PROLONGED SWING PHASE RECTUS FEMORIS ACTIVITY IS NOT ASSOCIATED WITH STIFF KNEE GAIT IN CHILDREN WITH CEREBRAL PALSY: A RETROSPECTIVE STUDY OF 407 LIMBS

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INTRODUCTION: Stiff-knee gait (SKG) is a common gait deviation affecting children with cerebral palsy (CP). Functionally, SKG can limit swing phase toe clearance and necessitate energy-costly compensations. Prolonged swing phase rectus femoris (RF) activity has long been implicated as a cause of SKG and continues to be cited as an indicator for RF intervention for the treatment of this common gait deviation[1]. However, more recent work has pointed to preswing factors, including RF activity, as the major determinants of SKG[2,4,5]. The purpose of this study was to determine what, if any, association exists between abnormal RF activity during preswing, initial swing and/or midswing and SKG in children with CP.

CLINICAL SIGNIFICANCE: If prolonged swing phase RF activity is not specific to those children with CP who demonstrate SKG, then this EMG finding should cease being thought of as an indicator for RF intervention in the treatment of SKG.

METHODS: This retrospective analysis involved three examiners independently reviewing sagittal plane knee kinematic and RF surface EMG data from 407 affected limbs of 234 pediatric CP patients (mean age 10 years and range 5-17 years). None of the limbs had undergone RF surgical intervention. Through visual inspection of a single representative gait cycle from each patient, the following five kinematic parameters were rated by each examiner separately as either normal or pathologic: (1) peak swing phase knee flexion, (2) knee flexion range of motion (ROM) during initial swing, (3) total knee ROM, (4) peak knee flexion timing, and (5) rate of knee flexion from preswing through midswing phase. These ratings were used to classify each limb into one of three groups: SKG (≥ 3/5 parameters pathologic), Borderline Stiff Knee Gait (BSKG; 2/5 parameters pathologic), or Non-Stiff Knee Gait (NSKG; < 2/5 parameters pathologic). Additionally, a representative EMG tracing for each patient was carefully divided into 3 phases of the gait cycle -- preswing (opposite foot contact to toe-off), initial swing (first third of swing), and midswing (middle third of swing). Because RF activity has been shown to normally occur during the latter half of preswing through the first third of initial swing[3], RF activity was examined only during: (a) the first half of preswing, (b) the latter 2/3 of initial swing, and/or (c) any portion of midswing (Figure 1). RF was considered active if its activity during that period was believed to be substantially higher in amplitude than the quietest baseline RF activity found elsewhere in the gait cycle.

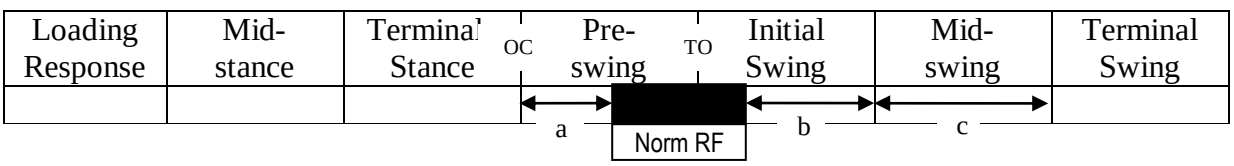

Figure 1: Points where RF EMG evaluated (a, b, c). OC=Opposite contact; TO=Toe-off.

In the rating of both the 5 kinematic indicators as well as the EMG activity during the 3 phases of the gait cycle, agreement by at least 2 of 3 examiners was required. For the purpose of assessing intrarater reliability, the data from a subset of 20 of the original 407 limbs (5%) were randomly selected for reevaluation. Examiners were blinded as to their original

assessment results, and their findings were compared against a computerized assessment. Cohen's Kappa was utilized to calculate intrarater and interrater reliability for the ratings of both the knee kinematics and the EMG. A post hoc analysis, with a threshold for pathology set at ≥ 2 standard deviations from normal compared to the lab's internal normative database, was performed on a subset of 44 of the 407 limbs surveyed (11%) in order to test the validity of examiners' classification of knee patterns. Chi-squared tests of independence were used to determine if significant associations existed between the 3 groups (SKG, BSKG, NSKG) and RF activation during the 3 portions of the gait cycle. Significance was set at α=0.001.

RESULTS: There was no association found between SKG and either prolonged RF activity during initial swing or midswing. In fact, 90% and 95% of all limbs demonstrated prolonged RF activity during initial and midswing respectively, regardless of knee pattern. A significant relationship between SKG and RF activity was found only for the preswing phase ($p<<0.001$): In general, those with SKG more often demonstrated premature RF activity during preswing (Table 1). Interrater reliability was moderate to substantial (0.46-0.62), while intrarater reliability was fair to excellent (0.31-0.92). Validity analysis of the knee pattern classification by the 3 examiners showed 86.4% agreement with the computerized assessment in this subset.

Table 1: Results of the Chi Squared Analysis of Independence.

Presence of RF EMG Activity		**Stiff Knee**	**Borderline Stiff Knee**	**Non-Stiff Knee**	**Chi Squared Test Result (*p < 0.001)**
Premature in Preswing	Yes	194 (78%)	48 (74%)	37 (40%)	**Chi^2 =46.7 * p<<0.001**
	No	55 (22%)	17 (26%)	56 (60%)	
Prolonged in Initial Swing	Yes	220 (88%)	87 (89%)	58 (94%)	Chi^2= 1.99 p = 0.37 (NS)
	No	29 (12%)	6 (11%)	7 (6%)	
Present in Midswing	Yes	236 (95%)	89 (95%)	62 (96%)	Chi^2 = 0.14 p = 0.93 (NS)
	No	13 (5%)	4 (5%)	3 (4%)	

DISCUSSION: Premature RF activity during the preswing phase of gait has a significant association with SKG. However, neither prolonged RF activity during initial swing, nor the presence of RF activity during midswing, are associated with SKG, thus refuting these commonly held associations. The current findings support the work of other authors which found preswing, rather than swing, phase RF activity to have the most impact on SKG [2,4,5]. However, the current study is the first to do so using a large sample of pediatric CP patients. Further investigation is needed to understand the cause and impact of prolonged swing phase RF activity seen in the vast majority of all patients reviewed regardless of their swing knee pattern. However, prolonged RF activity in swing should not be considered a cause of SKG in this population. Limitations of the current study include the retrospective design, the qualitative analysis of EMG data, and the broad range of reliability among raters.

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