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Abdominal Muscle Activity during Warm-up (Head to Toe) Exercise Compared to Tongue-stretching Exercise

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Warming up 운동과 Tongue-stretching 운동 시 복근 활성도의 비교

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<Abstract>

연구의 목적 : 건강한 20대 성인 남녀에게 복부 강화 운동의 하나인 warm-up (head to toe)와 tongue-stretching 운동 시 복근의 근 활성도를 비교하는데 연구의 목적이 있다.

연구의 방법 : 본 연구는 12명의 건강한 20대 성인 남녀(남 5, 여 7)를 대상으로 하였으며, 평균 연령은 26세이다. 연구의 대상자는 복근에 sEMG 도자를 부착하여 두 운동 적용 시 복부 근활성도에 대한 남녀의 차이와 개별 운동 시 각 근육간의 근활성도 차이를 SPSS 13.0을 이용하여 분석하였으며, 두 운동 적용 시 global 근육과 local 근육간의 비율을 1이라 가정하고 기여도를 측정하였다.

연구의 결과 : 연구의 결과는 다음과 같다. 1) 두 운동을 적용 시 남녀의 차이는 없었다. 2) 두 운동 적용 시 각 근육간 근활성도 차이는 보이지 않았으나, 배속빗근(internal oblique)는 차이를 보였다. 3) 두 운동 적용 시 global 근육과 local 근육간의 비율은 배곧은근(rectus abdominis)과 배속빗근과의 비율은 3으로 배속빗근이 배곧은근의 근활성도 보다 컸음을 보였으며, 배바깥빗근(exernal oblique)과 배속빗근과의 비율은 약 1.5로 배속빗근의 활성도가 컸다.

연구의 결론 : 복부 강화 운동의 하나인 warm-up과 tongue-stretching 운동을 적용 시 복근의 활성도를 비교한 결과에서 보여주듯이 local 근육 강화 운동 시 두 운동의 효과를 향후 분석하여 요통환자와 같이 복부 강화가 필요한 환자의 프로그램에 적용되어져 할 것이다.

Key Words : 근활성, 복근운동, sEMG

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Ⅰ. Introduction

Abdominal training is a popular aspect of any fitness program (Norris, 1999). Especially, strengthening exercises for the abdominal muscles are frequently used in the treatment of lower-back pain (LBP). The question of which abdominal muscles and exercises should be targeted in the treatment of low-back pain, however, is a subject of intense debate among clinicians. Popular training programs for the abdominal muscles tend to emphasize strength, but one of the most important functions of the abdominal muscles is to stabilize the spine (Norris, 1995).

Due to their anatomical, biomechanical, and physiological features, muscles may be categorized into two groups: the stabilisors and the mobilisors (Richardson et al., 1992). Moreover, Bergmark (1989) classified the muscles acting on the lumbosacral spine as either "local" or "global." It is hypothesized that the local muscles, such as the transverse abdominus (TrA) and internal oblique (IO) muscles, are essential for the stabilization of the lumbosacral spine (Saal, 1992). The global muscles, including the rectus abdominis (RA) and external oblique (EO) muscles, are responsible for producing gross movements of the trunk and pelvis (Norris, 1993).

The IO has a similar fiber orientation to the TrA yet receives much less attention with regard to its creation of hoop stresses. Together, the IO, EO, and TrA increase the intra-abdominal pressure from the hoop made via the thoracolumbar fascia, thus imparting functional stability of the lumbar spine (McGill, 2002). The EO, the largest and most superficial abdominal muscle, checks anterior pelvic tilt and acts eccentrically in lumbar extension and torsion (Proterfield and DeRosa, 1998). Finally, the RA is a paired, strap-like muscle of the anterior abdominal wall. Its contraction predominantly causes flexion of the lumbar spine.

Abdominal-muscle exercises are important more than just for trunk strengthening. In fact, in patients with LBP, the motor relearning of the inhibited muscles may be more important than strengthening. Muscle endurance appears to be more important than pure muscle strength (Taimela et al., 1999). The progressive resistance strengthening of some core muscles (involving the abdominal and back muscles), however, particularly the lumbar extensors, may be unsafe for the back. In fact, many traditional back-strengthening exercises may also be unsafe. For example, Roman chair exercises or back-extensor-strengthening machines require at least the torso mass as resistance, a load that is often injurious to the lumbar spine (McGill, 2002). Traditional sit-ups are also unsafe because they cause increased compression loads on the lumbar spine (Juker et al., 1998). These traditional exercises are nonfunctional (McGill, 2002). In individuals who are suspected to have instability, stretching exercises should be used with caution, particularly those encouraging end range lumbar flexion.

