THE ROLE OF EXPERIMENTALLY INDUCED HIP ABDUCTOR MUSCLE STRENGTH DEFICITS ON FRONTAL PLANE BIOMECHANICS DURING GAIT

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INTRODUCTION

Knee osteoarthritis (OA) is one of the most common joint diseases, with the majority of OA related changes being observed in the medial tibiofemoral compartment. Biomechanical changes in gait have been observed in patients with medial compartment knee OA (MC-KOA). In particular, the external knee adduction moment (KAM) has been linked with the presence, severity and progression of MC-KOA [1, 2].

It has been speculated that muscular strength of the hip abductors plays an important role in the progression of MC-KOA [1,3]. Indeed, greater internal hip adduction moments during gait have been associated with a reduced likelihood of MC-KOA progression [3]. The link between reduced hip abductor function and knee joint loading during gait was recently explored by injecting a pain-inducing solution into the gluteus medius [4]. Although the injection was successful in reducing hip abductor muscular activation, it resulted in an unexpected drop in the KAM. However, it remains unclear whether the gait adaptations observed post-injection were simply an antalgic gait response to pain.

An alternative method to reduce the force output of muscles is to perform a nerve block injection. This has the advantage of not inducing pain-related gait adaptations. Therefore, this study aimed to reduce hip abductor muscular strength in healthy subjects via a nerve block injection and observe subsequent alterations in gait. Specifically, it was hypothesised that the external KAM would be greater following the nerve block procedure. A secondary hypothesis was that alterations in hip adduction moment along with contralateral pelvic drop hip adduction angles would also be observed.

METHODS

Eight healthy male subjects with no lower extremity pathology participated (age: 27±6, mass: 76±10 kg). Subjects underwent hip abductor strength testing and a three-dimensional gait analysis both prior to (PRE) and following (POST) a unilateral superior gluteal nerve block procedure. Hip abductor strength was assessed using isometric maximal voluntary contractions (MVCs). Subjects were positioned in a side lying pose with the hip ab ducted against a fixed strap so that the thigh was horizontal to the surface. A force dynamometer was placed between the thigh and strap to measure force output. Over-ground gait analysis data were collected using a motion analysis system and force plate. Reflective markers were placed on the lower extremity with the position of each marker on the skin accurately marked using an ink stamp. Following a standing trial kinematic and kinetic gait data were collected for 5 trials of the right limb.

The gluteal nerve block procedure involved an ultrasound guided lidocaine injection performed on the right side. Following the injection hip abductor MVCs were collected. The reflective markers which had been removed for the nerve block procedure were then replaced on the ink stamps and a second gait analysis was conducted.

The mean of each subject’s 3 MVC trials was taken and normalised by body mass. Three-dimensional joint angles were calculated along with inverse dynamics to estimate external joint moments during gait. Wilcoxon signed-rank tests were used to compare PRE and POST values for the following variables during the stance phase: first peak knee adduction moment (PKAM1), second peak knee adduction moment (PKAM2), hip adduction moment (HAM) at the instance of PKAM1, contralateral pelvic drop angle (PelvDrop) at the instance of PKAM1, hip adduction angle (HipAdd) at the instance of PKAM1.

RESULTS AND DISCUSSION

Following the nerve block procedure the group mean hip abductor strength decreased from a PRE value of 3.50 (±1.05) to a POST value of 1.86
(±0.66) N/kg. This corresponded to 45% drop in MVC strength. The individual drops in MVC strength are illustrated in Figure 1. Walking speed as indicated by stance time was similar between PRE and POST.

Figure 1: PRE and POST hip strength values.

A comparison between the PRE and POST kinematic and kinetic variables are presented in Table 1. It was hypothesized that decreased force output of the hip abductors would lead to subsequent increases in the knee adduction moment. However, despite large reductions in hip abductor strength following the nerve block procedure, there was no change in either PKAM1 or PKAM2. In contrast to the findings of the present study, Henriksen et al. [4] reported a decrease in knee adduction moment following reduced hip abductor activation. However, the reduced muscle activation in the afore-mentioned study was achieved by inducing pain in the hip abductors so the changes in gait may have been an antalgic gait response to pain. Given that reduced hip strength was not pain-induced in the present study, it is likely that the observed gait pattern was more representative of reduced strength as opposed to hip pain.

The present study also found no significant changes in hip adduction moment, contralateral pelvic drop or hip adduction following the nerve block (Table 1). On a similar note, Bennel and colleagues [5] investigated the relationship between hip strength and hip/knee biomechanics by increasing abductor strength using rehabilitation. They found no biomechanical changes at the hip/knee in knee OA patients following the rehabilitation program. Thus, the relationship between hip strength with hip/ knee biomechanics remains unclear. One possibility is that the decrement in force output of the hip abductors was insufficient to induce changes in walking, given that only submaximal strength is required during this activity. Secondly, it may be that other muscles compensated to control hip and knee motion. Thirdly, subjects may have adopted biomechanical changes proximal to the pelvis, such as ipsilateral trunk lean. Finally, this study may not have been sufficiently powered to detect clinically relevant changes in knee moments. A small sample size was used due to the invasive nature of the protocol.

CONCLUSIONS

Within the limitations of this preliminary study it can be concluded that a 45% drop in force output of the hip abductor muscle group did not alter the external knee adduction moment. Further, no alterations in hip adduction moment, hip adduction or contralateral pelvic drop were associated with reduced hip abductor strength.

REFERENCES


ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of Craig Mathison in collecting the data and Dr. Janet Ronsky for the use of her laboratory. Funding was provided by Alberta Innovates-Health Solutions and the Workers Compensation Board – Alberta.

Table 1: Mean (±SD) values for kinetic and kinematic variable of interest. Joint moments are expressed as a percentage of body weight and height (%BW*ht). Comparisons are made using Wilcoxon signed-rank tests.

<table>
<thead>
<tr>
<th></th>
<th>PKAM1 (%BW*ht)</th>
<th>PKAM2 (%BW*ht)</th>
<th>HAM (%BW*ht)</th>
<th>PelvDrop (°)</th>
<th>HipAdd (°)</th>
<th>Stance Time (Secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE</td>
<td>3.0 ± 1.1</td>
<td>2.7 ± 0.6</td>
<td>4.7 ± 1.0</td>
<td>1.7 ± 2.7</td>
<td>3.5 ± 3.7</td>
<td>0.66 ± 0.04</td>
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<tr>
<td>POST</td>
<td>2.9 ± 1.0</td>
<td>2.7 ± 0.5</td>
<td>4.5 ± 1.0</td>
<td>1.3 ± 2.5</td>
<td>3.2 ± 3.4</td>
<td>0.65 ± 0.04</td>
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<tr>
<td>Z score</td>
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<td>-1.54</td>
<td>-0.63</td>
<td>-0.70</td>
<td>-1.26</td>
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<td>p-value</td>
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<td>0.50</td>
<td>0.08</td>
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