GAIT RETRAINING IN RUNNERS:

an application of the Vicon Real-Time System

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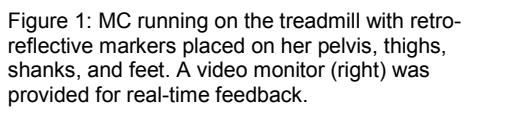

Figure 1: MC running on the treadmill with retro-reflective markers placed on her pelvis, thighs, shanks, and feet. A video monitor (right) was provided for real-time feedback.

The Running Injury Clinic (RIC) at the University of Delaware investigates the etiology of running related injuries. Irene McClay Davis PhD, PT is the director of the RIC and has been investigating running injuries for the past 20 years. With the assistance of Reed Ferber PhD, ATC, CAT(C), a post-doctoral fellow working with Dr McClay Davis, the RIC has begun to investigate how gait retraining may be used to prevent running related injuries.

While running has become one of the most popular forms of exercise because of its convenience, health benefits, and economical nature, it has been reported that between 25 and 65% of all runners experience running related injuries each year (Taunton et al., 2002). Several etiological factors have been identified as potential contributors to running injuries including training mileage and intensity, structural alignment, and running mechanics. Training errors are thought to account for the majority of injuries and are easily modifiable. Some structural characteristics can be altered through stretching and strengthening.

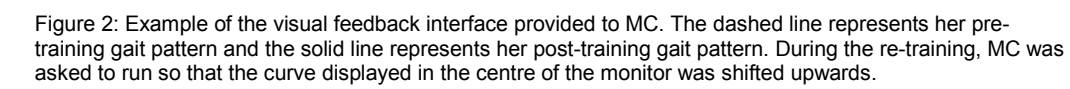

Figure 2: Example of the visual feedback interface provided to MC. The dashed line represents her pre-training gait pattern and the solid line represents her post-training gait pattern. During the re-training, MC was asked to run so that the curve displayed in the centre of the monitor was shifted upwards.

However, much of one's structure cannot be changed. Abnormal running mechanics are often cited as the cause of running related injuries and foot orthotic devices are commonly used to attempt to modify abnormal running mechanics. However, few sports medicine professionals suggest altering a person's running pattern in order to reduce the risk of injury. In part, this is because locomotion is thought to be automatic and thus difficult to change. From a historical perspective, therapists, coaches, and clinicians have often worked to alter movement patterns to increase performance and decrease injury. However, one must know which variables to change, and there is little research identifying the relationship between running mechanics and injury. One of the first studies investigating the alteration of a runner's gait patterns was presented by Dr. McClay Davis and colleagues (1999) at the American Society of Biomechanics. A single subject seeking treatment of plantar fasciitis was trained to modify her gait patterns while she ran on a treadmill using visual feedback from a mirror. Following the eight week training period, the runner was able to alter the running patterns and remain injury free. However, the feedback used in this situation was difficult to quantify from a research perspective. Vicon's new real-time system allows for this, and the Motion Analysis Lab at the University of Delaware has been chosen as a site to help develop the application of real-time feedback using the new system. The purpose of this pilot program is to assess the lower extremity running mechanics of an injured runner and investigate the effect of a gait retraining program on the alteration of mechanics as well as resolution of running injuries.

The subject, MC, is a 46-year-old female runner training for a marathon. She had been running approximately 15 years and ran 4-5 times per week averaging 20-30 miles. MC had been complaining of anterior knee pain which prompted her to visit the RIC for an assessment of her running mechanics. Visually, it was noted that MC exhibited increased hip adduction and internal rotation, genu valgum, and rearfoot pronation during the stance phase of running on a treadmill. It was hypothesized that MC's patellofemoral pain was due to an excessively internally rotated femur, and would be resolved if her gait mechanics could be altered so that she exhibited greater hip external rotation during the stance phase of gait. MC was placed in