The risk of lumbar injury is greatly increased when the spine is amply flexed and when it undergoes excessive repetitive torsion (Farfan et al., 1970). Exercise must progress from training isolated muscles to training as an integrated unit to facilitate functional activity (Akuthota and Nadler, 2004).

The work conducted by these researchers, which involved implanting intramuscular electrodes into the components of the abdominal wall, supported the impression that the RA muscle is recruited primarily to create trunk flexion, whereas the obliques are recruited for a variety of reasons [e.g., to enhance spine stability (Cholewicki and McGill, 1996), to assist challenged breathing during exercise or due to disease (McGill et al., 1995), and to generate lateral bending and twisting torques (Juker et al., 1998)].

EMG, when measured by surface electrode above an active muscle, represents an interference pattern that sums up the activities of the underlying muscle fibers (Petrofsky and Lind, 1980). The amplitude of the surface EMG is generally related to the tension developed in the muscle (Petrofsky and Laymon, 2005). Therefore, EMG has been proven to be a useful measure in assessing both the extent of muscle activity and muscle fatigue (Petrofsky and Laymon, 2005).

EMG was used in this study to quantify the abdominal-muscle activity during warm-up (head to toe) exercise vs. tongue-stretching exercise to understand the magnitude of muscle use associated with abdominal strengthening.

The purpose of this study, which was pursued through two abdominal exercises, was to evaluate the activity of the abdominal muscles. In other words, the strengthening of the abdominal muscles during the exercises suited to the focus was evaluated.

Ⅱ. Methods

1. Subjects

The study involved 12 healthy young subjects (5 males, 7 females) recruited from among university students. The exclusion criteria were that the subjects should not have any past or present neurologic, musculoskeletal, or cardiopulmonary disease and should not be experiencing pain in the lumbar-spine region while doing mat exercises. All the subjects gave their informed consent after being told of the purpose and method of the study. The subjects had a mean age of 24.25±0.51 years, a mean height of 169.83±7.0 cm, and a mean weight of 64.67±11.21 kg.

2. Instrumentation

A single-channel sEMG recording was obtained with an sEMG stand-alone differential surface electrode (Del-Sys, Trigno^{TM} Wireless) placed on the upper-rectus abdominal (URA), lower-rectus abdominal (LRA), IO, and EO muscles.

sEMG signals were recorded from eight different abdominal sites on the right and left sides of the body: the URA muscle (approximately 3 cm lateral and 5 cm upper to the umbilicus), the LRA muscle (approximately 3 cm lateral and 5 cm inferior to the umbilicus), the EO muscle (approximately 15 cm lateral to the umbilicus), and the IO muscle (halfway between the anterior superior iliac spine of the pelvis and the midline, just superior to the inguinal ligament).

The recording of the raw sEMG signals took place at a frequency of 2000 Hz, via eight channels, and the sEMG data were normalized by determining the signal amplitude percentage of the reference voluntary contraction (RVC) (Pirkko et al., 2005). Each exercise and muscle was represented by the mean value of three times for 5 sec per subject. These EMG was analyzed as sEMG amplitude using the pertinent computer software (Delsys, EMGworks Signal Acquisition and Analysis Software) (McCue and Guinan, 1994).

3. % reference voluntary contraction; %RVC

The root mean square (RMS) EMG amplitude was calculated for 3s at baseline and for 5s during the maneuver. The reference voluntary contraction was performed as an alternative task for sEMG normalization and involved the elevation of both legs so that the heels were 5 cm from the supporting surface (Urquhart et al., 2005).

During RVC testing, the subjects were instructed to push with a maximal effort for five seconds. There was a 30s rest period between each RVC trial and 1 min rest period between RVC testing for each muscle group.

sEMG activity was recorded for each muscle as subjects performed the reference voluntary contraction (RVC). The average RVC was used to normalize the EMG values recorded during the two exercises. and EMG data during two exercises were expressed as a percentage of RVC (%RVC).

4. Exercise Sessions

1) Warm-up exercise

Tuck down your head and keep your shoulders close to the mat. Clear your throat to pull your chest towards your spine.

Move your feet and lean your pelvis toward the belly button and with your legs straightened. Hold this position for 7 seconds (Figure. 1) (Brill, 2001).

