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Research article

AN UNSTABLE BASE ALTERS LIMB AND ABDOMINAL ACTIVATION STRATEGIES DURING THE FLEXION-RELAXATION RESPONSE

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ABSTRACT

The flexion-relaxation phenomenon consisting of an erector spinae silent period occurring with trunk flexion can place considerable stress upon tissues. Since individuals often flex their trunks while unstable, the purpose of the study was to examine the effect of an unstable base on the flexion-relaxation response. Fourteen participants flexed at the hips and back while standing on a stable floor or an unstable dyna-disc. Hip and trunk flexion were repeated four times each with one-minute rest. Electromyographic (EMG) electrodes were placed over the right lumbo-sacral erector spinae (LSES), upper lumbar erector spinae (ULES), lower abdominals (LA), biceps femoris and soleus. In addition to the flexion-relaxation phenomenon of the ES, a quiescence of biceps femoris and a burst of LA EMG activity was observed with the majority of stable trials. There was no effect of instability on the flexion-relaxation phenomenon of the ULES or LSES. The incidence of a biceps femoris silent period while stable was diminished with an unstable base. Similarly, the incidence of a LA EMG burst was curtailed with instability. Soleus EMG activity increased 29.5% with an unstable platform. An unstable base did not significantly affect LSES and ULES EMG flexion-relaxation, but did result in more persistent lower limb and LA activity.

KEY WORDS: Electromyography, erector spinae, hamstrings, trunk flexion.

INTRODUCTION

Chronic and acute back injuries leading to low back pain are endemic to our society. Factors can include poor mechanics such as excessive back or trunk flexion rather than a greater reliance on knee flexion/extension and unexpected perturbations from attempting to lift and maintain balance on unstable surfaces. Protection of the vertebral column during these maneuvers involves a number of components such as skeletal structures [(i.e. articulating facets, intervertebral discs (McGill and Kippers, 1994)], connective tissue [(i.e. ligaments and tendons (Dolan et al., 1994; McGill and Kippers, 1994)] and muscle (Gibbons and Comerford, 2001; Granata and Marras, 1995; Granata and Orishimo, 2001). However, during movements having excessive trunk and back flexion, the active muscular contribution