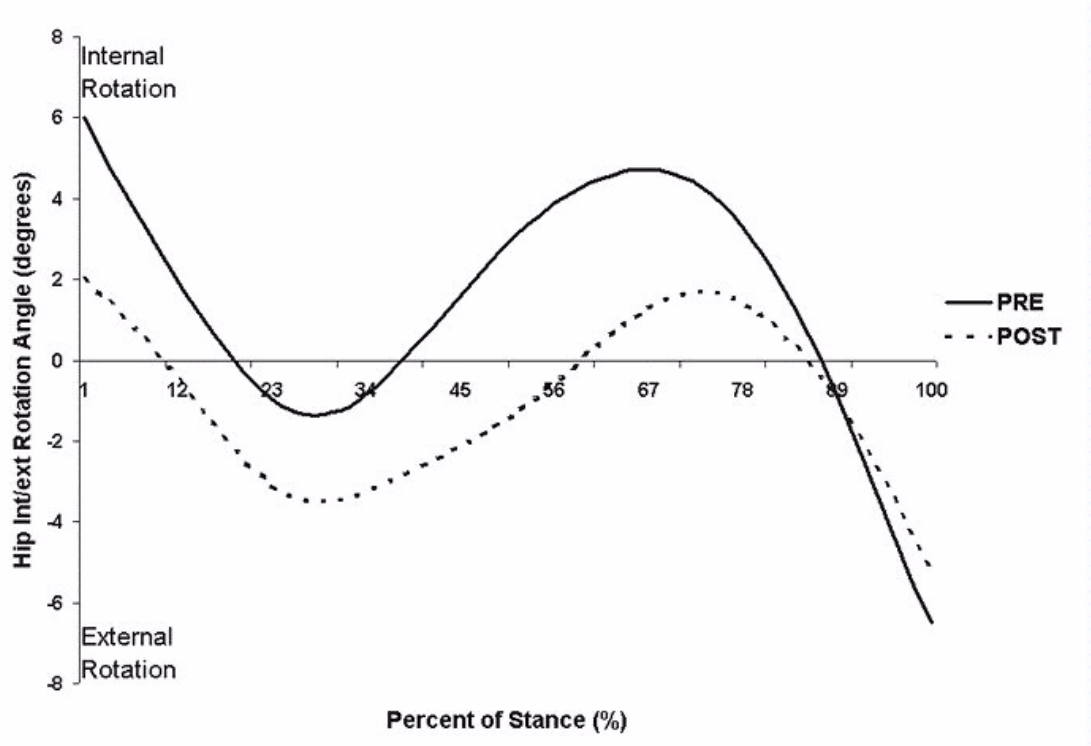

Figure 3: Hip internal/external rotation angular motion for MC prior to (solid line) and following the ten week training period (dashed line). Post-training, MC exhibited a greater hip external rotation joint angle compared to pre-training during most of stance.

a gait retraining program consisting of laboratory visits once a week for ten weeks. In addition, she was provided with a home rehabilitation program consisting of several strengthening and stretching exercises aimed at reducing hip adduction and internal rotation during weight bearing activities.

The Vicon 512 (Vicon Motion Systems) 120 Hz 6-camera motion analysis system was used to collect bilateral lower extremity 3D joint kinematic data while MC ran on a treadmill for 30 minutes (Figure 1). The processed 3D kinematic data collected by the Vicon DataStation (v3.7 Build 074) were transferred to the Vicon Real-Time Engine (Tarsus v1.0) with output marker and segment positions and rotations. This information was then on-line and transferred to Polygon v1.0 software where lower extremity segment and marker position data were displayed on a monitor for the subject to observe (Figure 2). Data were only presented during the stance phase of gait by selecting triggers based on heel and toe marker kinematic data. MC was asked to alter her gait mechanics by shifting the chosen angular curve in the appropriate direction to provide more normal alignment.

Results and Discussion

Initially, MC experienced muscle soreness in her hip abductors and external rotators. This soreness resolved over the course of one week. Over the ten week training period, the patellofemoral pain MC had experienced was resolved. In addition, she was able to reduce the amount of hip external rotation (Figure 3) throughout stance, and thus reduce the hip internal moment during early stance (Figure 4). Tiberio (1987) has suggested that excessive femoral internal rotation may be necessary to achieve the relative internal rotation needed at the knee. However, Tiberio (1987) suggested that this excessive internal rotation of the femur may result in malalignment of the patellofemoral joint and lead to anterior knee pain. We believe that by increasing the amount of hip external rotation, MC's femur is better aligned with respect to the patella allowing for more normal tracking of the patella within the patellar groove of the femur.

