THE EFFECTS OF AN EXERCISE INTERVENTION ON THE BIOMECHANICS OF AN ATHLETIC GROIN PAIN COHORT DURING THE LATERAL HURDLE HOP

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The purpose of this study was to determine the kinematic and kinetic variables that may be of importance in the investigation of athletic groin pain (AGP). This was achieved by examining the 3D kinematics and kinetics of 70 AGP patients, recorded during a lateral hurdle hop, pre and post a successful exercise rehabilitation program. Results from the Copenhagen Hip and Groin Outcome Score questionnaire demonstrated significant improvements in 5 out of the 6 subscales. Analysis of characterising phases was used to examine kinematic and kinetic changes. Multiple significant changes were identified in both angles at the pelvis, hip and thorax and moments at the hip. Findings of this study provide an insight into the kinematic and kinetic variables of importance in AGP.

KEY WORDS: Rehabilitation, Groin pain, Analysis of characterising phases

INTRODUCTION: Athletic groin pain (AGP) is a common injury in sports involving repetitive twisting, kicking and turning. In male soccer for example, AGP incidence has been reported to account for 8–16% of all soccer injuries (Ekstrand & Hilding, 1999; Werner, Hägglund, Waldén, & Ekstrand, 2009). Whilst the aetiology underlining AGP remains poorly understood, the modifiable risk factors that have been theorized to play a role in the development of AGP include muscular weakness and imbalance (Maffey & Emery, 2007; Mohammad et al., 2014), reduced muscular activity (Cowan et al., 2004; Morrissey et al., 2012) and reduced range of motion (Verrall et al., 2007). As such, non-optimal kinematics and kinetics during dynamic sporting activities may lead to increased loads being placed across the muscle, tendinous and bony structures of the anterior pelvis potentially leading to the development of AGP. To date however, no studies have reported the changes in kinematic and kinetics present after a successful exercise intervention. Such knowledge may be important for the evaluation of factors that potentially predispose to AGP and also for the management of this condition (e.g. screening, providing appropriate rehabilitation, examining the effectiveness of interventions, and providing targets for return to play decisions).
The aim of this study was to investigate the kinematic and kinetic variables that change in AGP patients after a successful exercise intervention. It was hypothesised that multiple significant changes would be identified post rehabilitation.

METHODS: Recruited through the Sports Surgery Clinic Dublin, were 70 AGP patients (mean ± *SD:* age 24.6 ± 4.8yrs, height 180.5 ± 5.8 cm, weight 81.5 ± 8.5 kg). The Sports Surgery Clinic Ethics Committee granted ethical approval for this study and all of the participants signed informed consent. This cross-sectional study involved each AGP participant attending the lab pre and post the intervention. Prior to the experimental testing, the subjects completed a standardised dynamic warm-up incorporating task specific movements. The lateral hurdle hop involved a lateral hop over a 15 cm hurdle followed by an immediate hop back to the initial starting position. The participant began on their dominant leg, contra lateral leg flexed at a 90 degree angle and hands unrestricted for balance. Participants were instructed to undertake the hop as explosively as possible. Three repetitions of this exercise were undertaken to obtain mean scores. Eight infra-red cameras (Vicon, UK), synchronized with two force platforms (AMTI, USA), were used to collect data. Reflective markers were placed at bony landmarks according to Plug-in-Gait marker

locations (Vicon, UK). Marker and force data were filtered using a fourth order Butterworth filter at 15 Hz (Kristianslund et al, 2013). Standard inverse dynamics techniques calculated segmental and joint mechanics (Winter, 2009). Analysis of characterising phases (ACP: Richter, O'Connor, Marshall, & Moran, 2014a) was conducted on the kinematic and kinetic waveforms of the trunk, hip and pelvis to generate subject scores in the magnitude domain. Subject scores were examined for differences using a paired t-test. Cohen's effect size was reported as small (0.2 – 0.5), medium (0.5 – 0.8), and large (>0.8).
All AGP patients undertook an individualised rehabilitation focused on control of the hip, pelvis and trunk during dynamic loading tasks. The intervention contained 4 phases: 1) Hip and pelvis stabilizing and strengthening exercises, 2) Lower limb rate of force development exercises and linear running drills, 3) Multidirectional running mechanics drills and 4) Return to training and competition. The progression through the phases was dictated by achieving competency in the previous level. The programme was unsupervised, but contact was made approximately every two weeks to judge progress of the patient.

RESULTS: Median recovery time was 9.14 weeks, ranging from 5.14 weeks – 29 weeks. The Copenhagen Hip and Groin Outcome Score (HAGOS) score demonstrated significant improvements in 5 out of the 6 subscales (Pain, Symptoms, Function in daily living, Function in sport and recreation and Quality of Life: $p<0.01$, d = 0.64 – 1.13). With recovery there were multiple changes in both kinematics (Table 1) and kinetics (Table 2) across all joints. At the pelvis there were significant changes in the frontal (p = <0.01, d = 0.29-0.40) and sagittal plane kinematics (p = <0.01, d = 0.22 to 0.35). At the thorax there was a reduction in thorax flexion angles (p = <0.01, d = 0.36 to 0.43) and an increase in contra lateral rotation with recovery (p = 0.02–0.03, d = 0.17 to 0.18). At the hip there was greater extension (p = <0.01, d = 0.29 to 0.33), abduction (p = 0.02, d = 0.23) and greater internal rotation (p = 0.04, d = 0.25). Significant differences were identified in all planes for hip moments. There was an increase in hip extension (p = <0.01, d = 0.32), abduction (p =0.04 d = 0.21) and a decrease in external rotation moments (p = 0.02, d = 0.30). There were no significant changes (p > 0.05) with recovery for resultant joint powers.

