“A Biomechanical Assessment of Gait Patterns and Risk of Associated Overuse Conditions among Mature Female Runners.”

Submitted by Kim Louise Lilley to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Sport and Health Sciences In February 2012.

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ABSTRACT

Due to a proliferation of health and social advantages, the popularity of running among the more mature members of the female population is expanding steadily. However, with both age and gender acting as possible risk factors, the incidence of running related injuries and associated conditions is high among this group. With the predominance of debilitating conditions such as knee joint osteoarthritis acting at the knee joint, knowledge of lower limb biomechanics during running will provide insight into possible risk factors and potential management strategies. Three biomechanical and one magnetic resonance imaging study focussed on the specific running gait of mature females and the effect of footwear on lower limb joint kinematics and loading. The biomechanical studies used synchronised ground reaction force and lower extremity kinematic data to provide three dimensional running data and knee moments for each female. The long term study objectives were to 1) determine whether the running gait of mature females could be a predisposing factor to injuries and conditions at the knee joint, and 2) determine if changes in footwear could modify biomechanical variables associated with the development of injuries and overuse conditions among this group.

In Study One, a direct comparison of mature and young female running gait was used to identify any biomechanical movement characteristics specific to the mature group that could predispose to injuries and debilitating conditions. It was found that rearfoot eversion, ankle dorsiflexion, knee internal rotation, and knee external adductor moment that are associated with increased loading of the lateral knee joint and possible medial knee joint osteoarthritis development, were significantly higher among the mature females compared to the younger group (p<0.05).
A common management strategy for running related conditions is the adaption of footwear. Therefore Study Two investigated the effect of a motion control running shoe on the running gait of young and mature females, with a specific focus on the variables associated with knee joint injury and osteoarthritis development. The results showed a motion control shoe to reduce certain biomechanical variables (rearfoot eversion and knee internal rotation) associated with mature female runners. However, one variable (knee external adductor moment) commonly associated with increased medial knee loading and osteoarthritis development, remained high among the mature females.

One specific method used to reduce the knee external adductor moment, is the implementation of a lateral wedge in running shoes. Therefore, Study Three assessed the singular effects of a medial wedge, a lateral wedge, and then the effect of an orthotic combining both interventions on the running gait of mature females. Results demonstrated non significant changes in any kinematic variable with the medial or lateral wedge, although the lateral wedge was shown to reduce the knee external adductor moment. The orthotic intervention however produced significant reductions in rearfoot eversion, knee internal rotation, and knee external adductor moment previously found to be high among mature female runners.

Although all mature females studied had previously been characterised as free from symptoms of knee injury or osteoarthritis, a final investigation was undertaken to assess the condition of the knee joint (Study Four). Magnetic resonance imaging scans of the knee were taken for ten of the mature females. Results indicated that eight out of the ten females had early stage osteoarthritis present, with an average 79% of features presenting on the medial side of the knee joint. Additionally, there was a strong positive correlation between knee osteoarthritis and the knee external adductor moments measured in the ongoing biomechanical study (Study Three).
These studies have shown that the running gait of mature females is significantly different to that of younger female runners, and could predispose the mature group to injury and knee osteoarthritis development. The trends in kinematic adaption to a motion control shoe have shown promising results, and indicated the potential for footwear to reduce rearfoot eversion and knee internal rotation among mature female runners. However, a specific orthotic, incorporating both medial and lateral support has been found to reduce biomechanical features of gait associated with overloading at both the medial and lateral knee joint. The positive correlation between the knee adductor moment and signs of osteoarthritis for an asymptomatic population suggests that the knee adductor moment may be a useful predictive tool for identifying female runners at risk of osteoarthritis development.
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PUBLICATIONS AND CONFERENCE PRESENTATIONS

Publications.


Presentations.


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<th>TERMINOLOGY</th>
<th>DEFINITION</th>
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<tr>
<td>Angular Velocity</td>
<td>Rate of change of angular displacement.</td>
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<tr>
<td>Calibration</td>
<td>Comparison of a measurement to a standard of known accuracy.</td>
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<tr>
<td>Gait</td>
<td>The pattern of movement of limbs during locomotion.</td>
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<tr>
<td>Ground Reaction Force</td>
<td>The force exerted by the ground on to a body.</td>
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<td>Injury</td>
<td>Damage to soft tissue or bone of the musculoskeletal system.</td>
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<tr>
<td>Insole</td>
<td>See footbed. Can be altered to increase cushioning.</td>
</tr>
<tr>
<td>Joint Stiffness</td>
<td>Relationship between the deformation of a body and a given force.</td>
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<tr>
<td>Moment</td>
<td>A combination of the force applied to a segment, and the distance to the centre of rotation.</td>
</tr>
<tr>
<td>Motion Capture System</td>
<td>Combination of cameras and force plates used to assess human motion.</td>
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<tr>
<td>Muscle Strength</td>
<td>Propensity of a muscle to move a limb about a joint.</td>
</tr>
<tr>
<td>Orthotic</td>
<td>Orthopaedic device designed to support or alter the alignment of the limb or torso. Lateral wedge</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>A multifactorial degenerative joint disease.</td>
</tr>
<tr>
<td>Overuse/Debilitating Condition</td>
<td>Degeneration of the bone or articular cartilage.</td>
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<tr>
<td>Plane of Movement</td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>Longitudinal plane that divides the body into anterior and posterior sections.</td>
</tr>
<tr>
<td>Sagittal</td>
<td>Vertical plane that divides the body into medial and lateral sections.</td>
</tr>
<tr>
<td>Transverse</td>
<td>Horizontal plane that divides the body into superior and inferior sections.</td>
</tr>
<tr>
<td>Smoothing</td>
<td>Removal of high frequency noise from a data set.</td>
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Footwear Variables

Footbed Manufacturer designed lining of shoe.
Orthotic Intervention Full length lateral wedge with medial arch support.
Wedge 6mm (medial/lateral) wedge placed under footbed.

Variables of Gait

Abduction Movement of a limb away from the midline of the body (frontal).
Adduction Movement of a limb towards the midline of the body (frontal).
Eversion Lateral tilt of the rearfoot on the oblique axis of the subtalar joint (frontal).
Extension Movement of a joint causing an increased angle between two segments (sagittal).
Flexion Movement of a joint causing a decreased angle between two segments (sagittal).
Inversion Medial tilt of the rearfoot on the oblique axis of the subtalar joint (frontal).
Rotation Rotation of a segment or joint about a rotation axis (transverse).

Abbreviations

KOOS Knee Osteoarthritis Observation Survey
MRI Magnetic Resonance Imaging