2) Tongue stretching exercise

While lying on your back, flex the knees to an angle of 90 degrees, and put your hands on your stomach. While in this position, stick your tongue out as far as possible toward the lower lip. At the same time, try to look backward and upward as much as possible but with your head fixed in one position. Hold this position for 7 seconds (Figure. 2) (Brill, 2001).

5. Statistical analysis

SPSS version 13 was used for data analysis. The intraclass correlation coefficient (Rankin and Stokes, 1998) was calculated to assess the reliability of the measurement between the three trials for each exercise. The Mann-Whitney U test and paired t

Fig 1. Warm-up exercise

Fig 2. Tongue stretching exercise

Table 1. Comparison of the muscle activity during the warm-up (head to toe) exercise by the males and females

(Unit: %RVC)

	Warm-up (Head to Toe)							
Muscle	URA		LRA		EO		IO	
Muscle	Right	Left	Right	Left	Right	Left	Right	Left
Males (n = 5)	51±39.34[a]	20.9±20.44	75.95±63.11	116.09±68.30	74.06±47.57	84.32±36.33	92.74±75.12	163.63±61.40
Females (n = 7)	27.04±15.46	36.53±20.44	41.24±8.05	38.64±9.36	46.23±23.16	83.77±27.20	77.93±26.11	118.28±97.31
U-value	-.89	-1.54	-1.21	-1.21	-1.54	-.08	1.24	-1.06

[a]MEa±SD.

URA (upper rectus abdominis), LRA (lower rectus abdominis), EO (external oblique), IO (internal oblique) test were used for muscle activation. The significance level of the study was set at α=.05. Descriptive statistics showed the relative abdominal-muscle activity ratio.

Ⅲ. Results

Table 2 and 3 show the RMS amplitude results expressed as a percentage of RVC. For the IO, the activation at the top of the two exercises was the greatest. This activity did not differ significantly between the males and females (Table 1, 2).

As for the IO, the activation at the top of the two exercises was the greatest, but this activity did not differ significantly between muscles (Table 3).

To emphasize the relation between the so-called "local segmental stabilizing muscle" and the "global torque-producing muscles," the relative activities were expressed as ratios. The mean ratios are presented in Figure 3.

In general, the ratio of the local to the global muscle activity was about 1 (Stevens et al., 2006). The IO/RA ratio was much higher than 1 during the two exercises (about 2.5 in the warm-up exercise and about 3.0 in the tongue-stretching exercise). The IO/EO ratio was higher than 1 during the two exercises (about 1.5 in the warm-up exercise and about 2 in the tongue-stretching exercise). During

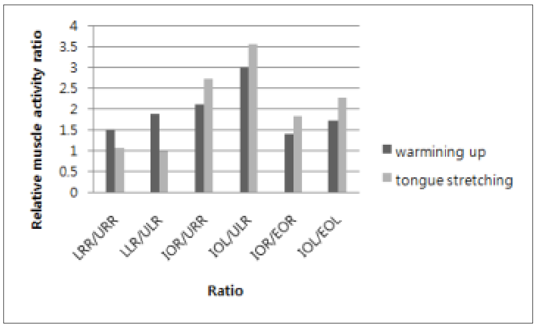

Fig 4. Mean ratios of relative local muscle activity to relative global abdominal muscle activity during the warming up and tongue stretching exercise. LRR=lower right ractus abdominis, URR=upper right ractus abdominis, LLR=lower left ractus abdominis, ULR=upper left ractus abdominis, IOL=internal oblique left, IOR=internal oblique right, EOR=external oblique right, EOL=external oblique left.

Table 2. Comparison of the muscle activity during the tongue-stretching exercise by the males and females

(Unit: %RVC)

	Tongue Stretching							
Muscle	URA		LRA		EO		IO	
Muscle	Right	Left	Right	Left	Right	Left	Right	Left
Males (n = 5)	51.09±27.70	60.30±29.89	47.91±18.07	59.67±33.43	64.41±27.30	83.29±28.73	138.14±59.79	218.78±132.68
Females (n = 7)	30.05±21.23	43.50±27.26	38.89±6.22	41.11±12.50	61.15±59.29	84.80±30.12	81.58±22.81	148.03±119.98
U-value	-.89	-1.22	-1.54	-1.22	-1.06	-.08	-.08	-.73

[a]MEa±SD.

