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EMG ACTIVITY OF FEMOROACETABULAR IMPINGEMENT PATIENTS DURING SQUATTING

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SUMMARY

Hip muscles activation and flexion/extension co-activation were investigated to explain the differences in pelvic mobility during squatting between patients with femoroacetabular impingement and healthy control participants. The reduced gluteus maximus and increased rectus femoris activations could be responsible for the lower pelvic recline and, consequently, for the significantly reduced squat depth, while no differences were found in flexion/extension co-activation.

INTRODUCTION

Femoroacetabular impingement (FAI) is an anatomical deformity of the hip joint, causing hip and groin pain. From a functional point of view, FAI reduces frontal and sagittal hip ranges of motion and pelvic mobility [1, 2]. These alterations may not be only due to the mechanical impingement at the hip, but also to different hip muscle recruitment strategies [1, 2]. Casartelli [3] found that FAI patients have a reduced ability to activate the tensor fasciae latae and rectus femoris during maximum voluntary contractions, in comparison with healthy controls. To our knowledge, no studies have investigated the activation patterns of FAI patients during functional tasks. Our pilot study showed a slight increase of flexion/extension co-activation in FAI patients, with respect to controls [4], which was compared to the increased muscular co-activation found for osteoarthritic patients. In the present study, we investigated muscular activation and co-activation. We hypothesized that muscular activation pattern for FAI patients would be different, in comparison with control subjects, justifying the functional differences found in the pelvic kinematics. This could also suggest a trend of increased muscle co-activation for FAI patients, with respect to control subjects, previously found.

METHODS

Three groups of participants were recruited: unilateral symptomatic FAI (sFAI) with a confirmed diagnosis of FAI, persistent pain, and waiting for surgical intervention; unilateral asymptomatic FAI (aFAI) with deformity but no pain or evidence of cartilage deterioration; and healthy control participants (CON) matched for age, gender, and body mass index (Table 1), where no lower limb abnormalities are present.

Table 1: Participants' demographics, body mass index (BMI), and radial alpha angle

	Number	Age (yrs)	BMI (kg/m^2)	Alpha Angle (°)
CON	16 males	32±7	26.1±3.2	51.9±3.4
aFAI	16 males	32±6	26.1±2.7	65.2±10.3
sFAI	10 males	37±7	25.5±3.9	66.1±8.6

A computer tomography scan of hips and pelvis was used to determine alpha angles that distinguished between aFAI and CON, with higher alpha angles are associated with the risks of developing hip degeneration [5]. The threshold to distinguish between normal and FAI hips is 60° in radial view [6], but to account for measurement errors, a 5° 'grey zone' was considered. Therefore, all patients falling in the range 57.5-62.5° were discarded. Prior to data acquisition, participants signed an informed written consent, which was approved by the institution's Research Ethics Board.

Marker trajectories, ground reaction forces, and electromyography (EMG) activities were acquired using Vicon MX-13 cameras at 200Hz, two Bertec force plates at 1000Hz, and 16 channels EMG (BTS FreeEMG300) at 1000Hz. EMG probes were placed according to Seniam guidelines. EMG was recorded from the affected leg for the following muscles: gluteus maximus (GMax), biceps femoris (BF), semitendinosus (ST), tensor fasciae latae (TFL), rectus femoris (RF) and erector spinae (ES).

Participants performed maximum squats while they were standing with arms anteriorly extended, feet shoulder-width apart and parallel to each other, 10 cm from the bench, and with heels in contact with the floor. Five repetitions of the same movement were executed at a self-selected pace [2].

EMG signals were high-pass filtered (dual pass fourth order Butterworth at 10Hz), full wave rectified and low pass filtered (dual pass fourth order Butterworth at 6Hz). A moving average filter with a 0.5s window was also applied to the maximum voluntary isometric contraction (MVIC) data. The EMG amplitude was divided by the peak activation of the filtered MVIC to normalize muscular activities. EMG curves were time-normalized over 1001 points for the descending and ascending phases.

To estimate muscular co-activation, the integrated EMG of extensor muscles was divided by the sum of the integrated EMG of extensor (GMax, BF and ST) and flexor (RF and TFL) muscles [7]. By using this metric, a co-activation index equal to 0.5 indicates the maximum co-activation, where either below 0.5 flexors or above 0.5 extensors would prevail. Statistical significance was investigated through

ANOVA test (confidence level: 95%, independent variable: group). Two different tests were run for the descending and ascending phases.

