THE RESPONSE OF THE FLEXION-RELAXATION PHENOMENON IN THE LOW BACK TO LOADING

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ABSTRACT

Fick[7] hypothesized in 1911 that the erector spinae muscles are not active when the trunk is in the fully flexed position. This effect was later called the flexion-relaxation phenomenon (FRP) and is believed to be the result of the ligaments and other passive elements of the spine taking over the load of the muscles. This study examined the effect of loading on the EMG activity of five males and five females during postures of standing at 45°, 90°, and full flexion. The results showed major differences in the relationship between the electromyographic signal (EMG) of the erector spinae and loading for the four postures. The erector spinae muscles did not activate in positions of full flexion (or even 90° for some subjects) for loading as high as 50% of their maximum voluntary contraction, suggesting that alternative muscles are being activated and that the passive tissues may be put under higher loads than originally thought in these positions. The results suggested that the FRP could be used as a biofeedback tool to illustrate to workers that their muscles are not turning on in the fully flexed positions, and therefore, these positions should be avoided.

Key Words: Electromyography, low back pain, flexion-relaxation phenomenon.

INTRODUCTION

The electromyographic activity of the dorsal muscles are anatomically related to the force in the muscles (Anderson et al.[2], Basmajian and DeLuca[5] & Pope et al.[22]). It has been established that electromyographic activity increases both with an increase of flexion angle and an increase in external loading at a fixed flexion angle (Anderson et al.[3,4], Morris et al.[18], Schultz et al.[24]).

One of the most common activities is forward flexion, yet it is a complex event. According to Carlsöö[6], the first fifty degrees of flexion occurs within the lumbar spine and the remainder by rotation of the pelvis. In extension the reverse happens, pelvic rotation followed by lumbar spine extension. Carlsöö[6] and Okada[20] have found that flexion is initiated by muscles that stabilize the pelvis and lock the hip joints (gluteus maximus, gluteus medius and hamstrings). Erector spinae activity increases with flexion to a point where it decreases completely (Allen[1], Floyd and Silver[8], Golding[10], Grieve[11], Morris et al.[19], Pauly[21], Valencia & Monroe[26]).

Flexion-relaxation, or a cessation of activity in the erector spinae muscle group, is generally thought to occur as a result of the passive tissue of the back (ligaments, fascia, disk, facets etc.) taking over the load for the muscles. If this is indeed the case, then a loss of muscular control in the trunk would be occurring in these bent over postures, suggesting that they should be avoided. However, investigators have recently suggested that when the loading on the trunk becomes enough, muscles activate even in the fully flexed postures in order to protect the passive tissues (Schultz[25]). Floyd and Silver[9] suggested that the phenomenon was due to stretch reflex inhibition.

The study is concerned with the action of the erector spinae musculature when a pull is performed during which the loading is gradually increased from 0-50% of a maximum voluntary contraction (MVC). Four different postures of 0° (standing), 45°, 90° and full flexion were tested as shown in Figure 1.

METHODS

Ten subjects, five male and five female, aged 18-40 years volunteered to participate in the study. None of them had any significant history of low back pain or present illness. All subjects were consented and no compensation was offered for participation in the study.

A metal frame was used to keep the subject in the correct postures for the testing. During the 0° posture (standing), a vest was worn which was connected to a rope and load cell. The other three postures were performed pulling up on a handle as shown in Figure 2. During these postures the length of the cable connected to the handle was controlled in such a way as to allow the subject to hold the desired posture during the pull. If the subject went out of a range of +/- 10° of the testing posture recorded by the inclinometer during a pull, the computer escaped and the trial was not recorded.

