very rare. Also, the Valsalva maneuver reportedly had an optimal breathing condition that created the maximal muscle strength. However, there has not been any comparative study of the maximal muscle strength by the Valsalva maneuver with that upon the core contraction. Thus, this study aimed to compare the impacts of the core contraction and the Valsalva maneuver on the isometric maximal muscle strengths at the internal rotation of a shoulder. The participants composed of 11 male and 24 female adults (age 21 ± 1.8). The measurement was performed 3 times with the single group. The experiment was carried out to measure the isometric maximal muscle strengths upon the internal rotation of a shoulder in the three groups consisting of the control group, the core stabilization group contracting transverses abdominal muscle and the Valsalva maneuver group using intra-abdominal pressure. A significant difference ($p < 0.05$) was shown between the core stabilization group (10.27 ± 7.06) and the Valsalva maneuver group (16.39 ± 9.09). As a result, it was found that the core stabilization group and the Valsalva maneuver group had impacts on the maximal muscle strength at the isometric internal rotation of a shoulder. If compared with the control group, the core stabilization group displayed the reduced maximal muscle strength while the Valsalva maneuver group showed the increased maximal muscle strength in comparison with the core stabilization group. Since there were no overlapping conditions between the core contraction and the measurement of muscle strength, which comprised the dual task, the concentration of the participation on the task was lowered and thus the maximal muscle strength of the core stabilization group was reduced. It has been known that the Valsalva maneuver enhanced the trunk stability and provided the additional muscle tension along with the increased intraperitoneal and intrathoracic pressures, leading to the improved power generation of the proximal and limb muscles. Consistent with this, the Valsalva maneuver group displayed the highest maximal muscle strength.

Keywords: Component, Core Stability, Isometric, Shoulder, Strength, Valsalva Maneuver

1. Introduction

The core stability was essential for sports (e.g., track and field, climbing, and soccer) and activities of daily living (e.g., sitting, standing, walking in an upright position). First, it provides stable foundation for the activities involving the rotation of trunk such as golf and tennis. Second, it improved the balance for the sports such as ski, snowboard and mountain bike. Third, the core assists enhancing the agility for soccer and hockey¹. Therefore, the core stabilization was performed generally in fitness, sport centers²⁻⁴. The core muscle strengthening was associated with the mobility of limbs⁵⁻⁷. The core muscles

assisted the effective production and adjustment of the force with limb movements. Panjabi (1992) defined the core stabilization as 'the capacity of the stabilizing system to maintain the intervertebral neutral zones within physiological limits'⁸. The core muscle consists of diaphragm, transverses abdominal, multifidus and pelvic floor muscle^{8,9}. The core has been used to describe the lumbo-pelvic-hip complex and the surrounding muscles¹⁰. The stability of the lumbo-pelvic-hip complex supported the load and protects the spinal nerve roots. It was very important because it provides the basis for the movement of limbs¹¹. The function of the core was divided into

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stability and the generation of force in the abdomen¹². Several recent studies suggested that the main function of the core was to stabilize the trunk⁹. In addition, the core stabilization improved the stability of the trunk, which affected the mobility of the limbs. Muscular strength, flexibility, endurance, coordination, and the effectiveness of balance and movement were the components required to achieve the functional movement in the motions¹³. Functional movement was maintaining a balance between the mobility and stability. This was essential for obtaining the work performance and sport related skills.

The Valsalva maneuver was vocal fold closure at the end of a deep inspiration followed by physical exertion such as required during a bowel movement, or lifting a heavy weight¹⁴. In previous studies, the effects of 4 types of respiratory conditions (normal breathing, forced expiration, forced inspiration and Valsalva maneuver) on the maximal isometric strength of large muscles were investigated. It was found that the maximal muscular strength was increased at the time of the isometric contraction of all muscles during the Valsalva maneuver. This showed that the breathing condition can have a significant effect on the maximal isometric strength. The Valsalva maneuver was the optimal breathing condition to generate the maximal muscular strength¹⁵. Theoretical basis to use the Valsalva maneuver for maximal muscular strength was that it increased the pressure in the abdominal and thoracic cavities. It was able to improve the stability of the trunk.

However, there was insufficient evidence for the relationship between the core stability and muscular strength. Therefore, more studies on the interrelation between the core stabilization and the muscular strength in limbs were needed. In the current study, we attempted to elucidate the effects of the core contraction and the Valsalva maneuver on the isometric maximal muscle strengths at the internal rotation of a shoulder.

