The effect of adopting proper running form techniques on hip strength in healthy females

Patrick J. Lawrence; Heather Gulgin, Ph.D, ATC; Jason Burgess

Grand Valley State University, Allendale, MI 49401

Introduction

It is estimated that over 50% of recreational runners sustain a running-related injury per year, with half of those injuries occurring at the knee.[10] Several of those knee injuries, especially patellofemoral pain (PFP) and Iliotibial Band Syndrome (ITBS), are linked to weakness in the hip abductor muscles and hip external rotator muscles, and can be effectively treated with strength training of those muscles.[2,3,4] Females are have a higher incidence of these injuries than males.[5,9] Thus, the discovery and implication of effective methods of hip strengthening may be essential for a widespread reduction in running-related knee injuries, especially in females.

Adopting a "proper" running form is claimed to reduce the risk of running-related injuries relative to traditional heel-striking running forms.[1,6,7] Despite these claims, scientific research linking running form and injury rate is preliminary and remains inconclusive. However, if a correlation is found between proper running form and hip muscle strength, it could help validate the application of proper running form adoption as a method for injury prevention and rehabilitation.

Purpose and Hypothesis

The purpose of this study is to determine whether instruction and practice in proper running form techniques can strengthen the hip abductor and hip external rotator muscles in female recreational runners. It was hypothesized that female runners who practiced proper form techniques over six weeks of running would show a greater increase in hip abduction and hip external rotation strength than a control group of female runners that did not receive instruction.

Materials and methods

Four college-aged females volunteered and completed the six-week running protocol (demographics in **Table 1**). All subjects met the inclusion criteria of having at least two weeks of running 10-20 miles per week and having no injuries two months prior to the start of the study. All subjects signed an informed consent form before testing.

Subjects were randomly placed in the experimental (E) or control (C) group. Both groups were assigned six weeks of running 12 to 16 miles per week on a treadmill at a self-selected pace. Subjects were instructed to avoid any other consistent physical activity that worked the core and legs for the study. Subjects recorded mileage and physical status in an electronic journal that was emailed to the researchers at the end of each week.

Strength testing occurred before the first week (baseline), after the third week (midline), and after the sixth week (endline) of the protocol. The methods used for testing hip external rotation (ER, **Figure 1**) and hip abduction (ABD, **Figure 2**) and measured isometric force output with a manual muscle tester (MMT). For ABD, subjects lifted their leg as hard as they could up into the MMT for three seconds. Likewise for ER, subjects rotated their femur and pushed as hard as they could into the MMT for three seconds. The peak force of each trial was recorded. Four trials (one practice and three actual) of each strength test were performed on both legs with thirty seconds of rest in between.

Six separate (one for each side and strength test) two-way repeated measure ANOVA tests were performed in which time and treatment were the variables. A confidence value of 0.95 was set to assess significance.

Figure 1. Set up for external rotation strength test.

Figure 2. Set up for hip abduction strength test.

Proper Running Form Training

The E group received three sessions of form training with the primary researcher: in the first week, second week, and fourth week of the protocol. They received training in the following set of techniques characteristic of proper form (note: this is a condensed list):

- Straight posture with a slight forward lean from the ankles (utilizes the force of gravity to pull the runner forward)
- Head up and looking forward
- Shoulders relaxed and dropped down
- Arms relaxed at the sides, with elbows held at 90 degrees. When running, arms swing forward and back, never crossing the midline of the body.
- Landing on a bent/flexed knee (rather than a straight knee)
- Short strides with a high cadence (stride rate) of 180 steps per minute
- Landing near one's center of gravity (underneath the hips).
- Aiming to land on the middle (midfoot) or front (forefoot) of the foot rather than at the heel (heel strike).
- Lower leg (below the knee) is relaxed

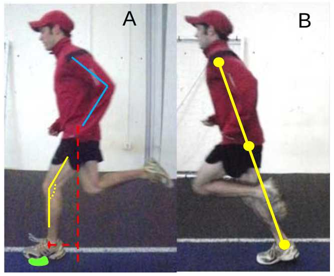

Figure 3. Visual representation of proper running form techniques. At footstrike (A), note the flexed knee, midfoot strike (indicated by the green zone), elbows bent at 90 degrees, and the close proximity of the foot to the hip center (red line). In stance (B), note the straight posture, raised head, and forward lean originating from the ankles (a straight line can be passed through the shoulder, hip, and knee joints).

