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Different Myoelectric Behavior of the Erector Spinae in Flexion and Reextension During Trunk Foward Bending

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Trunk forward bending plays a role in development of low back pain. However, a relationship between the bending kinematics and electromyographic (EMG) activity of the erector spinae is not well understood. We studied trunk flexion and reextension during this motion to determine EMG activity of these muscles in relation to kinematics by using surface EMG and an electromagnetic tracking device in 15 healthy young adults. The EMG profile exhibited two asymmetric bursts interrupted by a period of a low level that occurred near full flexion. Mean peak amplitude of reextension was larger by 70% than that of flexion. Angular orientation of T 12 and S 2 segments showed that the EMG reached to the peak at mid-range of flexion with a few degrees of lumbar lordosis. In contrast, the peak EMG in reextension was attained immediately after lumbar extension was initiated in a more flexed position with, presumably, a high degree of bending moment. These results of the angle-EMG relationship of reextension, with a sudden increase of the high EMG activity of the muscles, may offer a possibility that the reextension position is at a risk of back injuries such as lumbar disc herniation.

Key Words

Erector spinae,
Electromyography,
Lumbar spine,
Kinesiology.

Introduction

Surface electromyography (EMG) is an electric signal of muscles collected on the overlying skin and provides good information of activity of superficial muscles[1]. It is widely used to asssess muscle functions in various situations of sports and rehabilitaiton medicine.

The extensor muscles of the back function in a checkrein fashion[2]. One of the best examples is trunk forward bending, in which the erector spinae resist the gravity acting on the upper body. Previous EMG studies on activity of these muscles revealed flexion-relaxation during this motion[3-8]. It is a myoelectric silence or a decrease in activity near full flexion through yet unknown mechanism. In weight lifting, relaxation of these muscles could lead to failure of the spinal structures such as the posterior ligaments, intervertebral joint capsules or discs because stability of the spine is largely dependent on these stuructures at this position[3]. Another important point in the light of bending- or lifting-associated back injury is that the compressive force exerted by the muscles and the

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bending stress can damage the discs[9]. It is, thus, important to understand the flexion position at the time of peak EMG activity during trunk forward bending with respect to possible injuries of the back. However, a relationship between the flexion angle and EMG activity is poorly understood in dynamic conditions when bending forward.

There were two purposes of this study; we examined a sequential pattern of EMG activity of the erector spinae in flexion and reextension cycles of trunk forward bending in healthy young adults. The second was to determine the flexion position of the pelvis and lumbar spine when the peak EMG activity was attained in flexion and reextension.

Materials and Methods

Data were acquired from a part of the subjects of a previous study[10]. Fifteen normal subjects (10 men and 5 women) ranged in age from 20–28 years (mean, 21.8 ± 0.3 years); in height from 150–180 cm (mean, 164.7 ± 3.6 cm); in body weight from 45–83 kg (mean, 60.8 ± 2.5 kg). All subjects were informed of the purpose and safety of an experiment before participation in the study.

Subjects were guided to perform the experimental task of natural forward bending to full flexion with the knees extended. They returned to an upright position after 1 or 2 seconds of rest at bent position. The feet were kept slightly apart (10–20 cm) during the motion.

An electromagnetic tracking device (3 SPACE FASTRAK, Polhemus Navigation, Colchester, VT, USA) was used to monitor lumbar and pelvic motion. Sensors were placed over the spinous processes of T 12 (sensor 1) and S 2 (sensor 2) with double-sided adhesive tape and elastic adhesive bandage. A rate of the data sampling was 60 Hz with two sensors used.

EMG activity of the erector spinae was recorded with surface EMG (ME 3000 P, Mega Electronics Ltd., Kuopio, Finland) at a sampling rate of 1,000 Hz with a frequency band of 20–500 Hz. Disposable electrodes (Blue Sensor, Medicotest, Olstykke, Denmark) were placed over the right side of the muscle belly at the L 2–L 3 level. The EMG signal was amplified and digitized, then transferred to a personal computer (Dynabook Tecra, Toshiba Co. Ltd., Tokyo) for further processing.