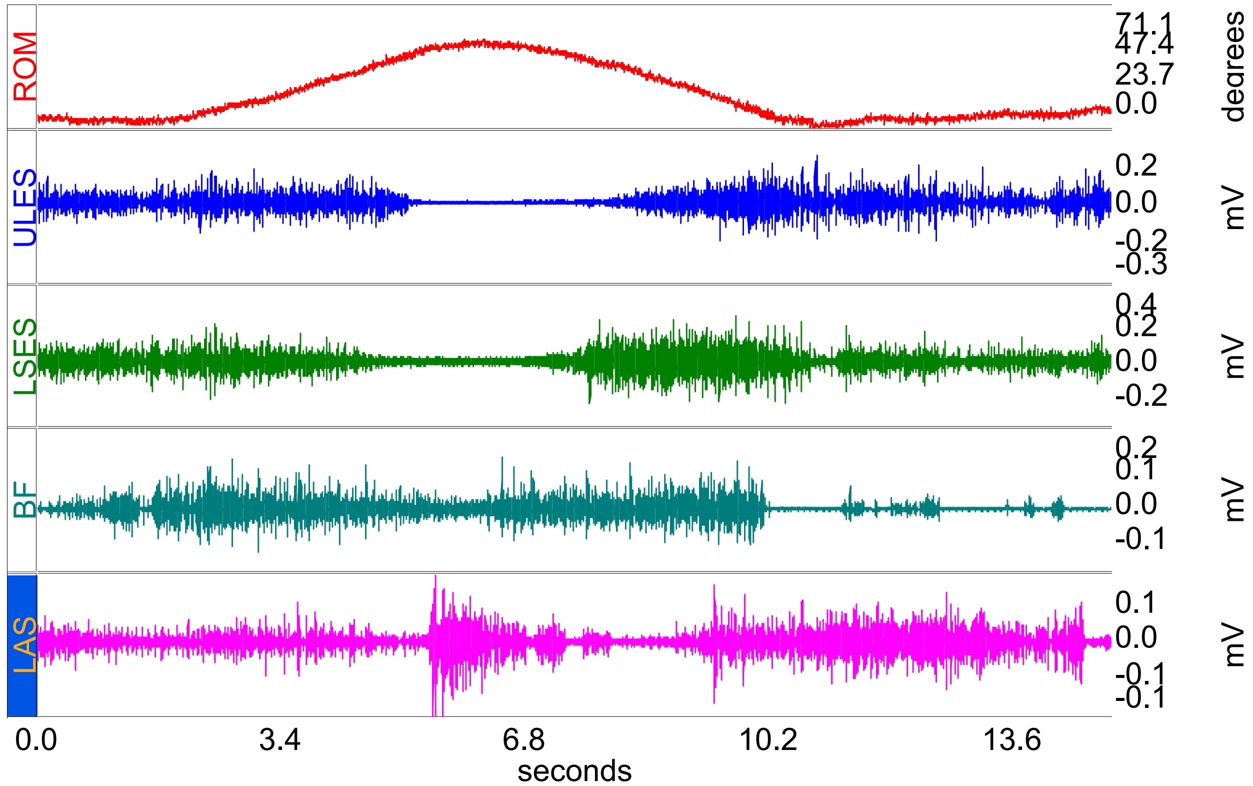

Figure 1. Sample of a flexion-relaxation response with the flexion relaxation response of the ULES (first EMG channel) and LSES (second EMG channel). An example of a lower abdominals (LA) EMG burst is illustrated in the fourth EMG or bottom channel (row).

may be reduced, a phenomenon referred to in the literature as the flexion-relaxation response (Floyd and Silver, 1955; Schultz et al., 1985).

The flexion-relaxation response entails a quiescence of the erector spinae musculature in response to deep trunk and back flexion (Floyd and Silver, 1955; Gupta, 2001; Kippers and Parker, 1984; Schultz et al., 1985) (Figure 1). The movement due to the mass of the trunk segment must then be supported by increased tension from the connective (Dolan et al., 1994; Floyd and Silver, 1955; Gupta, 2001; McGill and Kippers, 1994) and passive muscular (McGill and Kippers, 1994) tissues. It has been suggested that the receptors within the ligaments may determine the erector spinae activity (Kippers and Parker, 1984). Other studies suggest that the increased tension on the intervertebral ligaments allowed for a balance between the trunk extensor moment and connective tissue tensile forces (Kippers and Parker, 1984), while others indicate that the lumbodorsal fascia and non-contractile elements of the erector spinae muscles provide approximately 75% of the passive extensor moment (Dolan et al., 1994). Regardless of the source of the compensatory mechanism, significant vertebral stresses (e.g. compressive loads of 3000 N and anterior shear of 755 N when holding a 8 kg weight (McGill and Kippers, 1994)) must be accommodated by the passive tension of connective and muscular tissue as well as active deep muscles that may be difficult to measure (i.e. quadratus lumborum).

Individuals with chronic low back pain may not demonstrate the flexion-relaxation response (Kaigle et al., 1998). The persistent muscular activity may help to increase the stability of damaged or diseased vertebral structures (Kaigle et al., 1998). Individuals with lumbar instability may experience an “instability catch” or sudden aberrant motions, which contribute to the increased back muscle activity (Paris, 1985). It is unknown whether individuals with healthy backs attempting to maintain balance on an unstable platform would also demonstrate the flexion-relaxation response. Perhaps the flexion-relaxation response would be diminished, similar to the persistent muscular activity of less stable injured backs. A number of studies from this laboratory have reported increased trunk muscle electromyographic (EMG) activity in healthy individuals with activities using unstable bases (Anderson and Behm, 2005; Behm et al., 2005). While it is common for individuals to bend at the hips and back while on an unstable surface (i.e. picking up objects while on snow, ice, sand, wet or other surfaces), there are no studies documenting the effect of an unstable base on the flexion-relaxation response. Due to the precarious nature of lifting activities while on an unstable surface, it would be important to examine the response of the trunk to flexing or lifting while attempting to maintain balance on an unstable platform.