Future Directions

The gait pattern of increased hip adduction, internal rotation, and genu valgum is commonly seen in injured runners. The RIC is continuing to collect data using Vicon's real-time feedback system with more subjects who exhibit this gait pattern. Since this project is in the

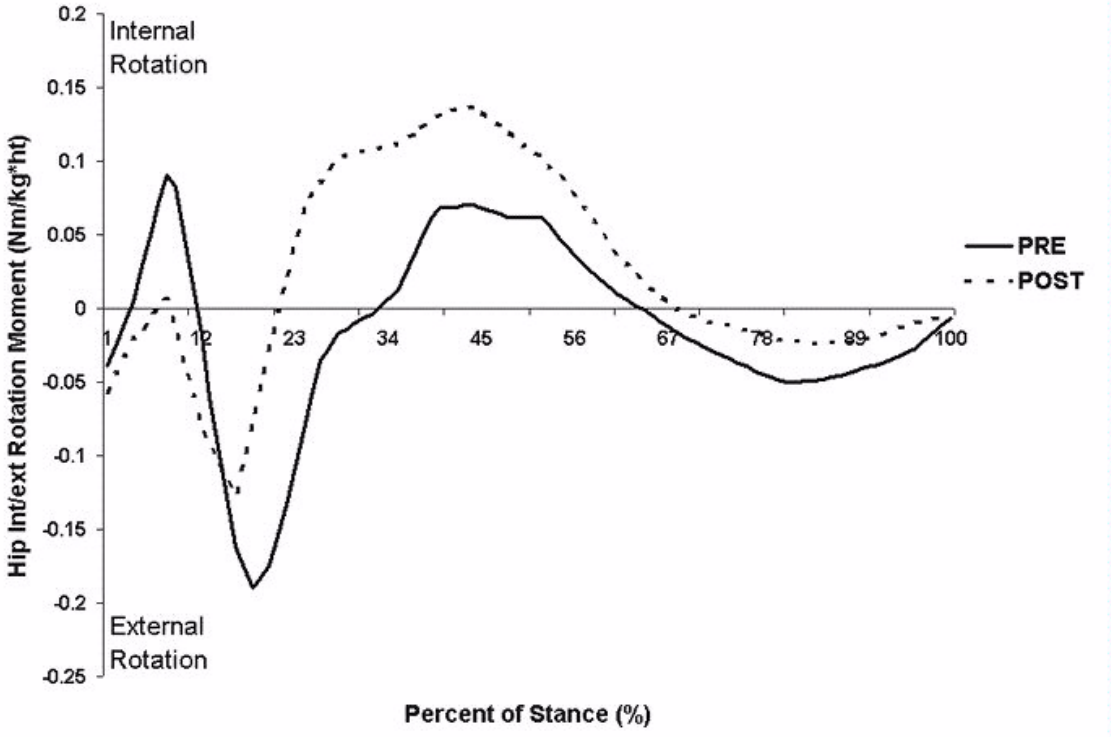

Figure 4: Hip internal/external rotation moment for MC prior to (solid line) and following the ten week training period (dashed line). Post-training, MC exhibited less hip internal rotation torque during early stance compared to pre-training.

infancy stages, we are continuing to determine which variables are the best indicators of improper gait mechanics and which variables should be provided for real-time feedback. In addition, it is important to determine whether or not subjects involved in this type of gait retraining can maintain the new gait patterns or if they revert to their pre-training pattern over time. Thus, it may be necessary to bring runners back at some determined time intervals to "tune-up" their gait pattern. It is hoped that this new technology will provide a treatment option for those runners whose injuries are deemed related to abnormal mechanics.

References

McClay, IS, Williams, DS & Laughton, CA. **Can Gait be Retrained to Prevent Injury in Runners?** Presented at the American Society of Biomechanics, 10/99, Pittsburgh, PA.

Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. **A retrospective case-control analysis of 2002 running injuries.** Br J Sports Med. 2002; 36(2):95-101.

Tiberio, D. **The effect of excessive subtalar joint pronation on patellofemoral mechanics: a theoretical model.** J Orthop Sports Phys Ther. 1987; 9(4):160-165.