Quantification of the Lumbar Flexion-Relaxation Phenomenon: Comparing Outcomes of Lumbar Erector Spinae and Superficial Lumbar Multifidus in Standing Full Trunk Flexion and Slumped Sitting Postures

Alison Schinkel-Ivy, MHK,[a] Brian C. Nairn, MSc,[a] and Janessa D.M. Drake, PhD[b]

Abstract

Objective: The purpose of this study was to identify differences in flexion-relaxation outcomes in asymptomatic participants, with respect to both flexion-relaxation phenomenon (FRP) occurrence and spinal onset angles, as a function of posture and choice of muscle being examined.

Methods: This was a cross-sectional study in a laboratory setting. Thirty asymptomatic participants performed standing full trunk flexion and slumped sitting postures while activation levels of the lumbar erector spinae and superficial lumbar multifidus were monitored. Two thresholds were used to define whether FRP was present in each muscle and, if present, at what trunk flexion angle it occurred. These outcomes were compared descriptively between muscles and between postures.

Results: Most participants displayed FRP in both muscles during standing full flexion; occurrences were more variable in slumped sitting. On average, FRP during standing full flexion and slumped sitting occurred at approximately 80% and 52% of participants' maximum flexion value, respectively. Variability in the slumped sitting onset angles was greater than that in standing full flexion.

Conclusion: Outcomes for FRP during standing full flexion in asymptomatic participants appeared to be more robust and were not affected by the choice of either lumbar erector spinae or superficial lumbar multifidus. Conversely, during slumped sitting, FRP occurrence varied substantially depending on choice of muscle, although onset angles were relatively consistent between muscles. Although the choice of one muscle over the other may be warranted, it may be prudent to examine both muscles during FRP investigations in sitting postures, in order to fully characterize the behavior and activation patterns of the lumbar musculature. (J Manipulative Physiol Ther 2014;37:494-501)

Key Indexing Terms: *Methods; Low Back Pain; Electromyography; Muscles*

The term *flexion-relaxation phenomenon* (FRP) was coined by Floyd and Silver[1] to describe the tendency of the low back musculature to activate as an individual begins to flex forward, quiet during full flexion, and reactivate during trunk extension and subsequent return to upright standing. The clinical relevance of FRP has been demonstrated by various authors,[2–4] in that this response is typical in healthy individuals, whereas patients with low back pain (LBP) tend not to show FRP. The use of FRP in LBP diagnosis has great potential because an observable pathology is often not present in LBP patients.[3] Flexion-relaxation phenomenon assessment, therefore, provides an objective tool to aid in a diagnosis.[3,5] Although there is general agreement that FRP is relevant in a clinical context, there has been little standardization of the methods by which FRP is identified and/or quantified.[6]

Early work examining FRP in the lumbar spine traditionally investigated the lumbar erector spinae (LES) muscles[1,7,8] during standing full flexion. In previous studies examining standing full flexion, FRP has been identified in 100% of 25[9,10] and 12[6,11] asymptomatic participants. Furthermore, analyses of the sensitivity and specificity of

[a] PhD Candidate, School of Kinesiology & Health Science, York University, Toronto, Ontario, Canada.
[b] Assistant Professor, School of Kinesiology & Health Science, York University, Toronto, Ontario, Canada.
Submit requests for reprints to: Janessa D.M. Drake, PhD, 2030 Sherman Health Science Research Centre, School of Kinesiology & Health Science, York University, 4700 Keele St, Toronto, ON, Canada M3J 1P3. (e-mail: *jdrake@yorku.ca*).
Paper submitted January 25, 2013; in revised form January 15, 2014; accepted January 17, 2014.
0161-4754

http://dx.doi.org/10.1016/j.jmpt.2014.07.003

FRP in identifying LBP patients were reported by Ahern et al[12] and Watson et al.[4] When the results of the 2 studies were combined (110 LBP patients and 60 asymptomatic participants), the sensitivity and specificity were 88.8% and 83.1%, respectively.[3] More recently, studies have focused on the activation patterns of either the LES[13–17] or the superficial lumbar multifidus (SLM),[2,18–20] along with the corresponding spinal angles at FRP onset. Although standing full flexion has typically only been characterized by LES activation patterns, both LES[14,15] and SLM[18,20] have been used in the investigation of activation patterns during slumped sitting.