The objective of the study was to compare the effects of stable and unstable bases on the flexion-relaxation response. It was hypothesized that back and abdominal EMG activity would persist, resulting in a delay or inhibition of the flexion-relaxation response. Furthermore, it was hypothesized that limb EMG activity would be increased in response to an unstable base.

METHODS

Participants

Seven male and seven female participants (mean ± SD age = 21.4 ± 0.9 years, height = 1.75 ± 0.07 m, mass = 74.2 ± 16.6 kg) participated in the study. All participants were from a university student population and completed a Physical Activity Readiness Questionnaire (PAR-Q) form (Canadian Society for Exercise Physiology, 2003) to identify any significant health problems. Exclusion criteria included any individual with known acute or chronic back pain. Each subject was required to read and sign a consent form prior to participating in the study. The university's Human Investigations Committee approved the study.

Independent variables

All participants performed a five-minute warm-up on a cycle ergometer at 70 rpm and a resistance of 1 kp (70 Watts). Hip and trunk flexion movements were performed while standing on both stable and unstable surfaces. Stable flexion was conducted while standing on a wood platform over a concrete floor, whereas unstable trunk flexion was performed on a 60 cm diameter, fully inflated (360 kg/cm) rubber disc (Dyna-disc; Fitter International, Calgary, Alberta, Canada). Foot positioning for both conditions was shoulder width apart. An orientation session two days prior to testing allowed participants to become accustomed to the dyna-disc. From a standing erect posture with arms crossed and knees locked in an extended position, participants flexed at the hips and back in order to bend forwards as far as possible along the sagittal plane. The flexion movements were repeated four times each under stable and unstable conditions. Thus, a total of eight actions were conducted with one minute rest between movements. A metronome was used to guide the rhythm of the participants with hip and trunk flexion and extension performed over three second time intervals respectively. Participants paused for 1 second at the limit of their hip-trunk flexion. The order of the testing conditions (1. stable flexion, 2. unstable flexion) was randomly assigned.

Dependent variables

Electromyography: Bipolar surface EMG electrodes were used to measure signals from the lumbo-sacral erector spinae (LSES), upper lumbar erector spinae (ULES), lower abdominals (LA), biceps femoris and soleus muscle groups. General descriptive (i.e. LSES, ULES, LA) rather than specific (i.e. multifidus, longissimus, transversus abdominus, internal obliques) trunk muscle terminology was used in this paper based on the conflicting findings of similar studies. A number of studies have used a similar L5-S1 electrode placement to measure the EMG activity of the multifidus (Danneels et al., 2001; Hermann and Barnes, 2001; Hodges and Richardson, 1996; Ng et al., 1998). In contrast, Stokes et al. (2003) reported that accurate measurement of the multifidus requires intra-muscular electrodes. Thus, the EMG activity detected by these electrodes in the present study is referred to as LSES muscle activity. Erector spinae muscles according to anatomic nomenclature include both superficial (spinalis, longissimus, iliocostalis) and deep (multifidus) vertebral muscles (Jonsson, 1969; Martini, 2001). The ULES EMG electrode positioning was more lateral than the lower back (LSES) EMG positioning in order to diminish the detection of multifidus activity and thus emphasize the measurement of longissimus activity. Additional electrodes were placed superior to the inguinal ligament and medial to the anterior superior iliac spine (ASIS) for the LA. McGill et al. (1996) reported that surface electrodes adequately represent the EMG amplitude of the deep abdominal muscles within a 15% RMS difference. However, Ng et al. (1998) indicated that electrodes placed medial to the ASIS would receive competing signals from the external obliques and transverse abdominus with the internal obliques. Based on these findings, the EMG signals obtained from this abdominal location are described in the present study as the LA, which would be assumed to include EMG information from both the transverse abdominus and internal obliques.