The subject performed two trials of MVC for each posture. The highest value in these two pulls was taken as the MVC value. After two MCV pulls, one trial of increasing a pull from a 0 load value to 50% of the MVC

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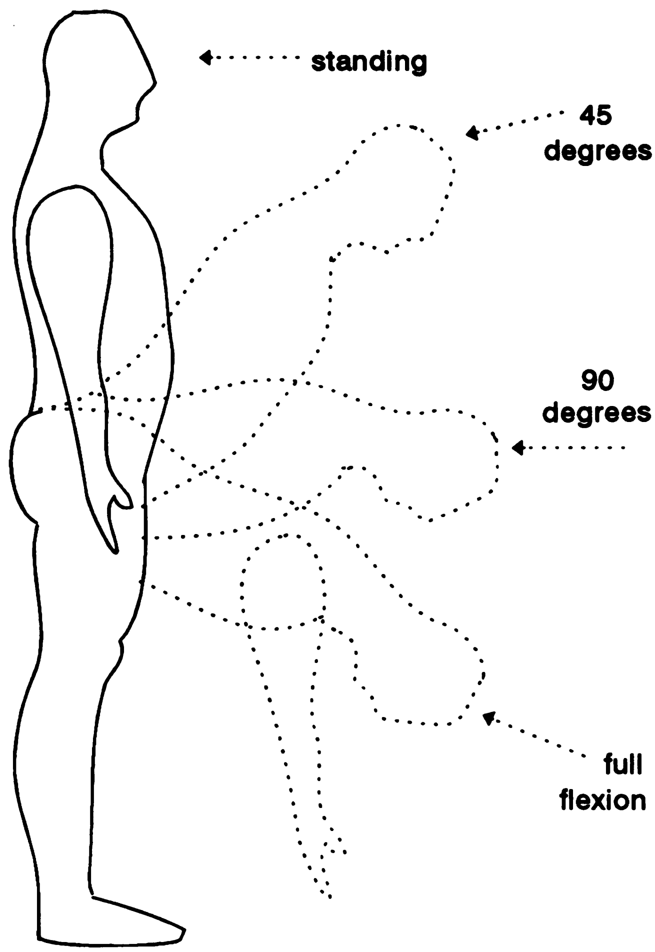


Figure 1. Four different testing postures

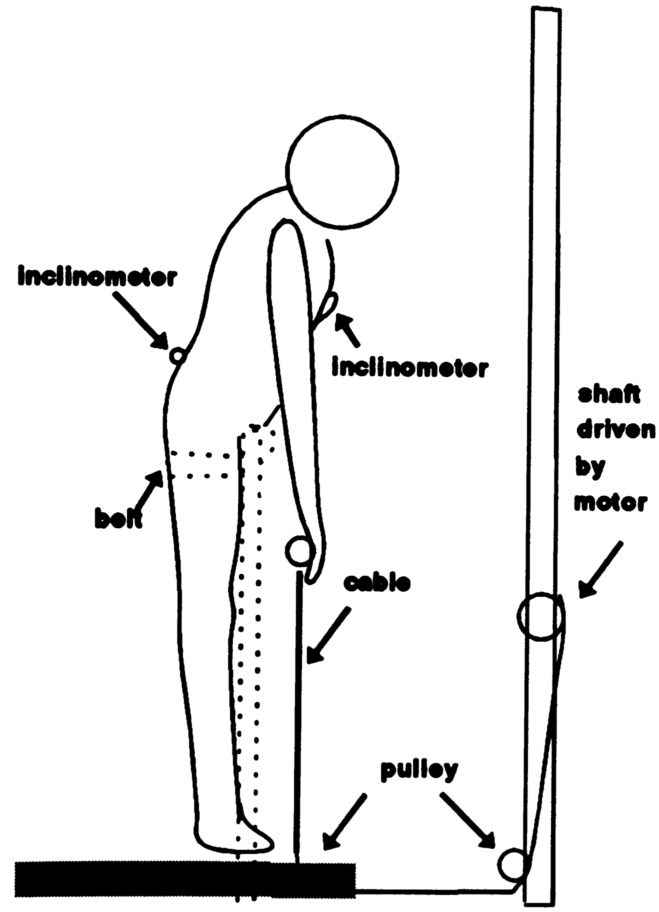


Figure 2. Subject in testing frame

load value was recorded. A biofeedback system of tones was used to signal to the subject the amount they were pulling. Electromyographic activity of the erectors spinae was recorded bilaterally by Davicon electrodes (with a gain of 1000) during the 0-50% MVC trials at the level of the third lumbar vertebrae, approximately 3 cm. from the midline of the spine. Palpation was done by using the level of the iliac crest as level with the L4/L5 interspace.

