ALTERATIONS IN KNEE LAXITY DURING THE MENSTRUAL CYCLE CHANGE MUSCLE ACTIVATION PATTERNS DURING SELECTED ATHLETIC MOVEMENTS

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INTRODUCTION

Female athletes experience a much higher incidence of anterior cruciate ligament (ACL) injuries during sporting activities compared to their male counterparts [1]. Epidemiology studies have found a relationship between a high number of ACL injuries and a certain phase of the menstrual cycle [2]. Biomechanical studies have investigated the ACL injury mechanism behind this relationship, speculating that changes in female hormones during the cycle may have an impact on dynamic joint function of the knee, which may lead to more injurious situations [3, 4]. A recent study has found that increased knee joint laxity (KJL) during the menstrual cycle leads to increased knee joint loads [5]. However, whether alterations in knee joint laxity during the menstrual cycle are also associated with alterations in muscle activations of the lower extremity during athletic movements has not been studied. Therefore, the purpose of this study was to investigate whether altered KJL during the menstrual cycle has an influence on different neuromuscular control of the lower extremity.

METHODS

Twenty-six healthy females (height, 170.1±7.1cm; mass, 65.0±9.3kg; age, 22.7±3.3years) participated in the study. They had been actively involved in sporting activities (8.7±4.4 h/wk). Inclusion criteria required that the subject have a normal menstrual cycle (28.9 ± 2.7days), no history of oral contraceptive use, and no knee injury during the previous six months. Each subject performed a series of tests (blood sample, KJL and electromyography (EMG)) at three different phases of the menstrual cycle (Follicular Phase: 6.1±1.4, Ovulation: 16.1±3.0, Luteal Phase: 22.8±3.2days, p<0.001) [5]. The timing of data collection was confirmed with a blood sample and ovulation predictor kit (Clearblue, UK). Blood samples were sent to a local laboratory to determine levels of estradiol and progesterone. Passive KJL was measured at a load of 89N using the KT-2000 (MEDmetric Corp, USA). After completion of blood sample and KJL tests, EMG was collected using round bipolar surface electrodes (Biovision, Germany). EMG electrodes were placed on the skin overlying the muscle belly of the medial head of the gastrocnemius (GAS), the biceps femoris (BF) vastus medialis (VM) and the vastus lateralis (VL) on the right leg (Figure 1). Muscle activation onsets before heel contact (HC) as indicated from a force plate (Kistler, Switzerland) were calculated. Co-contraction between lower extremity muscles using correlation coefficients (CC), and time (%) to reach peak EMG in each muscle during the stance phase (100%) were calculated using a Matlab7.6 (Mathworks, USA). The subject performed ten trials of cutting at 3.5m/s within ±10% range (Figure 1). A repeated measure analysis of variance determined whether there was a laxity effect on muscle activations with SPSS (SPSS Inc., USA) at p<0.05.

Figure 1: Experimental set up (left: placements of EMG electrodes, right: cutting on a runway).
RESULTS

This study found that increased KJL during ovulation changes muscle activations, showing delayed VM onset and decreased CC during movement. Increased KJL was observed during ovulation (Table 1). Figure 2 shows delayed onset of VM activation during ovulation and the luteal phase compared to the follicular phase. In addition, delayed onset of VL activation was found during the luteal phase compared to ovulation (Figure 2). A lower level of co-contraction between GAS and VM was found during ovulation compared to the luteal phase (Table 1). However, there were no significant differences in time to reach peak EMG between the three phases.

![Figure 2: Onset of muscle activations (pre-activation) between follicular phase (top), ovulation (middle) and luteal (bottom) phase (* indicates significant difference at p<0.05).](image)

DISCUSSION/CONCLUSIONS

Studies have found that greater KJL in females delays timing of muscle reflex [6] and increases knee joint load [5]. This greater KJL in females is known to be a strong risk factor for a high incidence of ACL injuries during sports. Furthermore, increased KJL during ovulation has been observed in several studies [5]. However, the links between increased KJL during the menstrual cycle and changes in muscle activations during movement has not been well understood.

Current findings suggest that increased KJL during ovulation may increase the risk of ACL injury by delayed muscle activations and possibly, decreased muscle co-contraction during movement. Pre-activation or onset of muscles is required to prepare the body for high rates of loading during landing. Appropriate co-contraction between antagonistic muscles surrounding the knee such as quadriceps and hamstrings or quadriceps and gastrocnemius reduce the strain on the ACL and provide dynamic stability during movement. However, a difference in co-contraction of GAS/VM between ovulation and luteal phase is small. Whether this difference is clinically meaningful is questionable. Further investigation will be required in this relationship. Our previous study found that increased KJL during the menstrual cycle leads to increased knee joint load in healthy females [5]. Thus, the findings of different EMG activation, influenced by an increased KJL during the menstrual cycle, may provide important information toward creating an overall picture of the ACL injury mechanism in females.

REFERENCES


ACKNOWLEDGEMENTS

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Table 1: Changes in KJL and muscle activations during the menstrual cycle.

<table>
<thead>
<tr>
<th>Laxity Phase</th>
<th>Time to Peak EMG (%)</th>
<th>Muscle Co-contraction (CC: Correlation Coefficients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GAS</td>
<td>VM</td>
</tr>
<tr>
<td>Follicular</td>
<td>4.72</td>
<td>47.9</td>
</tr>
<tr>
<td></td>
<td>(1.66)</td>
<td>(34.7)</td>
</tr>
<tr>
<td>Ovulation</td>
<td>5.13*</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td>(1.73)</td>
<td>(28.7)</td>
</tr>
<tr>
<td>Luteal</td>
<td>4.55</td>
<td>38.9</td>
</tr>
<tr>
<td></td>
<td>(1.53)</td>
<td>(34.4)</td>
</tr>
</tbody>
</table>

* indicates significant difference from Luteal Phase at p<0.05 with Bonferroni correction.