All electrodes were placed collar to collar (approximately 2 cm) on the right side of the body. Skin surfaces for electrode placement were shaved, abraded, and cleansed with alcohol to improve the conductivity of the EMG signal. Electrodes (Kendall ® Medi-trace 100 series, Chikopee, MA) were placed 2 cm lateral to L5-S1 spinous processes for the LSES and 6 cm lateral to the L1-L2 spinous processes for the ULES muscles. Additional electrodes were placed superior to the inguinal ligament and 1 cm medial to the anterior superior iliac spine (ASIS) for the LA. Electrodes for the biceps femoris were placed over the mid-belly of the muscle. Soleus electrodes were placed on the mid-line of the muscle directly below the gastrocnemius-soleus intersection. Ground electrodes were placed along the iliac crest for the LSES, ULES and LA, and on the fibular head and lateral malleolus for the biceps femoris and soleus respectively. EMG activity was sampled at 2000 Hz, with a Blackman -61 dB band-pass filter between 10-500 Hz, amplified (Biopac Systems MEC bi-polar differential 100 amplifier, Santa Barbara, CA., input impedance = 2M , common mode rejection ratio $\geq$ 110 dB min (50/60 Hz), gain x 1000, noise $\geq$ 5 µV), and analog-to-digitally converted (12 bit) and stored on personal computer (Sona, St. John's NL) for further analysis. The EMG signal was rectified and smoothed (10 samples) and the amplitude of the root mean square (RMS) EMG signal was calculated during the flexion-relaxation response of the erector spinae using the AcqKnowledge software program (AcqKnowledge III, Biopac System Inc., Holliston, MA).

LSES and ULES EMG activity was normalized to a back extension maximum voluntary contraction (MVC). Since all exercises were performed in one session and the comparisons were within subject, a normalization procedure would not be necessary. However, this normalization procedure allowed a comparison of the relative activation of the LSES and ULES during the flexion-relaxation response in this study to other similar studies.

Normalization exercises: Subjects were asked to lie prone on a padded table for a maximal exertion back extension exercise. After the investigator palpated the subject's anterior superior iliac spine (ASIS), the subject was positioned so body segments superior to the ASIS extended off the supporting table. The subject's lower body was then secured to the table using three straps located just superior to the ankles, knees and gluteal folds. A strap which encircled the subject's trunk, positioned at the T5 or T6 level maintained the upper body parallel to the floor. A high-tension wire to a metal plate on the floor attached the strap.

Trunk Range of Motion (ROM): Hip and trunk flexion range of motion (ROM) was monitored with an electro-goniometer (Biopac Systems TSD 130B Santa Barbara, CA.). One end of the electro-goniometer was taped at the mid-frontal plane of the trunk at the height of the iliac crest. The other end was taped in the mid-frontal plane of the thigh, distal to the greater trochanter of the femur. The pivot point was placed over the greater trochanter of the femur. The starting or reference position was the erect posture of the participant. The signals were amplified (Biopac Systems MEC 100 amplifier, Santa Barbara, CA.), monitored and directed through an analog-digital converter (Biopac MP100) to be stored on the computer (Sona, St. John's NL). Signals were collected at 2000 Hz, and amplified (1000X). The signal was filtered (1-20 Hz) in order to remove movement artifacts, using the AcqKnowledge software program (AcqKnowledge III, Biopac System Inc., Holliston, MA).

Measurements included the initial hip-trunk angle for the onset of EMG flexion-relaxation as well as the range of hip-trunk angles for flexion-relaxation. The period of EMG quiescence signaling the beginning of the flexion-relaxation response was determined to occur when the RMS EMG signal of the LSES or ULES dropped by more than 60% from the mean recorded activity of the experimental trials for that individual prior to the flexion-relaxation response. Similarly, the end of the flexion-relaxation response was noted when EMG activity reoccurred and returned to at least 60% of the mean recorded activity of the pre-flexion-relaxation response for that individual. These two landmarks provided the onset and duration of the flexion-relaxation response. This cut-off standard was determined by analyzing a representative sample of data from each subject (at least one file each for stable and unstable movements). EMG activity during most of the flexion-relaxation period averaged between baseline values and 20% of maximum EMG activity, which corresponds with other studies (Callaghan and Dunk 2002; Schultz et al. 1985)(see Figures 1-2). LA, biceps femoris and soleus EMG activity reported in the results refers to that activity occurring during the period of erector spinae flexion-relaxation response.