The EMG signal was digitally smoothed to 125 Hz and rectified. Because the motion varied in length from one subject to another, cycle duration was normalized such that flexion and reextension represented from 0% to 100%. Mean rectified signal was calculated for each 10% interval of flexion and reextension. Simultaneous measurements of kinematics and EMG enabled to determine angular orienteation of the sensors that was read at a mid-point of the interval when the peak EMG value was attained. Percentage range of motion (ROM) represented from 0% (standing) to 100% (full flexion).

Results

Mean EMG activity of the erector spinae changed over flexion and reextension cycles (Figure 1). The activity was very low and almost absent while standing position was maintained and then increased almost linealy as flexion advanced and reached to the peak at 80% of flexion cylce. There was a sudden and sharp decrease toward full flexion

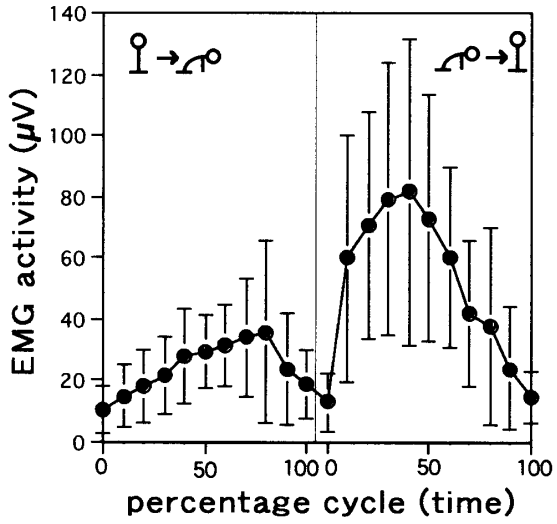

Figure 1. Electromyographic activation pattern of erector spinae in flexion and reextension cycles of trunk forward bending.
Mean EMG activity in 15 normal subjects were plotted against percentage cycle of flexion (left half) and reextension (right half) with standard deviation.

thereafter and the activity reached closely to the baseline level. When reextension was initiated, the EMG rose suddenly and reached to the peak at 40% of reextension cycle. It then gradually decreased to the baseline level as the motion progressed to the end.

The peak EMG value in flexion was compared with that in reextension for each subject. A mean of the peak value in reextension (106.9 ± 48.1 μV) was significantly larger by 70% than that in flexion (63.6 ± 48.0 μV) (paired *t*–test, P <0.01).

Mean angle of the sensors at the peak EMG activity was expressed as a shift from an initial angle and summarized for both flexion and reextension in Table 1. Mean values of sensors 1, 2 and sensors 1–2 of flexion were all significantly lower than those of reextension (flexion ; 58 ± 17, 24 ± 16 and 34 ± 10 vs. reextension ; 86 ± 14, 33 ± 11 and 53 ± 11, respectively, paired *t*–test, P<0.001). Percentage ROM of the sensor angles in flexon ranged from 40% (S 2) to 58% (lumbar), lying in mid–range. In reextension, percentage ROM varied more from 59% (S 2) to 90% (lumbar).

For better presentation of the sensor angles described above, Figure 2 illustrated schematic angular orientation of the two sensors at the peak EMG activity as seen from the right side of a subject. T 12 and S 2 sensors in flexion were almost parallel (dotted line). The two sensors of reextension were more flexed than those of flexion, indicating that the peak EMG was attained early in reextetnsion (broken line). Another different finding from flexion is that S 2 sensor rotated more from full flexion than T 12 sensor, thereby creating only 10% (6 degrees) change of the lumbar angle

Table 1. Mean range of motion (ROM) of sensors and mean sensor angles at the time of peak EMG activity of the erector spinae in flexion and reextension.

sensor	ROM degrees (%)	angle at peak EMG activity degrees (%ROM)	
		flexion	reextension
sens1 (T12)	114 ± 13 (100)	58 ± 17 (50) ◀— * —▶	86 ± 14 (76)
sens2 (S2)	55 ± 13 (100)	24 ± 16 (40) ◀— * —▶	33 ± 11 (59)
sens1-2 (Lumbar)	59 ± 13 (100)	34 ± 10 (58) ◀— * —▶	53 ± 11 (90)

Angle values were expressed as degrees of change from standing position. *P < 0.001 (paired *t*–test). Values in brackets represent percentage range of motion.

