INTRODUCTION

Knee injuries are common and often result in quadriceps weakness [1]. This weakness likely alters movement mechanics, including ground reaction force and knee joint loading patterns. If allowed to persist, these mechanical alterations may contribute to knee joint degeneration. Researchers have reported that knee pain [2] and knee joint effusion [3] are related to knee injury and contribute to quadriceps weakness; however, the additive effect of knee pain and effusion on arthrogenic muscle inhibition and corresponding mechanical alterations is unclear. Independent effects of knee pain and effusion on movement mechanics have been studied, yet, pain or effusion rarely occur alone in knee injury. The purpose of this study was to evaluate the influence of anterior knee pain, knee joint effusion, and a combination of both of these stimuli on walking vertical ground reaction force (VGRF). Because the quadriceps contribute to VGRF during walking, we hypothesized that: (1) knee pain and effusion would independently decrease walking VGRF, and (2) knee pain and effusion, in combination, would further decrease walking VGRF, relative to pain and effusion alone.

METHODS

The independent variables were session (pain, effusion, pain and effusion, and control) and time (Times 1-3). The dependent variables were perceived pain, walking VGRF, and walking speed. Nineteen healthy subjects (10 males and 9 females; age = 22 ± 2 yrs; height: 1.73 ± 0.10 m; mass: 73 ± 16 kg) provided informed consent form and then participated.

Subjects completed four data collection sessions one week apart: (1) pain, (2) effusion, (3) pain and effusion, and (4) control. For each session, subjects performed nine walking trials at a preferred speed: three trials at Time 1, Time 2, and Time 3. Subjects performed landing trials after the walking trials; those results are not reported here. For each walking trial, subjects contacted a separate force platform with each foot. For the pain session, subjects first completed the Time 1 trials. Next, we injected 1 ml of hypertonic (5.0% NaCl) saline into the infrapatellar fat pad. Subjects then completed the Time 2 walking trials, rested for 20 minutes, and completed the Time 3 trials. The effusion session was identical, except that prior to the Time 2 trials, we injected sterile lidocaine for anesthetic purposes and 50 ml of isotonic (0.9% NaCl) saline into the superolateral knee joint. For the pain and effusion session, prior to the Time 2 trials, three injections were performed in the following order: lidocaine, 0.9% isotonic saline, and 5% hypertonic saline. All injections were performed in the right leg. No injections were performed for the control session. Two ANOVAs were used to compare (1) perceived pain, measured every two minutes using a 10-cm visual analog scale, and (2) walking speed between sessions and times ($\alpha = 0.05$). A functional analysis was used to compare VGRF between sessions and times ($\alpha = 0.05$); we used this analysis to compare VGRF as cubic functions rather than discrete values.

RESULTS AND DISCUSSION

Significant session × time interactions existed for each dependent variable. Mean perceived pain was greater for Time 2 than for Times 1 and 3, for each session except the control session (Figure 1). For Time 2, pain was greater than zero pain for 10, 6, and 16 min for the pain, effusion, and pain and effusion session, respectively. These pain levels were expected, although we were somewhat surprised by the elevated pain levels for the effusion session; we speculate that slight nociceptor
stimulation occurred during this session and that this may have partially confounded the VGRF results. Contrary to our hypotheses, the only session that exhibited between-time differences for walking VGRF was the pain and effusion session. For this session only, walking VGRF for the involved leg was affected by time. For Time 2, VGRF was less at 20% and 80% of stance (impact and push-off peaks) relative to Times 1 and 3; however, VGRF was greater at midstance (Figure 2). We observed the opposite for the uninvolved leg for the same session: Time 2 VGRF was greater at 20 and 80% of stance than for Times 1 and 3, but were less at midstance. We are unsure why the pain and effusion sessions did not also significantly affect VGRF. Finally, although walking speed exhibited session × time interactions (Table 1), the observed VGRF differences probably should not be completely attributed to different walking speeds.

This is the first attempt to evaluate the independent effects of anterior knee pain, knee joint effusion, and the combined effects of these stimuli on walking mechanics. These findings show that simultaneous anterior knee pain and knee joint effusion alter walking VGRF. This is consistent with the idea that injury factors, such as pain and edema, can result in additive mechanical alterations to movement. We speculate that the VGRF alterations reported in this study cause abnormal knee joint loading patterns throughout stance and, under chronic circumstances, could lead to knee joint degeneration. Additional research should be conducted to evaluate this idea.

REFERENCES


Table 1: Mean walking speeds for each session and time. Time 2 speed was significantly decreased, relative to Times 1 and 3, for all sessions except the control session.

<table>
<thead>
<tr>
<th>Time</th>
<th>control</th>
<th>effusion</th>
<th>pain</th>
<th>pain and effusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>1.32 (0.08)</td>
<td>1.35 (0.10)</td>
<td>1.33 (0.12)</td>
<td>1.34 (0.10)</td>
</tr>
<tr>
<td>Time 2</td>
<td>1.34 (0.09)</td>
<td>1.29 (0.10)</td>
<td>1.33 (0.16)</td>
<td>1.22 (0.13)</td>
</tr>
<tr>
<td>Time 3</td>
<td>1.34 (0.07)</td>
<td>1.31 (0.08)</td>
<td>1.30 (0.08)</td>
<td>1.29 (0.09)</td>
</tr>
</tbody>
</table>