Instability-Induced Motion: A tri-axial accelerometer (Silicon Designs, Issaquah, Washington) was mounted on the dorsal region of the trunk, at the L5/S1 level, along the mid-line of the vertebral column. Thus the accelerations in the medio-lateral, cephalo-caudal and anterior-posterior planes, all defined relative to the subject's trunk segment were measured at a rate of 60Hz. The acceleration-time histories were filtered using a second-order Butterworth routine in order to remove the artifact associated with the flexion-extension movement. These data were then submitted to a fast Fourier transformation in order to determine the power and frequency characteristics of the signal.

Statistical analysis

Measures included the onset and duration (ROM) of the flexion-relaxation period for the LSES, ULES

Table 1. Incidence (% occurrence in all trials) of lower abdominals (LA) EMG burst during the flexion-relaxation response. Each subject performed four trials under stable and unstable base conditions.

	Stable	Unstable
4 / 4 trials	44.4%	0%
2-3 / 4 trials	27.7%	16.6%
0-1 / 4 trials	27.7%	83.3%

and biceps femoris; onset, duration and amplitude of the LA EMG burst (doubling of the RMS EMG amplitude for a minimum duration of 50 ms) and the amplitude of the soleus EMG activity. The onset and duration of the EMG flexion-relaxation response were only analyzed from trials that produced an erector spinae flexion-relaxation response. Similarly, the analysis of the LA EMG burst was only obtained from the trials that illustrated the EMG burst. Trials without a flexion-relaxation response or LA EMG burst were included when describing the incidence of these occurrences.

A two way repeated measures ANOVA (2x2) was used to analyze the data. The data analyzed included the mean scores of each individual from the four attempts of each condition (1. stable base 2. unstable base). Levels included gender, and the extent of stability. F ratios were considered significant at $p < 0.05$. If significant main effects or interactions were present a LSD post hoc analysis (SPSS 11.0.1 for Microsoft Windows) was conducted. Effect sizes (ES) were also calculated and reported (Cohen, 1988). Descriptive statistics included means ± standard deviation (SD).

RESULTS

There were no gender effects associated with the flexion-relaxation response. Thus, all data have been collapsed over gender in the results.

Stability

There were no significant effects of an unstable base on the onset or duration of the flexion-relaxation response of the ULES and LSES. According to the criteria (60% decrease in EMG), two of the fourteen subjects did not exhibit a ULES or LSES flexion-relaxation response under stable or unstable conditions. Thus, their data were not utilized. The mean onset of the flexion-relaxation period with the ULES began at 63.8° ± 11.7 and 64.6° ± 9.4 from the erect standing position for stable and unstable conditions respectively. The ULES flexion-relaxation period persisted for 27.0° ± 9.1 and 20.1° ± 5.2 for stable and unstable conditions respectively. The onset of LSES quiescence averaged 64.8° ± 9.8 and 64.1° ± 6.4 from the erect standing position for stable and unstable conditions respectively. The LSES quiescence continued for 24.6° ± 8.1 and 20.6° ± 5.1 for stable and unstable conditions respectively. There were no significant differences in the onset or duration of the flexion-relaxation period for either muscle or condition. There were also no significant differences in the maximum hip-trunk flexion angles for stable (90.8° ± 8.6) and unstable (89.4° ± 10.2) conditions.