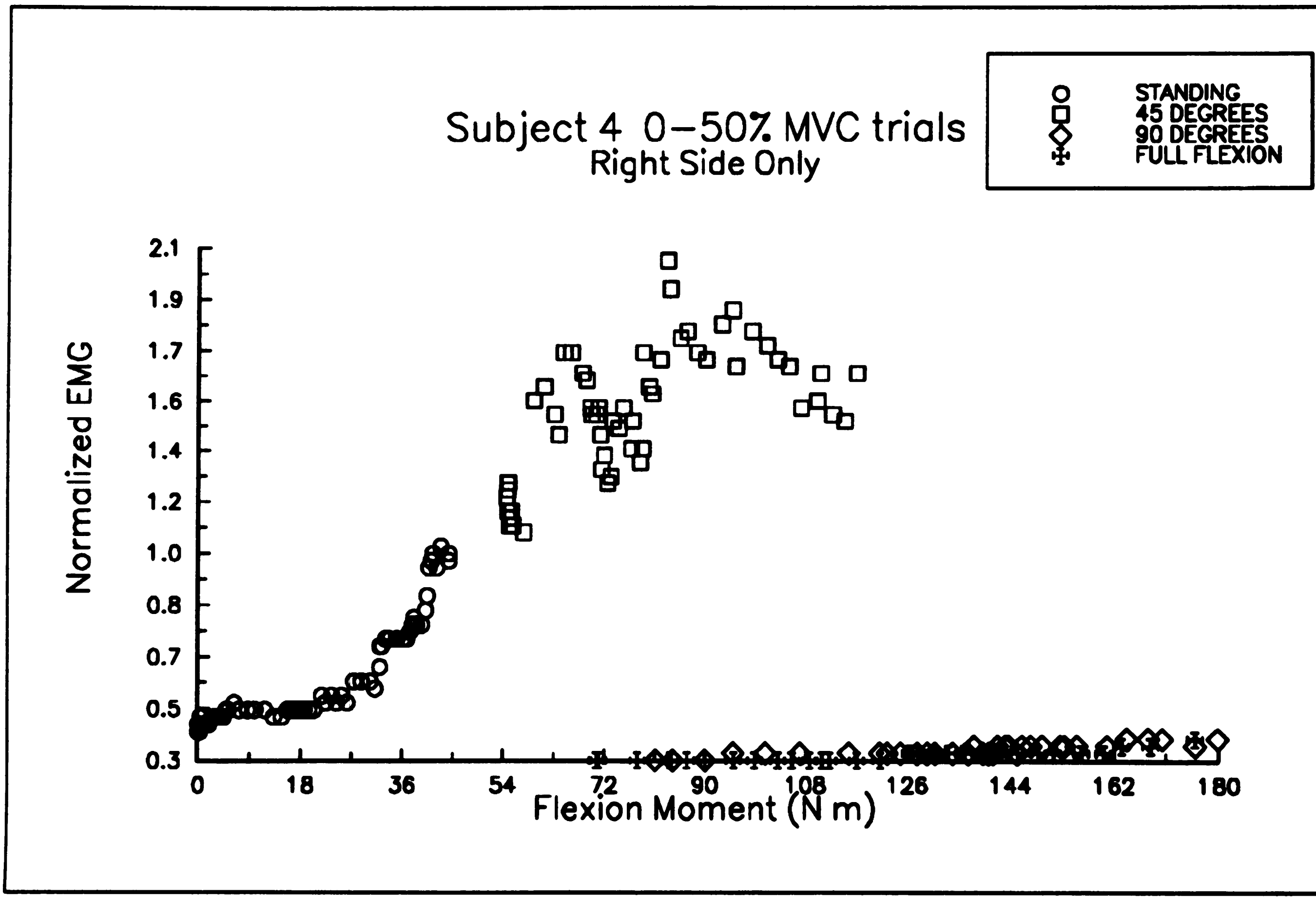
The EMG signal was amplified (gain of 3.365) in the power supply and a 100 ms RMS conversion was performed on the signal before recording by the computer at 20 Hertz. A fluid-filled Spectron inclinometer with a linear range of 120 degrees was used for the angle measurements. The inclinometer was mounted on the sternum with velcro straps (Haig et al.[12]). The readings from the inclinometer were recorded simultaneously with the EMG readings.