EMG activity of all muscles was parametrized to the squat depth percentage, to study the dependency of EMG activity on this variable. Squat depth was calculated by tracking the vertical displacement of the hip joint centres, as a ratio of the full leg length. An ANOVA test investigated statistical differences in maximal squat depth reachable by each group (confidence level: 95%, independent variable: group). A Bonferroni correction was used for the post-hoc analysis.

RESULTS AND DISCUSSION

Maximum squat depth among the three groups was significantly different (p=0.031). sFAI participants were not able to squat as deep as the other two groups of participants. The average maximum squat depths were 42.9±6.1% for CON, 48.9±10.0% for A-FAI, 52.5±11.1% for sFAI. The pairwise comparisons showed significance for CON/sFAI (p=0.008) but no significance was found for CON/aFAI (p=0.054), and aFAI/sFAI (p=0.387).

Reduced maximum squat depth in FAI is associated with reduced pelvic mobility, responsible for the abnormal contact between the acetabulum and the proximal femur [2]. The EMG activation parametrized by percentage of squat depth for TFL, BF, ST and ES had similar patterns among the three groups but the curve was stretched along the squat depth axis for the controls (Figure 1). Conversely, for equal squat depth, RF EMG activity of sFAI was higher than for CON group, while GMax EMG activity was lower. The reduced GMax activity in association with a normal ES activity could reduce pelvic recline and consequently pelvic mobility. Moreover, a lower GMax activity does not favor hip extension during the ascending phase. If the hip was not properly contributing to the ascending phase, the knee had to contribute more, justifying the higher RF EMG activity of sFAI.

The co-activation indices (Figure 2) were not significantly different among the three groups, neither in the descending nor in the ascending phases (respectively, p=0.497 and p=0.201). This could be due a large variability in the dataset. However, from these results we cannot confirm the previously speculated analogy between the increased muscular co-activation for FAI and osteoarthritic patients [4].

CONCLUSIONS

The lower GMax and higher RF muscular activities were consistent with the observed reduced pelvic mobility found for sFAI, with respect to CON group. Maximum squat depth was different between the sFAI and CON groups, which was previously demonstrated [2]. However, the previously reported trend of increased flexion/extension co-activation was not confirmed.

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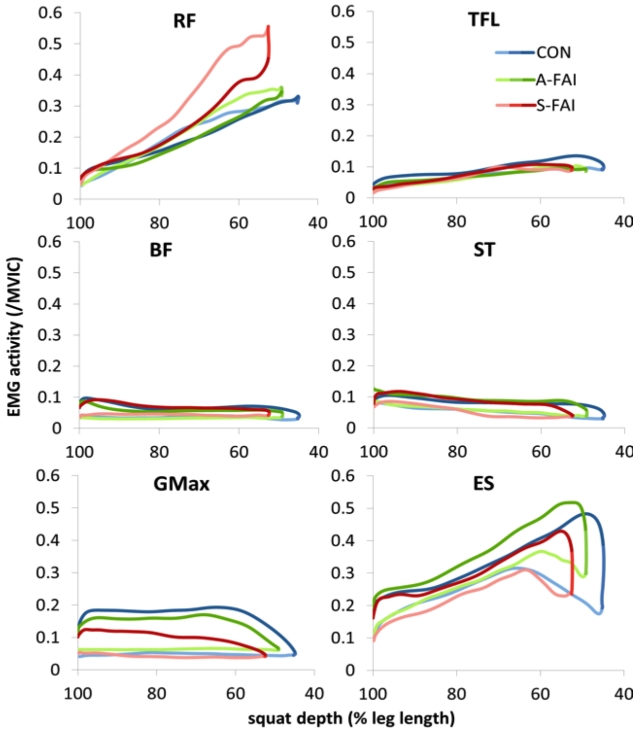

Figure 1: Average EMG activities (normalized by MVIC) are parametrized by squat depth. The segments of the curves drawn in lighter colors represent the descending phase; medium light colors represent the phase when participants hold the maximum squat depth position; the darker colors represent the ascending phase.

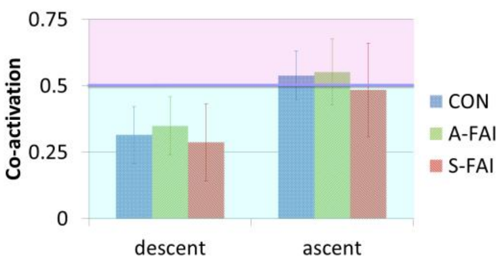

Figure 2: Average co-activation indices divided by group and phase. 0.5 indicates maximum co-activation. The transparent blue area indicates flexors predominance; the transparent pink area indicates extensors predominance.

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