LA: There was within and between subject variability in the LA muscle activation strategies used during the bending activity of the back muscles (Table 1). In some trials, subjects would exhibit continuous LA EMG activity with minor fluctuations in EMG amplitude, while in other trials or subjects there would be a dramatic increase (burst) in the amplitude of the EMG activity corresponding with the quiescent period of the erector spinae (Figure 1). A LA burst was defined as at least a doubling in the RMS EMG amplitude for a minimum duration of 50 ms as compared to the EMG activity during the hip-trunk flexion movement prior to the burst. Table 1 documents the greater incidence of LA EMG burst activity under stable conditions. In 72.1% of the stable trials, participants would display a burst of high amplitude LA EMG activity in two or more of the four trials. In contrast, with an unstable base, the LA burst of EMG activity occurred in two or more of the four trials only 16.6% of the time. When the burst of LA EMG activity did occur under stable conditions, it had a tendency to commence 6.4% ($p = 0.1$) sooner (63.6° ± 8.5 vs. 67.9° ± 5.4 from the erect standing position), possessed a 36.7% ($p = 0.03$; ES = 0.76) greater RMS amplitude (102.7 μV ± 49.4 vs. 64.9 μV ± 33.7) and persisted over a 21.7% ($p = 0.04$; ES = 0.66) greater ROM (17.5° ± 5.7 vs. 13.7° ± 4.1) than with an unstable surface.

Biceps Femoris: There was also variability in the biceps femoris response to the hip-trunk flexion. Whereas in some trials there would be continuous biceps femoris EMG activity (Figure 1), other trials experienced a quiescence of biceps femoris EMG generally corresponding to the flexion-relaxation period of the erector spinae muscles (Figure 2). Although not statistically significant, the mean onset

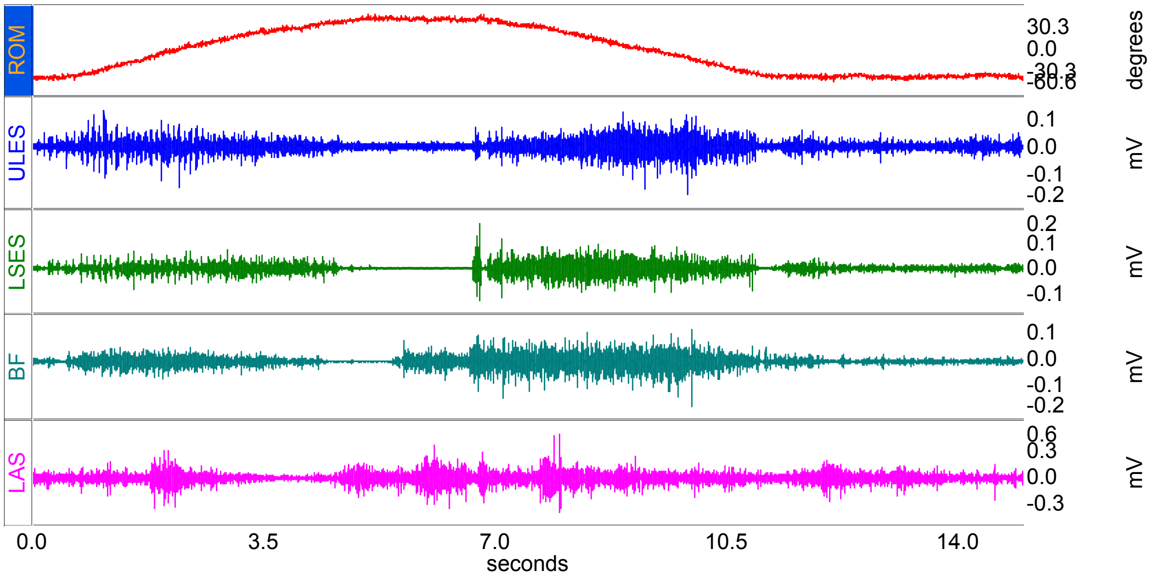

Figure 2. Sample of a biceps femoris quiescent period with the flexion relaxation response of the ULES and LSES on the first and second EMG channels. Biceps femoris (BF) EMG recordings are exhibited in the third EMG channel (row).

of biceps femoris quiescence began earlier (61.4° ± 18.5 from the erect standing position) and continued for a lesser ROM (7.2° ± 4.2) than the erector spinae flexion-relaxation period. Table 2 illustrates the greater incidence of biceps femoris quiescence under stable conditions. With stable conditions, biceps femoris quiescence occurred two or more times during a participant's four trials in 55.5% of the subjects. However, only 33.2% of the subjects experienced biceps femoris quiescence in two or more of the four trials with an unstable base.