RESULTS

For comparisons to be made between subjects, a normalization technique was performed on the EMG readings. This consisted of dividing all the EMG values by the value of the EMG activity at the 50% MVC load in the standing position. An EMG value corresponding to the 50% MVC load was used instead of the full MVC EMG value because the EMG is still in the linear range at the 50% MVC load. The standing posture was used for normalization instead of the flexed postures to minimize the effect of body segment weights on the pull.

Calculations of body segment weights were done using the following values: 36% of body weight (BW) as the weight of the trunk above L3, 9% of BW as the weight of the two arms and 5% of BW as the weight of the head and neck. The mass center of the trunk above L3 was estimated as 30% of the distance between L3 and the ear in the upright standing position (Magnusson[17]). The distance from the muscle to the center of the L3 vertebral body was taken from the work of Kumar[15].

The individual segment weights were then multiplied by their respective moment arms. The moment arms were determined using the anthropometric data collected during the testing. The resultant values for flexion moment were then plotted against the normalized EMG activity as shown in Graphs 1 and 2.



Graph 1 Subject #4 right sided EMG vs. flexion moment

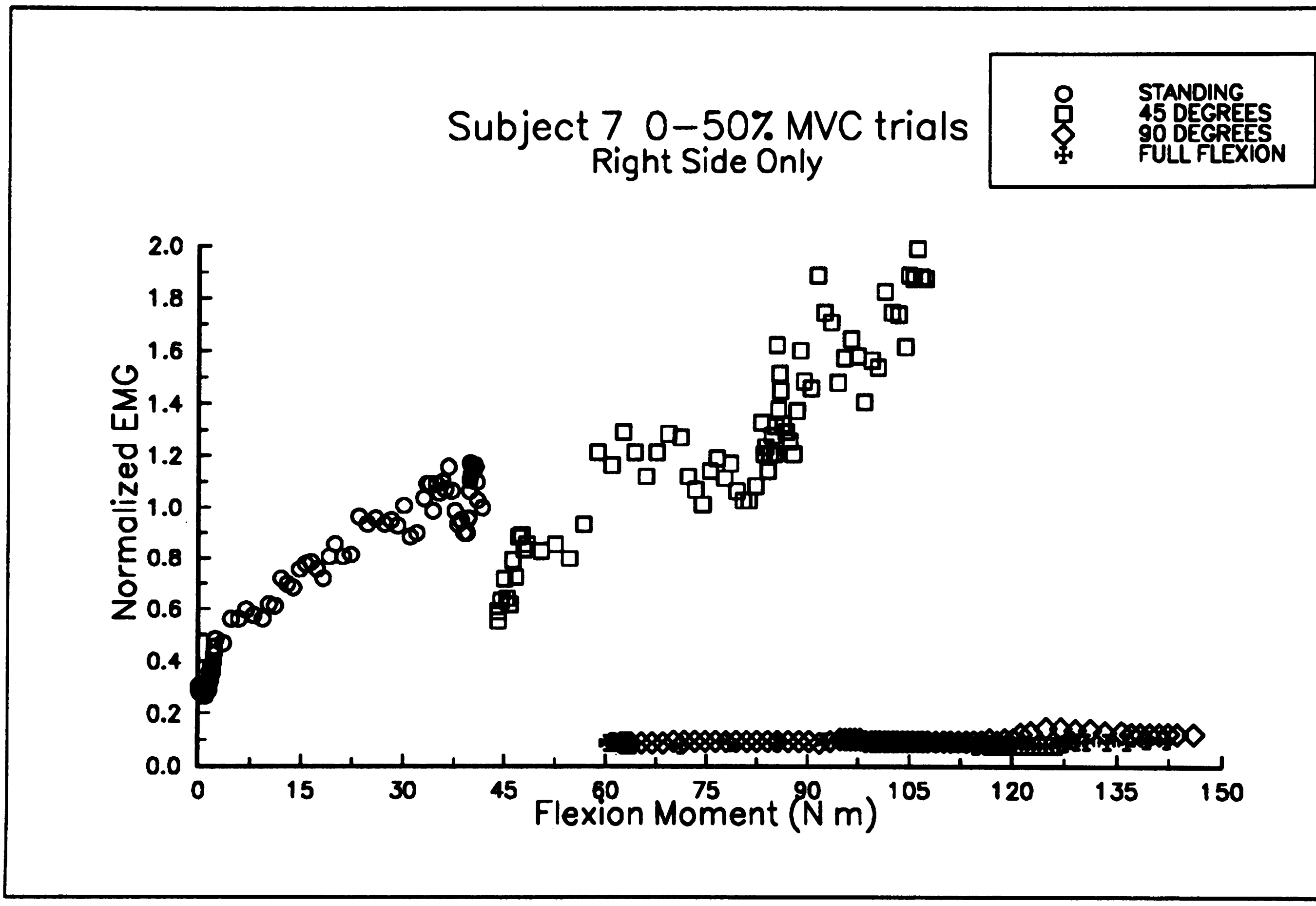
DISCUSSION

From Graphs 1 and 2 of the 0-50% MCV trials, it can be observed that a higher flexion movement is achieved in the flexed postures than in the standing posture. This was due in part because of the larger moment arms for the body segments in the flexed positions and also due to the fact the subjects showed a greater ability to produce force in the flexed postures.

The normalized EMG values for the subjects stay close to zero in the fully flexed posture and 90° posture, even for values as high as 50% MVC, indicating that muscles other than the erector spinae are generating the torque. These findings agree with those of Floyd and Silver[9] who found that the erector spinae remain inactive in the initial stages of heavy weight lifting, but disputes the findings of Schultz et al.