Table 1: Significant differences between pre- and post-intervention joint angles (°)

	Variable	Phase (%)	Mean Change	% Change	Sig (p)	Cohen's D
Pelvis	Ab/Adduction	1 -11	-0.8	33.4	<0.01	0.29
		30- 52	-1.5	54.2	<0.01	0.40
		89- 100	-1.4	43.0	<0.01	0.37
	Flex/Extension	1-16	-1.2	6.1	0.01	0.22
		40-57	-1.9	11.5	<0.01	0.35
		91- 100	-1.1	6.8	0.01	0.22
Hip	Ab/Adduction	29-43	-0.9	13.8	0.02	0.23
	Flex/Extension	1-6	-2.1	5.9	<0.01	0.29
		27-68	-2.1	5.7	<0.01	0.33
	Int/External Rotation	89-100	2.2	95.3	0.04	0.25
Thorax	Flex/Extension	1-8	-2.6	14.3	<0.01	0.43
		94- 100	-2.4	15.5	<0.01	0.40
		36 - 60	-2.2	13.0	<0.01	0.36
	Int/External Rotation	1-10	0.8	18.2	0.02	0.18
		39 -60	0.8	26.5	0.03	0.17

Table 2: Significant differences between pre- and post-intervention joint moments (Nm/Kg)

	Variable	Phase (%)	Mean Change	% Change	Sig (p)	Cohen's D
Hip	Ab/Adduction	98 - 100	0.08	29.9	0.04	0.21
	Flex/Extension	83 - 88	0.11	145.3	<0.01	0.32
	Int/External Rotation	51 - 58	0.05	10.7	0.02	0.30
		70 - 80	0.04	12.5	0.01	0.28

DISCUSSION: AGP represents a widespread problem in sport. Despite this it remains poorly understood, potentially because of the anatomical complexity of the pubic region. This study presents for the first time the effects of a successful rehabilitation on the kinematic and kinetic variables of AGP. As a result of the intervention, multiple significant biomechanical changes were identified suggesting that the null hypothesis can be rejected. The results from this study also suggest that exercise therapy can be an effective means of treatment for AGP, as supported by Holmich et al., (1999). Post intervention HAGOS scores improved in 5 out of the 6 subsections with only the subsection "participation in physical activities" showing no significant changes. Median return to play time in this study was 9.14 weeks which is 9.36 weeks and 8.16 weeks earlier than the times reported by (Holmich et al., 1999) and (Weir et al., 2011) respectively. The different rehabilitation programs utilized may explain the discrepancy in return to play times.

Post rehabilitation, the reduction in trunk flexion observed may be due to an increase in trunk stability resulting from the exercise programme. Previous research has demonstrated both reduced transversus abdominis (TA) activation (Cowan et al., 2004) and thickness (J. Jansen et al., 2010) in AGP populations. This muscle is thought to be particularly important in stabilizing the spine prior to movement of the limbs (Hodges & Richardson, 1997).The clinical relevance of TA activity as a causative factor for AGP is questionable however, since artificially induced acute groin pain also reduces relative TA thickness (J. Jansen, Poot, Mens, Backx, & Stam, 2010). At the pelvis there was a reduction in anterior tilt and an increase in contralateral obliquity post recovery. These finding are supported by previous literature in which AGP populations demonstrated reduced eccentric abdominal strength (Sayed Mohammad, Ragaa Abdelraouf, & Abdel-Aziem, 2013) and reduced gluteus medius activity (Morrissey et al., 2012). This alteration in pelvic control may highlight the potential role of excessive eccentric loading and strain to the abdominals and pubis symphysis as a mechanism for injury (Sayed Mohammad et al., 2013). Changes in pelvic kinematics also seem to have an impact further down the chain at the hip where the hip kinematics are influenced by how the hip is defined relative to the pelvis. Indeed the lack of overlap between the significant phases in hip kinematics and kinetics indicate that the observed changes in hip kinematics may not be completely attributed to neuromuscular control at the hip. Contrary to previous investigations (Kopper, Ureczky, & Tihanyi, 2012) there was an increase in hip extension moments with the reduced trunk flexion post intervention. These results indicate that during the propulsive phase of the movement the hip extensor muscles are working concentrically more. In the transverse plane the hip is more internally rotated post recovery. This change may be due to the decrease in hip external rotator moments and the trend towards decreased pelvis internal rotation in this phase.

Due to the cross-sectional design employed, it is unknown if the abnormal biomechanics associated with the AGP group are causative in nature or were as a result of the pain present with this condition. Despite this, the present study provides an interesting overview of the biomechanical changes that occur in a group of AGP patients post recovery during a lateral hurdle hop exercise. These results may allow for more targeted research investigating AGP and provide a focus for evaluating the outcomes of exercise interventions. It is acknowledged that the observed changes were generally low in magnitude (e.g. $< 3°$), so further investigations are warranted to determine the clinical relevance of these results. In addition the post rehabilitation changes demonstrated relatively low effect size scores (from 0.13 to 0.42). This is likely due to the large variability in movement patterns and magnitudes as evidenced by the standard deviations in the results. Whilst outside the scope of this paper, it is possible that the presence of sub groups demonstrating distinct movement patterns may have masked some of the changes observed (Richter, O'Connor, Marshall, & Moran, 2014b). Future studies should determine if this is the case and replicate the study using a cluster analysis.

CONCLUSION: Our findings indicate that an exercise rehabilitation program can be an effective means of rehabilitation for AGP. The biomechanical results of this study are a novelty in the area of AGP and significant differences from pre to post recovery were identified across multiple phases and at all joints examined. These results provide an insight into the biomechanical variables of importance in AGP and may provide a focus for future research into this condition.

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