Soleus: An unstable base (1093 µV ± 345) led to 29.5% significantly ($p = 0.002$; ES = 0.72) greater EMG activity than under stable conditions (844 µV ± 314) during the hip-trunk flexion.

Accelerometer: There was significantly ($p < 0.0001$) greater motion at the trunk level associated with the unstable base. Motion along the medial-lateral, cephalo-caudal and anterior-posterior planes were 2.95 fold (ES = 8.82), 53.4% (ES = 2.58) and 2.89 (ES = 8.83) fold greater under unstable base conditions (Table 3).

DISCUSSION

Instability: The most important findings in the present paper were the lack of an unstable base effect on the flexion-relaxation response for the LSES and ULES and the effect of an unstable base on the LA and biceps femoris activation strategies.

It was hypothesized that the quiescence of erector spinae EMG activity associated with the flexion-relaxation response would be inhibited by the unstable surface. Other studies have illustrated significant increases in trunk muscle activation with activity on unstable surfaces (Anderson and Behm, 2005; Behm et al., 2005). It may be possible that the flexion-relaxation response of the erector spinae may be somewhat resistant to small movement perturbations. It has been suggested that afferent inhibition of erector spinae activity arises from intervertebral ligaments (Kippers and Parker, 1984). However, Gupta (2001) argued that the appearance of the silent period earlier or later in vertebral flexion goes against the theory of stretch receptor-induced inhibition from the ligaments. On the other hand, the muscles may become silent since variables such as raised intra-abdominal pressure in concert with the passive tension of intervertebral and supraspinous ligaments, lumbodorsal fascia, other connective and muscle tissue (Dolan et al., 1994) may be sufficient to counterbalance the trunk torque without the aid of active erector spinae contractions.

Table 2. Incidence (% occurrence in all trials) of biceps femoris quiescence during hip-trunk flexion. Each subject performed four trials under stable and unstable base conditions.

	Stable	Unstable
4 / 4 trials	44.4%	5.5%
2-3 / 4 trials	11.1%	27.7%
0-1 / 4 trials	44.4%	66.6%

Table 3. Means (± SD) of the frequency (Hz) characteristics of trunk movement under stable and unstable base conditions.

	Medial-lateral Movement	Cephalo-caudal Movement	Anterior-posterior Movement
Stable Base	.41 (.09)	.58 (.12)	.56 (.12)
Unstable Base	1.21 (.87)	.89 (.31)	1.62 (.85)

The accommodation of instability-induced movement perturbations may be relegated to limb and postural muscles. Partial compensation for these movement fluctuations may have been accomplished with greater activity of the plantar flexors. EMG activity of the soleus was approximately 30% greater on the unstable as compared to the stable surface. Whereas some researchers contend that activation of the plantar flexors alone cannot stabilize balance perturbations (Loram and Lakie, 2002; Morasso and Sanguineti, 2001), others have reported that the passive stiffness of the plantar flexors are sufficient to maintain an erect posture during quiet stance (Winter et al., 1998). According to Peterka (2002) the active torque generated by feedback control mechanisms provide the dominant contribution to quiet stance stability. Thus, both passive and active plantar flexor contractions may have compensated to some extent for the instability of the dyna-disc. However, data obtained from the trunk accelerometer readings demonstrated greater movement frequencies with an unstable base indicating that the plantar flexors could not totally compensate for the instability.