At the form training sessions, a camera was used to videotape subject's form and replay it back for teaching. Mental imagery and drills of wall leaning and "falling" into stride outs were used to help adopt the form. Subjects were instructed to learn the form gradually and advised to practice it only partially during each run in the beginning weeks. Soreness and other physical statuses were monitored through the running journals and email communication.

Results

Table 1. Subject demographics with average weekly mileage over 6-week protocol (Mean ± SD)

Group	Age (years)	Height (cm)	Weight (kg)	Average Weekly Mileage (miles)
C (n = 2)	20.5 ± 0.7	162.3 ± 3.9	64.6 ± 12.2	12.8 ± 1.1
E (n = 2)	19.0 ± 0	166.8 ± 3.9	59.4 ± 5.2	14.8 ± 0.4

Table 2. Force output (Mean ± SD) of isometric hip abduction over time per side (R = right, L = left) and group (E = experimental, C = control)

Abduction		Force Output (kg)			Significance Between Groups
Side	Group	Baseline	Midline	Endline	
R	E	16.1 ± 5.8	13.8 ± 4.5	17.9 ± 2.8	0.522
	C	16.6 ± 2.6	14.1 ± 3.2	13.3 ± 1.1	
L	E	14.0 ± 1.5	12.6 ± 1.5	17.3 ± 1.2	0.372
	C	14.9 ± 2.4	14.3 ± 3.0	11.8 ± 2.3	

Hip Abduction*:* The E group showed an initial decrease in mean force output on both sides from baseline to midline, followed by an increase from midline to endline, finishing with a higher force output than at the start (**Table 2**). The C group showed a general decrease from start to finish. Although the two groups showed different trends, the difference in strength change was not significant.

Table 3. Force output (Mean ± SD) of isometric hip external rotation over time per side (R = right, L = left) and group (E = experimental, C = control)

External Rotation		Force Output (kg)			Significance Between Groups
Side	Group	Baseline	Midline	Endline	
R	E	6.4 ± 2.1	6.4 ± 3.1	5.7 ± 1.6	0.931
	C	6.5 ± 0.7	5.7 ± 2.6	6.1 ± 3.0	
L	E	6.1 ± 2.3	6.0 ± 2.1	5.6 ± 0.6	0.386
	C	4.4 ± 1.1	5.2 ± 2.9	4.8 ± 3.8	

External Rotation: The E group showed a small decrease in mean force output from start to finish (**Table 3**). The C group showed an initial decrease on the right and an initial increase on the left, followed by a return towards baseline values. The difference in strength change over time between the E and C groups was not significant.

Table 4. Symmetry of hip strength as measured by the difference of force output (Mean ± SD) between the left and right side for hip abduction and external rotation over time.

Hip Symmetry		Difference in Force Output (kg)			Significance Between Groups
Test	Group	Baseline	Midline	Endline	
Abd	E	2.0 ± 4.7	1.2 ± 4.9	0.6 ± 2.4	0.875
	C	1.7 ± 1.8	0.2 ± 1.4	1.5 ± 2.4	
ER	E	6.1 ± 2.3	6.0 ± 2.1	5.6 ± 0.6	0.026*
	C	4.4 ± 1.1	5.2 ± 2.9	4.8 ± 3.8	

Symmetry of Hip Strength: The E group showed a decrease in both ABD and ER force output difference between sides, indicating a progression towards improved symmetry (**Table 4**). The C group's difference in the ABD and ER tests was unchanged between baseline and endline, despite changes seen at midline. This indicates no overall change in symmetry. The difference between groups for abduction was not significant, while the difference between groups for ER was significant (*).

Within-group Effects: Additional analysis determined whether time had a significant interaction with the change in force output when the groups were combined. The effect of time was found to be significant ($< .05$) for right and left ABD.

Conclusions

In ABD, the E group showed an overall increase in force output, suggesting that an increase in strength occurred in the hip abductors. The researchers theorize that in order to balance the leg and prevent the knee from collapsing inward (valgus), more muscle activation occurs when landing on a flexed knee than landing on a straight leg where the skeletal structure provides the rigidity of the knee joint. The initial decrease in force output from baseline to midline in the E group could be related to the initial performance drop seen in other sports and physical activities when a new protocol is started.