Although the reliability of standing FRP in asymptomatic individuals and corresponding absence in LBP patients has been well documented, the examination of FRP in slumped sitting has only begun relatively recently.[2,14,18,20] Although not the focus of the present study, the mechanics of slumped sitting have been recently reported by Nairn et al.[21] The slumped sitting posture is clinically relevant as LBP patients exhibit lower muscular endurance and greater posterior pelvic tilt and tend to move to passive postures such as slumped sitting.[20] Furthermore, differences in slumped sitting postures have been identified across subclassifications of LBP patients.[2,18] Although no published work to date has evaluated the sensitivity and specificity of FRP during slumped sitting in distinguishing LBP from asymptomatic participants, LBP patients tend to exhibit less relaxation during slumped sitting than their asymptomatic counterparts.[2,15] Taken together, these findings highlight the clinical importance of considering FRP in slumped sitting.

Although the behavior of the trunk musculature during standing full flexion and slumped sitting has been documented to an extent, a comprehensive investigation of FRP in both the LES and SLM muscles during standing full flexion and slumped sitting simultaneously has yet to be published. Therefore, the purpose of this study was to identify differences in FRP outcomes with respect to both FRP occurrence and spinal onset angles as a function of posture and muscle in asymptomatic participants, thereby indicating which muscle provided more consistent FRP outcomes. It was hypothesized that LES would provide the most consistent outcomes for standing and SLM for sitting.

Methods

Participants

Thirty participants (15 men and 15 women) participated in the study. Mean (SD) age, body mass, and height were 23.9 (2.7) years, 83.5 (13.8) kg, and 1.83 (0.08) m for the men and 24.3 (3.0) years, 58.5 (7.9) kg, and 1.61 (0.09) m for the women, respectively. The inclusion criteria were right-hand dominant and asymptomatic for back pain during the previous 12 months, in that they had not sought medical treatment of back pain or missed any days of school or work due to back pain. Procedures were approved by the York University Office of Research Ethics, and all participants provided informed consent prior to data collection.

Instrumentation

After shaving and swabbing of the skin with rubbing alcohol, pairs of disposable silver/silver-chloride surface electromyography (EMG) electrodes (interelectrode spacing of 2.5 cm; Ambu Blue Sensor N, Ambu A/S, Denmark) were applied over the left (L) and right (R) LES (L_3 level)[14] and SLM (L_5 level).[2,22] Electromyography signals were differentially amplified (frequency response, 10-1000 Hz; common mode rejection, 115 dB at 60 Hz; input impedance, 10 GΩ; model AMT-8, Bortec, Calgary, Canada) and sampled at 2400 Hz (Vicon MX motion capture system; Vicon Systems Ltd, Oxford, UK).

Reflective markers (12 mm in diameter) were placed on the iliac crests, anterior (ASIS) and posterior (PSIS) superior iliac spines, and the greater trochanters to track the motion of the pelvis using a 7-camera Vicon motion capture system (Vicon Systems Ltd; measurement error ±1 mm). Also, 2 triangular plates were constructed from foam board, and 3 reflective markers (8 mm in diameter) were adhered to each plate in a triangular pattern. The 2 plates were placed over the L_1 spinous process and PSISs, in order to track the motion of the lumbar segment (Figure 1). Kinematic data were sampled at 50 Hz.

Procedures

After electrode application, participants rested quietly in a supine position for 5 minutes to obtain the resting level of muscle activity. Participants then performed 3 back extensions against resistance to elicit the maximum voluntary contraction (MVC) level, as in McGill.[23] The markers were then applied, and 3 trials in each of 2 postures were then performed (Figure 2): moving from upright standing to full flexion[14] and moving from upright sitting to slumped sitting.[2,14,20] Slumped sitting has been previously described as rounding of the spine to achieve a relaxed, "slouched" posture.[2,14] Presently, participants were specifically told to "sit slumped as you normally would," with the only restriction being the head looking forward throughout.[21] The order of trials was held constant for each participant (standing full flexion, followed by slumped sitting). Dickey et al[24] have previously found that repetitive trunk flexion-extension movements affected the timing of FRP, in that onset angles increased toward the end of a 100-trial protocol. However, the number of trials in the present study (3 of each posture) would likely not be sufficient to induce this type of response in the