Electromyographic study of muscular activity during trunk forward bending
and trunk twisting in standing posture

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1. Introduction
Two postures which are most adopted in various tasks and believed as major cause of musculoskeletal problem, forward bending and twisting, were observed in this study. Their effects on muscular activity were evaluated by surface Electromyography (EMG) method. Our purpose was to seek both optimal bending and twisting postures with minimum risk on musculoskeletal problem. Postures have been standardized in natural, simple and reliable postures, in approaching condition in real life.

Earlier study on this posture by observing low back muscles demonstrated that in maximum bending level, muscles activity extremely decreased. It was called as flexion-relaxation (FR) phenomenon (Floyd and Silver, 1951), however, results of study on the cause, onset, and the role of other muscles during the phenomenon remain unclear. Present study aimed to observe the FR onset, also role of lower limb muscles during naturally performed forward bending posture.

2. Method
Subjects were 12 healthy males (age 22-27 years). Each posture was kept in 10 seconds, with rest between trials to prevent fatigue. A stable 2.56 seconds interval was selected for FFT processing with 1 kHz sampling frequency. The process delivered EMG power spectrum (PS), the total power (TP), and the mean power frequency (MPF).

Obtained TP and MPF value data were normalized to standardized values, which was applied to overcome the dependence upon the standard deviation (SD). Here, each value during performing α degree of posture \(X\alpha\) in each subject was standardized \(sX\alpha\) by considering mean \(X\) and SD of whole value during performing all postures in the subject, where: \(sX\alpha = (X\alpha - X) / SD(X)\).

(2.1) Experiment of bending posture:
The bending posture were taken in 0, 30, 45, 60, 90 degree and 180 degree (or maximum bending), where visual feedback was applied to maintain the posture (Fig.1 (a)). The measured muscles were Erector Spinae (ES) at level of lumbar 1 (L1) and lumbar 5 (L5) as low back muscle, gastrocnemius in calf, and hamstring in thigh.

(2.2) Experiment for twisting posture:
Twisting postures refer to trunk rotation movements; an axial movement to turn trunk around the longitudinal axis, which ideally without move any lower body parts.

Twisting was performed in \(\alpha\) degrees (0,10,20,30, and 40 degrees) of twisting angle and a maximum twisting, for both right and left directions, as described in Fig.2 (a).

Erector Spinae (ES) at L2 and L5 levels which represent low-back muscles, and External Oblique (EO) and Internal Oblique (IO) Abdominis, which
represents abdominal muscles, were investigated. Observation on those muscles were conducted for both right and left side.

![Fig. 2: (a) Standardization of twisting posture. (b) Setting of twisting angle.](image)

3. Results and Discussion

Standardized value of TP (sTP) of each bending angle for Erector spinae is showed as example in Fig.3. Referring to TP results for all the muscles taken, the activity increasing of ES muscles continued from 0 to 45 degree of angle. Beyond 60 degree, their activities returned to its initial level, this result agreed with the existence of Flexion-Relaxation (FR) phenomenon, which showed that activity of ES reduced when the trunk fully flexed.

The results note the onset of FR is in 45 degree and fully FR occurs at 90 degree of flexion. While activities of hamstrings and gastrocnemius gradually increase, reach the maximum at 90 degree, and slightly decrease at 180 degree. There was coordination between low back and lower limb muscles in forward bending posture. At a little flexion, ES activities significantly increased to maintain the balance, but in deep flexion they were inactive.

Lower limb muscles active during whole posture and gave higher contribution when ES was inactive. Thus, can be considered, light to moderate bending associated with higher risk on low back, while deep bending is closer to the risk on lower limb muscles.

By referring to the TP in the study shown as example in Fig. 4, the muscular activity pattern of the erector spinae (ES) both at L2 and L5 level showed that activities of the contralateral side are higher than the ipsilateral side. Certain side (for example left side) of ES gave higher activity when the trunk twists to the opposite direction of the side (right side) with curved and inclined lines of action in both oblique muscles make these muscles to have diverse actions. Therefore both EO and IO could act as either an agonist or an antagonist depending on the direction of twisting.

The small activity of the antagonist muscles was observed, it was considerably caused by insufficient load to activate them and that during such of twisting some other muscles possibly also act as stabilizer. These findings is important in view that biomechanical examinations of trunk twisting in a test frame, where external resistance is applied, do not always mirror the activity patterns and levels in natural or freely performed twisting in real working posture. All significances were shown when the twisting angle was at least reaching 30 degree. Thus naturally performed twisting in less than 30 degrees of twisting angles is supposed relatively safe as it apparently did not bear trunk muscles.

![Fig. 3: Standardized value of total power in each angle of bending posture (**=1%, *=5% significant).](image)

![Fig. 4: Standardized TP of observed muscles in both of directions a twisting angle (+a=right, -a=left).](image)

References