THE EFFECT OF HIP STRENGTHENING ON RUNNING AND SQUATTING MECHANICS IN FEMALE RUNNERS

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INTRODUCTION

Excessive hip adduction and internal rotation during running has recently been associated with a number of running-related injuries including patellofemoral pain syndrome and iliotibial band syndrome [1,2]. This pattern is especially noted in females. Hip strengthening is often advocated for these individuals to improve their mechanics and reduce their symptoms. It has been shown that these programs improve strength [3] and reduce symptoms [4]. However, it is not clear whether strengthening the hip results in a change in movement patterns during functional activities.

Only one study has examined the effect of hip strengthening on running mechanics [5]. The study involved active females with normal hip mechanics. A small but significant increase (1.4°) in peak hip adduction excursion during running was noted. The change in the opposite direction may have been due to between-day error resulting from marker placement. Strengthening alone may not result in meaningful improvements in hip kinematics. It is also plausible that subjects with normal hip mechanics do not have much capacity for improvement.

Therefore, the purpose of this study was to examine the effect of a hip strengthening program on both running and squatting mechanics in females with excessive peak hip adduction during running. It was hypothesized that hip adduction would not be improved during running. However, as the program included single leg squat exercises, a decrease in hip adduction during this activity was expected.

METHODS

An a priori power analysis revealed that 10 subjects per group were required to adequately power this investigation. To date, 5 subjects (23.1 years ±3.5) and 4 controls (22.4±2.1) have been analyzed. All subjects were healthy and running at least 6 miles a week. For inclusion, peak hip adduction during running had to be ≥ 20°, which was 1 sd above the mean of a normative database of healthy runners.

Baseline data were collected on all subjects. 35 retroreflective markers were utilized to analyze running kinematics (VICON, Oxford, UK). Anatomical marker placement was recorded via a marker placement device, which has been shown to improve day-to-day reliability [6]. Data were first collected during a single leg squat. Subjects were asked to squat to at least 45° knee flexion for 5 consecutive repetitions. Hip adduction and internal rotation were analyzed at the point of 45° knee flexion. Next, participants ran at 3.35 m/sec on an instrumented treadmill (AMTI, Watertown, MA). Following a 5 minute warm-up, kinematic and kinetic data were sampled at 200 Hz and 1000 Hz, respectively. 3-D joint angles were calculated with Visual 3-D software (C-Motion Bethesda, MD). Customized software (National Instruments, Austin, TX) was utilized to extract variables of interest.

Peak hip abduction and external rotation strength values were collected via a handheld dynamometer (Nicholas, Lafayette, IN). The dynamometer was stabilized against the subjects with straps to eliminate the potential effect of examiner strength. Strength values were normalized to body weight and limb length. The peak of three maximal effort trials was used for analysis.

Subjects in the strength training group (STR) completed a 6-week, 3x/week hip strengthening protocol aimed at the hip abductors and external rotators. Exercises were progressed weekly under the supervision of a physical therapist. They included both supine and standing exercises. Standing exercises included single leg squats and were performed in front of a mirror in order to monitor proper lower extremity alignment. Subjects in the control group (CON) did not engage in any strength training. Following the 6-week intervention or control period, all subjects returned for a final hip strength measurement and motion analysis session. The marker placement device was used to place the anatomical markers using the positions recorded during the first visit. The analysis of running and
squatting kinematics were repeated. Meaningful changes were operationally defined as $\geq 15\%$.

RESULTS
Hip strengthening resulted in a 45.3\% increase in hip abduction strength and a 29.1\% gain in hip external rotation strength (Fig. 1). No changes were noted in the CON group for either measure.

![Graph showing hip torque comparison](image)

**Fig. 1:** Comparison of hip torque, pre- and post-intervention.

During the single leg squat, hip adduction was decreased by $7.5^\circ \pm 6.3$ (-85.4\%) in the STR group (Fig. 2). Hip internal rotation was not changed. No changes were seen in either measure in the CON group.

![Graph showing single leg squatting kinematics](image)

**Fig. 2:** Single leg squatting kinematics, pre- and post-strengthening for the STR and CON groups.

As expected, there were no changes in hip kinematics during running as a result of the strengthening program (Fig. 3). No changes were noted in the CON group as well.

![Graph showing running kinematics](image)

**Fig. 3:** Hip kinematics during running, pre- and post-strengthening for the STR and CON groups.

DISCUSSION
It appears that the 6-week intervention produced a marked gain in hip strength. In addition to the hip abductor and external rotator strengthening exercises, subjects also performed single leg squats. This single leg squat training likely explains the improvements seen in the single leg squat. Perhaps more importantly, subjects were instructed in proper alignment during this activity and were able to monitor themselves in a mirror as they performed their squat training. This feedback may be considered neuromuscular training that is specific to single leg squatting. The incorporation of this neuromuscular retraining may have contributed the most to the reductions in peak hip adduction values during single leg squatting.

While hip strength was notably increased, hip mechanics during running were completely unaffected by the strengthening program. While these runners were healthy, the peak hip adduction they exhibited was similar to that of runners with patellofemoral pain syndrome and iliotibial band syndrome. Hip strengthening, including single leg squats, is often part of treatment for these injuries. It is unlikely that this standard approach will improve abnormal running mechanics in these patients.

It has recently been shown that neuromuscular re-education, using real-time feedback during running, can significantly reduce abnormal hip mechanics [7]. This was accomplished in the absence of a strengthening program. Therefore, if the goal of an intervention is to improve mechanics, it appears that neuromuscular re-education is needed and strength training alone is inadequate.

CONCLUSIONS
These preliminary data suggest that hip strengthening alone does not result in meaningful changes in hip kinematics during running.

REFERENCES

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