Table 3. Comparison of the normalized sEMG data of each muscle during each exercise

(Unit: %RVC)

Muscle	URA		LRA		EO		IO	
Muscle	Right	Left	Right	Left	Right	Left	Right	Left
Warm-up	41.02±32.92	48.32±22.33	61.49±50.16	89.82±30.66	62.46±40.43	84.09±31.45	86.57±58.17	144.74±77.75
Tongue stretching	42.32±26.42	53.30±28.85	44.15±14.62	51.94±27.53	63.05±41.08	83.92±27.97	114.57±60.33	189.3±127.14
t value	-.26	-1.13	1.33	.93	-.06	.04	-1.21	-1.89

[a]MEa±SD.

the warm-up exercise, the right/left RA was higher than 1, but during the tongue-stretching exercise, it was about 1 (Figure 3).

Ⅳ. Discussion

In this study, the activation levels of the muscles of the lumbopelvic region during the performance of warm-up (head to toe) and tongue-stretching exercises were compared. The relations between the EO, IO, URA, and LRA were also examined by comparing their relative activity levels.

Core exercise was recently introduced in physical therapy to promote rehabilitation programs focusing on lumbar stabilization. The exercise develops the trunk and strengthens the extremities (Hodges and Richardson, 1996). The most basic principle of this training is core strengthening. The “core” has been described as a box with the abdominals in the anterior part, the paraspinals and gluteals in the posterior part, the diaphragm as the roof, and the pelvic floor and hip muscles as the bottom. These are situated at the centre of the human body and are referred to as the “powerhouse” (Richardson et al., 1999). The increased muscle strength of the “powerhouse” may prevent injury of the spine and enables the core to serve as a muscular corset that works as a unit that stabilizes the body and spine with and without limb movement (Akuthota and Nadler, 2004; Willson et al., 2005).

Previous studies on abdominal muscle activity could be classified into three types. The first type focuses on stability on the ground, the second focuses on the degree of strength, and the third on the use of tools, such as a Swiss Ball (Behn et al, 2005; Behn et al, 2002). More recent studies were performed on abdominal muscle activity in relation to exercises such as yoga and Pilates (Petrofsky et al, 2005; Kim et al, 2007; Queiroz et al, 2010). However, studies on abdominal muscle activity in relation with basic movements such as warm-up exercise and tongue stretching are rare. All of these studies emphasize on the importance of strengthening the local abdominal muscle in particular, isolating it from the other abdominal muscles.

Studies on abdominal muscle activity focusing on ground stability showed that elbow-toe exercises on unstable surface revealed significant differences in activity between trunk muscles (Atsushi et al, 2010). Besides, exercises using a Swiss Ball on unstable surface revealed significant differences between RA and EO, but not between IO and TrA (Lehman et al, 2005). However, studies conducted by Atsushi et al revealed differences between ES (erector spinae) and MF (multifidi). In this study, the IO muscle activity showed significant differences, while the differences in other muscles such as the upper and lower RA and EO were insignificant.

A study that compared yoga breathing exercises and abdominal crunches revealed that breathing exercises had muscle activity that utilized 41% of MVCI. The study also determined that breathing exercises are more significant and effective than abdominal crunches (Petrofsky et al, 2005). Particularly, it is significantly different from that of the oblique muscle.

In this study in which tongue stretching exercise was performed in relation with breathing, the differences were greater in the IO muscle. Moreover, when trunk muscle activities were compared during trunk flexion and extension after Pilates exercises, significant differences were identified in the multifidus, gluteus maximus, RA, EA, and IO, but not in the iliocostalis. (Herrington and Davies, 2005)

In addition, upon comparing muscle activity in the abdominal muscles in the two exercises related with breathing, it was observed that there was greater activity in the lower RA than in the upper RA, and in IO than in EO.

This indicates that both warm-up exercises and tongue stretching are involved in strengthening the lower trunk in terms of abdominal muscle activity. There were only 12 subjects in this study, and so the results could not directly be applied to patients of different ages and genders, and those with backache. Further studies with greater number of subjects of wider range of ages should be performed in relation with abdominal muscle activity.

Ⅴ. Conclusions

In this study, the sEMG activities of the abdominal muscles during warm-up exercise were compared to those during tongue-stretching exercise. It was found that after these exercises, the muscle activities of the IO, EO, URA, and LRA muscles significantly increased, but the muscle activity was unrelated to gender. Further studies are needed to search for scientific evidence for and for the foundation of the changes in the muscle activity on account of abdominal exercises.

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