Since the act of standing and then flexing the hips and back on the unstable dyna-discs may not exactly equate with quiet stance study results, more than just plantar flexors control may be necessary to adjust for the unstable platform. While movement perturbations in the anterior-posterior alignment may be compensated by the plantar flexors, medial-lateral movements are reported to be counteracted by hip abductors and adductors (Winter et al., 1998). Hodges et al. (2002) suggested that instability may be counteracted by small angular displacements of the lower trunk and limbs and that stability is dependent on the contraction of multiple body segments. Therefore as might be expected from Hodge’s (2002) report, LA and biceps femoris activity were affected by the unstable discs. Under stable conditions, the biceps femoris activity during the flexion-relaxation silent period of the erector spinae was also quiescent in more than half the trials (Table 2). Gupta (2001) reported silent activity in the hamstrings of only 3 of 25 subjects in his flexion-relaxation study. However, his subjects positioned their buttocks against a wall to limit the movement of the hips during trunk flexion, whereas in the present study the hip movements were unrestricted. Silvonen (1997) reported hamstring silence, which had a later onset (97% of full lumbar flexion) than back muscle silence. Since, the lumbodorsal fascia and non-contractile elements of the erector spinae muscles may provide approximately 75% of the passive extensor moment (Dolan et al., 1994), more passive rather than active stiffness of the hamstrings may provide further counterbalancing torque in some individuals under stable conditions. However, with an unstable surface, the biceps femoris quiescence was replaced with continuous EMG activity in the majority (66%) of the trials (Table 2). An increased incidence of biceps femoris activity may have been used to help stabilize the pelvis. This finding concurs with a number of other studies that have reported increased limb and especially limb co-contractile activity with decreased stability (Gantchev and Dimitrova, 1996; Mochizuki et al., 2004; Nakazawa et al., 2004).

In addition, a burst of higher amplitude LA EMG activity occurred approximately 72% of the time in a majority of individual stable trials (two or more of the four trials). Other studies have reported a minimum of abdominal activity during trunk flexion. However, differences in methodologies such as examining the rectus abdominus (Floyd and Silver, 1955) rather than the LA, performing isometric (Tan et al., 1993) rather than dynamic contractions and restricting hip movement (Gupta, 2001) may contribute to the disparity with the present study. It has been suggested that one of the functions of the LA is to increase intra-abdominal pressure and thereby provide greater stability to the abdominal cavity and vertebral column (Cresswell and Thorstensson, 1989; Jenkins, 2003). However, this burst of LA EMG activity was substantially reduced in incidence, amplitude and ROM by instability (Table 1). Perhaps since the neuromuscular system could not successfully predict the movement perturbations while standing and flexing on the dyna-disc, the preferred strategy was to maintain a constant and moderate amount of LA EMG activity.

Not all subjects experienced this burst-like activity of the LA under stable conditions (Figure 1). Similar to the typical unstable response, a number of subjects exhibited a constant level of contraction throughout the flexion and extension movement under stable conditions. Thus, these individuals may have used different strategies to increase intra-abdominal pressure or improve balance in order to increase trunk stability while flexing. Studies have reported increases in intra-abdominal pressure with diaphragmatic contractions (Cresswell and Thorstensson, 1989; Hodges et al., 2001) and the Valsalva maneuver (Cresswell and Thorstensson, 1989). Mueller et al. (1998) found higher intra-abdominal pressures with kyphotic postures compared to erect postures. Furthermore, trunk posture can be augmented with increased diaphragmatic activity (Hodges and Gandevia, 2000). Similarly, the unstable condition may have caused many of the subjects to also modify their strategies for increasing stability resulting in a more constant but lower amplitude of LA EMG activity.

Two of the fourteen subjects did not experience an erector spinae flexion-relaxation response. While this may be considered unusual in healthy subjects, individuals with chronic low back pain do not always exhibit the flexion-relaxation response (Kaigle et al., 1998). Although all participants completed a PAR-Q form (Canadian Society for Exercise Physiology, 2003) and were excluded if they indicated acute or chronic back pain, these two subjects may have had an underlying pathology which at their age (young 20s) had not yet resulted in symptoms. Their data were not included in the analysis.

CONCLUSION

The present study found no effect of an unstable base on the flexion-relaxation response of the ULES and LSES. It was hypothesized that the greater instability of the dyna-disc was dampened to some extent by the greater activity of the plantar flexors and biceps femoris. The incidence of biceps femoris EMG quiescence and LA burst activity was also minimized under unstable conditions.

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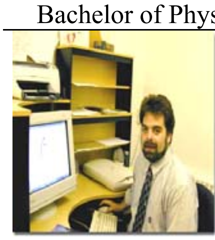

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KEY POINTS

- An unstable base did not affect the flexion relaxation response of the erector spinae.
- An unstable base decreased the incidence of biceps femoris quiescent period.
- An unstable base diminished the incidence of the lower abdominals EMG burst.

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