The observed decrease in ER strength in the E group may be due to the shortening of the subjects' stride length. Longer strides show more transverse (rotational) movement of the hip in order to extend the leg in front of the body; thus, shorter strides require less rotation, and the external rotators of the hip would be less activated.

The symmetry of hip strength was also focused on in this study since some evidence suggests that hip strength asymmetry, not just overall muscle weakness, is a factor in knee injuries such as PFP.[8] The E group showed an increase in symmetry while the C group remained unchanged, possibly suggesting that the form alterations promoted a more balanced muscle recruitment.

Many limitations existed in this study. The mileage was self-reported by the subjects. Other uncontrolled variables may have affected results, including sleep status, motivation, and time of testing. There was also no standardized system to evaluate subjects' running form before and after the protocol, so a subject's level of form adoption was not taken into account in the results. Regardless of the results, however, this study proposes a novel method of testing proper running form over a multi-week period and as a set of combined techniques rather separate techniques (i.e. focusing only on midfoot strike). Future studies should measure the kinematic and kinetic changes during long-term form training.

Literature cited

1. Dreyer, D. (2009). *Chi running: A revolutionary approach to effortless, injury-free running.* New York: Fireside
2. Ferber, R., Kendall, K. D., Farr, L. (2011). Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome. *Journal of Athletic Training,* 46(*2*), 142-149. Retrieved from http://www.mendeley.com/research/changes-knee-biomechanics-after-hipabductor-strengthening-protocol-runners-patellofemoral-pain-syndrome/
3. Fredericson, M., Cookingham, C. L., Chaudhari, A. M., Dowdell, B. C., Oestreicher, N., & Sahrmann, S. A. (2000). Hip abductor weakness in distance runners with iliotibial band syndrome. *Clinical Journal of Sport Medicine*, 10, 169-175. Retrieved from http://www.udel.edu/PT/davis/Hip_strength_PFP.pdf
4. Ireland, M. L., Willson, J. D., Ballantyne, B. T., & Davis, I. M. (2003). Hip strength in females with and without patellofemoral pain. *Journal of Orthopedic and Sports Physical Therapy,* 33(*11*), 671-676. Retrieved from http://www.udel.edu/PT/davis/Hip_strength_PFP.pdf
5. Jacobs, C. A., Uhl, T. L., Mattacola, C. G., Shapiro, R., Rayens, W. S. (2007). Hip abductor function and lower extremity landing kinematics: Sex differences. *Journal of Athletic Training,*42*(1)*, 76-83. Retrieved from: http://www.ncbi.nlm.nih.gov.ezproxy.gvsu.edu/pmc/articles/PMC1896084/pdf/i1062-6050-42-1-76.pdf
6. Playmakers. (2011). Good form running: Four simple steps to good form. Retrieved from http://www.goodformrunning.com/
7. Pose Tech Corp. (2009). Pose method in running. Retrieved from http://www.posetech.com/pose_method/pose-method-of-running-technique.html
8. Robinson, R., & Nee, R. (2007). Analysis of hip strength in females seeking physical therapy treatment for unilateral patellofemoral pain syndrome. *Journal of Orthopedic and Sports Physical Therapy,* 37*(5)*. Doi:10.2519/jospt.2007.2439
9. Taunton, J. E., Ryan, M. B., Clement, D. B., McKenzie, D. C., Lloyd-Smith, D. R., & Zumbo, B. D. (2002). A retrospective case-control analysis of 2002 running injuries. *British Journal of Sports Medicine,* 36, 95-101. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1724490/pdf/v036p00095.pdf
10. van Gent, R. N., van Middlekoop, M., van Os, A. G., Bierma-Zeinstra, S. M. A., & Koes, B. W. (2007). Incidence and determinants of lower extremity running injuries in long distance runners: A systematic review. *British Journal of Sports Medicine,* 41, 469-480. doi: 10.1136/bjsm.2006.033548

Acknowledgments

We thank the Physical Therapy Department of GVSU for their lending of the handheld dynamometer, inclinometer, and lap belts used in this study . We also thank Michelle Emmanuel for her assistance with pilot study data collection.

For further information

regarding this study, please contact Patrick J. Lawrence at *lawrenpa@mail.gvsu.edu.*