2. Materials and Method

2.1 Subjects

The experiment was conducted on 35 current students (11 males and 24 females) of S University (Republic of Korea), who had no musculoskeletal disorders. Before the experiment, the height and the weight of all the participants were measured using a body composition analyzer (Inbody 570, Biospace, Korea, 2013). The average age of the participants was 21 ± 1.8 ; and the average height

Table 1. General characteristics of subjects

	participants (n=35)
Age	21 ± 1.80^a
Height (cm)	160.85 ± 26.7
Weight (kg)	59.66 ± 7.77
Skeletal muscle mass (kg)	24.44 ± 5.42
BMI (kg/m^2)	21.80 ± 2.59
Body fat percentage (%)	25.91 ± 9.39
Analysis of muscle by region	
Right arm (kg)	2.14 ± 0.65
Left arm (kg)	2.11 ± 0.63
Trunk (kg)	19.34 ± 3.83
Right leg (kg)	7.08 ± 1.50
Left leg (kg)	7.08 ± 1.49

and weight were 160.85 ± 26.7 cm and 59.66 ± 7.77 Kg, respectively. The general characteristics of participants are shown in Table 1.

2.2 Procedures

The isometric maximal muscle strengths of internal rotation for the shoulder were measured in the three groups using Humac Norm Testing and Rehabilitation Systems (Humac Co, U.S.A). The measurement system was calibrated. Isometric torque measurements were taken in the supine position. The dynamometer axis was positioned according to the anatomical rotation axis of the examined shoulder joint. The strengths were performed three times with shoulder abducted 90 degrees, elbow flexed 90 degrees. The subject started maximal isometric muscle contractions on the "start" signal and finished them on the "stop" signal. The duration of a single contraction was 6 seconds. In the control group, the normal daily maximal muscle strengths were measured. In the core stabilization group, the maximal muscle strengths were measured while the contraction of transverses abdominal muscle was monitored by an ultrasonic diagnostic instrument. The measurements were made using the Valsalva maneuver in the Valsalva maneuver group. All subjects were assigned to three groups and the performance order was randomized. The subject rested 30 minutes between the performances.

2.3 Statistical Analysis

All the measured values were statistically processed using SPSS 18.0 for Windows. For the analysis, one-way

ANOVA was used, and Scheffe's method was used for post-hoc test. The significance level for all the statistical analyses was set at $p < 0.05$.

3. Results

Subjects performed maximum voluntary isometric contractions of shoulder internal rotation with three conditions (control, core stabilization, Valsalva maneuver). The dominant arm was the right arm for all of 33 participants. The comparison of the maximal muscle strengths is shown in Table 2. As a result, significant differences were shown among groups (the control group; 13.06 ± 8.22 , the core stabilization group; 10.27 ± 7.06 , the Valsalva maneuver group; 16.39 ± 9.09). In the post-hoc test, a significant difference was observed between the core stabilization group and the Valsalva maneuver group (Figure 1).

Table 2. Maximum muscular strength between the group unit: Nm/kg

Group	Maximum muscular strength	F
Control group	13.06 ± 8.22	1.431
Core stabilization group	10.27 ± 7.06	1.229*
Valsalva maneuver group	16.39 ± 9.09	1.583*

Values indicate mean $\pm$ standard deviation. * $p < 0.05$.

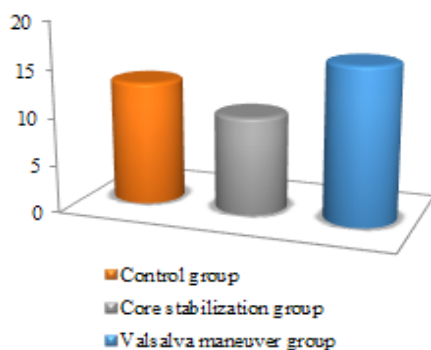


Figure 1. Post-hoc comparison result, unit: Nm/kg.

4. Discussion and Conclusion

This study investigated the effects of the core contraction and the Valsalva maneuver on the isometric maximal

muscle strengths at the internal rotation of a shoulder. There were significant differences among the control group (13.06 ± 8.22), the core stabilization group (10.27 ± 7.06) and the Valsalva maneuver group (16.39 ± 9.09). The core muscles can be described including the abdominals in the front, paraspinals and glutes in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom¹⁶. The function of core muscle was the kinetic link that facilitated the transfer of torques and angular momentum between the lower and upper extremities⁶. Previous studies used various experimental approaches regarding the core stabilization. These studies indicated significant relationships between variables of core muscle strength, sprint, throw, and jump performance in young healthy individuals^{17,18}. They suggested that core strength training might have the potential to improve core muscle strength as well as health-related (i.e., strength, flexibility) and skill-related (i.e., balance, coordination, speed) components of physical fitness in youth¹⁹. Teyhen et al. Measured changes in muscle thickness of transverse abdominal and external oblique muscles during the core stabilization. In their experiment, 120 normal people were divided into the 3 groups (18–30 years, 31–40 years and 41–50 years) by age, and the changes were compared by measuring them with ultrasonic diagnostic apparatus. As a result, the thickness of transverse abdominal muscle was increased and it was verified that the age-dependent difference did not exist²².