[25] who reported that the erector spinae muscles would turn on in full flexion to compensate for any increase in loading over that which is caused by the weight of the upper body. Schultz et al.[25] also suggest that a similar relationship exists between EMG/Load in the back regardless of the flexion angle. From the graphs, it appears that a different pattern of EMG activity in relation to force occurs in the 90° and full flexed postures than in the 45° and standing postures. This changing relationship for the most flexed postures suggests that a mechanism is present to relieve the loading from the muscles that is not present in the slightly flexed postures. Kippers & Parker[14] have also shown that the FRP would occur later in the bending cycle when additional weight was carried, suggesting that it would take longer for the ligaments to take over for the muscles.

Portney and Morin[23] demonstrated that the hamstrings stay active during the flexed postures which could suggest that these muscles play a role in relieving the erector spinae muscles. The gluteus muscles relax on full flexion and the abdominal muscles are only active during the first few degrees of flexion. Another possible relief mechanism is suggested by Hukins et al.[13] and Macintosh et al.[16] by which the thoracolumbar fascia is used to enclose the erector spinae muscles and thereby increase their efficiency.

The results suggest that the passive mechanisms of the trunk are under greater stress than originally thought in



Graph 2 Subject #7 right sided EMG vs. flexion moment

the fully flexed postures. The flexion-relaxation phenomenon could possibly be used to train workers by illustrating to them that the nonmuscular parts of the their spine are at risk for injury in these fully flexed postures. This technique could also be used as biofeedback in lifting in combination with angle, so that when angle is increased and muscle activity drops substantially the wearer would be warned with a tone.

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