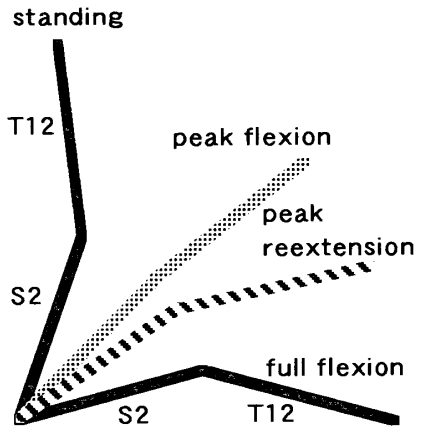

Figure 2. Scheme illustrating orientation of the mean angles of T 12 and S 2 sensors at peak EMG in flexion and reextension.
The scheme represents sensors as seen from the right seide of a subject. peak flexion (dotted line) = flexion position at peak EMG activity, peak reextension (broken line) = reextension position at peak EMG activity.

from full flexion (Table 1).

Discussion

Trunk forward bending and weight lifting consist of coordinated motion of the pelvis and lumbar spine[10, 11] and are associated with development of low back pain and disc herniation[12, 13]. The erector spinae play an important role in this cyclic motion. Although the muscles function primarily in a concentric fashion as the extensors of the spine, they contract in an eccentric fashion and are lengthend in flexion. Different contraction behavior of flexion and reextension is well reflected in the EMG profiles in Figure 1 and in the mean values of the peak EMG activity described in the results. The mean peak amplitude in reextension was larger and attained earlier than that in flexion. Previous studies by others also demonstrated different activation profiles of flexion and reextension where larger peak EMG activity of reextension[6, 8] and different timing of peak EMG[15] were described. These different peak EMG activities can be explained, at least partly, by the gravity acting on the upper trunk as bending moment during the motion. Trunk flexion is accomplished in the same direction of the gravity whereas reextension in the opposite direction that would require more activity.

Many investigators reported flexion–relaxation of the erector spinae during trunk forward bending[3–8]. There is still a controversy concerning a definition of this phenomenon. Some stated a silence of the electric signal[3, 4] while others did a decrease, but not abolition, in the activity[5–8]. We agreed with the latter observation. All subjects in this study exhibited varying degrees of a decrease, but never a silence or an absence at full flexion. Some hypotheses to explain how relaxation occurs have been proposed. In flexion, activity of the extensor muscles would be determined by a relationship between an increasing bending moment by the gravity and tension of the posterior ligaments acting as an extensor moment. It seems likely that the increasing ligamentous tension through stretching unloads the muscles beyond a certain point. Although there was no supporting evidence that the point represented the time at the peak EMG, it was interesting that T 12 and S 2 sensors were almost parallel in Figure 2. This finding probably suggested that lumbar lordosis was of minute degrees at the time of the peak EMG with significant ligamentous tension. With video analyser, Tanii and Masuda demonstrated that, in flexion, a sudden decrease in the EMG activity was seen when the angle of trunk flexion coincided with the pel-

vic inclination[15]. Their different technique of measurement made it difficult to compare that with our results.

In reextension, angular orientation of the sensors suggested that the peak EMG was attained immediately after the lumbar spine started to extend with only 10% change of lumbar angle from full flexion. Moreover, T 12 was nearly horizontal, presumably having a relatively high degree of bending moment against the extensor moment. These findings appear to have clinical relevance to a flexed posture when compressive and bending stresses potentially damage the intervertebral discs[9] and when intradiscal pressures are increased[16]. Our results may suggest that loading in the high flexed position at the peak EMG during reextension contributes to a cumulative trauma of the discs. In addition, the position may be at a risk of disc herniation particularly for those with disc degeneration.

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