The Valsalva maneuver is the optimal breathing pattern for producing maximal force. Sato et al. investigated an effect of 4 types of respiratory conditions (normal breathing, forced expiration, forced inspiration and Valsalva maneuver) on the maximal muscular strength of the isometric contraction of large muscles. The maximal strength was no difference during the forced inspiration condition. By contrast, the maximal muscular strength was increased in the isometric contraction of all muscles in case of the Valsalva maneuver. They reported that the breathing condition imposed a significant effect on the maximal isometric strength. It was identified that the Valsalva maneuver was the optimal respiratory condition to generate the maximal muscular strength²³. Findley et al. suggested that the Valsalva maneuver increased the pressure in the abdominal and chest cavities, and improved the stability of the trunk. In addition, it was suggested that the Valsalva maneuver provided additional muscle tension, which improved the power production of the proximal and limb muscles²⁴. Accordingly in this study, the highest maximal

muscular strength was observed also during the Valsalva maneuver, and a significant difference was observed in comparison with the core contraction group. Granacher et al. reported that improvements in measures of flexibility, coordination, and balance following core strength training in youths¹⁹. With reference to the literature^{20,21}, core strength training appeared to be a well-suited conditioning program for the promotion of health-related and skill-related physical fitness in youth. These studies suggested that the positive effects of core strength training on physical performance of the lower extremities could most likely be explained by the specific role of the trunk as a linkage between upper and lower extremities. Yu et al. divided normal people into the control group and the core stabilization group, and allowed only the core stabilization group to perform Pilate's workout for the core stabilization. The isokinetic muscular strength and balance for lower limbs were measured after 8 weeks. It was found that the muscular strength and the postural stability for the core stabilization group were increased²⁵. They reported that it was able to be considered to result in improvements in the ability to perform a single movement. However, it was considered that such improvements were not observed in our study since the isometric muscular strength was measured. By contrast, Ikeda et al. investigated an effect of the core muscles on improvements in the exercise capacity, and performed an experiment on 28 normal people for 6 weeks. The core stability exercise affected performance ability of gait, while the muscular strength in lower limbs was not affected. The improvement of the performance ability might be seen as a psychological placebo effect in the participants of the core stabilization group who did workout. Thus, it was necessary to analyze whether the core stabilization improved movements and stability levels on the basis of the balance test¹⁵. Although the study of Ikeda et al. was different from our study in that the muscular strength and stability in lower limbs was measured, it was significant that the core stabilization had no effect on the muscular strength.

Schumacher et al. had tested the dual-task effect on healthy adults. The concentration on the task was reduced when there were no overlapping conditions between the task conditions. They suggested that the dual task interfered with the experiment²⁶. Based on this mechanism, this study conducted the dual task of measuring the strength of the upper limbs while the core was contracted. In this case, there were no overlapping conditions between the core contraction and the measurement of muscle

strength. Therefore, it was likely that the concentration of the participants on the task might reduce and this lead to a disturbance in the experiment. In particular, the Valsalva maneuver was commonly used when people exercise or wanted to exert the maximal muscular strength, and thus it was considered that the participants had already learned of it. However, the core contraction was not familiar to the participants, which made the measurement of the muscle strength difficult while the contraction was maintained. Therefore, it was considered that the loss of concentration would be more significant. Ivancic et al. suggested that wearing corset or belt increased the stability of the trunk²⁷. Arjmand et al. reported that the activation of the entire abdominal muscles reduced the weight load along with the abdominal pressure, and contributed to the body stabilization²⁸. Grillner et al. argued that the abdominal pressure contributed to the strength and stability of the trunk²⁹. The study showed higher abdominal pressure in the Valsalva maneuver group that used more muscles by contracting them than the core stabilization group did. Thus, it was considered that an increase in the rigidity and stability of the trunk had an effect on the maximal strength. To the best of our knowledge, there is only one study that investigated the influence of abdominal muscles on shoulder isometric muscular strength with various conditions. This study demonstrated that the maximal strength in the Valsalva maneuver group increased in comparison with the core contraction group because of stability of the trunk such as the loss of concentration and lower abdominal pressure for core stabilization group.

5. Conclusion

In conclusion, this study proved the decrease in the maximal muscle strength in the core stabilization group and the increase in the maximal muscle strength in the Valsalva maneuver group. The Valsalva maneuver was beneficial for the temporary improvement in the maximal muscle strength while the Valsalva maneuver has been reported to have negative impacts on the cardiovascular system such as the increase in blood pressure and heart rate^{30,31}. Because a Valsalva maneuver is associated with blood pressure and heart rate fluctuations related to blood flow changes and blood vessels constriction and re-expansion, which could cause the mobilization of venous thrombi, bleeding, ventricular arrhythmias, and a systole, it may be contraindicated for the patients with severe coronary artery disease, acute myocardial infarction, or

moderate to severe hypovolemia^{32–34}. Therefore, it was not recommended for those who intended to train for muscle strength or who had particularly higher systemic blood pressure. The core stabilization was more useful for the long-term training for muscle strength. Limitation of this experiment was that the core muscle contraction training period was short. Therefore, the subjects were insufficient core stabilization training. Further studies involving long-term core stabilization are warranted.

6. References

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