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Differences in Foot-strike Patterns during Jogging: A Literature Review

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ABSTRACT (100-200 WORDS):

The title of my project is called Differences in Foot-strike Patterns during Jogging: A Literature Review. The purpose of this literature review was to find out which foot-strike pattern, forefoot or rearfoot, induces the least amount of injury. The procedure involved reviewing four different studies and comparing and contrasting their results. After comparing and contrasting the four separate studies it was found that by using the forefoot foot-strike pattern the runner is exerting less pressure and shock on the joints; therefore, leading to a lower rate of injury, as opposed to rearfoot runners. In conclusion, it seems that by utilizing a forefoot strike pattern while running will help reduce injuries. This literature review has provided me the information to perform my own experiment to find out whether forefoot strikes or rearfoot strikes will produce less injury in a runner.

"Over the course of a 5-k run, the average runner will strike the ground approximately 3,000 times, placing ground reaction force loads of 2.0 to 3.0 times body weight on each leg (Clarke, Frederick, & Cooper, 1983; Hennig & Lafortune, 1991; Hennig, Milani, & Lafortune, 1993; McClay & Manal, 1995b). The repetitive loading of weight after a long period of time could lead to injury. The question that arises is: when striking the ground, which part of the foot would be able to hold the most weight and be less likely to lead to injury?

There has been much debate over the correct running form that runners should use. Examining runner's style through experiments has shown that there are two main striking patterns for a runner's foot: forefoot and heel. The forefoot strike means landing in plantar flexion and inversion and then dorsiflexes and everts (McMclay and Manal). In simpler terms, the forefoot strike is when a person lands on the balls of their feet, and barely touches their heel to the ground during the running process. Whereas, the heel striking means landing on a person's heel first. During a study performed on elite runners in a marathon, it was found that 75% of the runners were heel strikers (Hasegawa). Although the majority of the runners were heel-strikers, that does not mean that heel-striking is the correct running style.

Many scientists perform experiments to compare the forefoot and heel strike. "The forefoot strike happens naturally right below a person's center of gravity; when using the forefoot strike a person runs smoothly and does not waste energy bouncing up and down" (Newton Natural Running). By using the forefoot strike, a person is not putting excess stress on their joints (knees, hips, and ankles). The forefoot strike "helps decrease the vertical velocity of the center of mass and may effectively attenuate some of the impact shock of foot strike" (Laughton, Davis, & Hamill). On the other hand, heel striking happens in front of a person's center of gravity, causing that person to slow down at the point of impact. By leading with their heel, a person is actually causing more shock to their joints, which is likely to cause more injuries. Also, all of the impact energy is being transferred to that person's knees and hips, instead of into forward motion, causing the person to bounce up and down more often and not travel as far (Newton Natural Running).

Recent studies have studied the difference in foot strike (forefoot vs. heel) in two separate groups over a period of time. This literature review will encompass looking at four approaches to figuring out which foot-strike is the best and compare and contrast the findings. This study will

also provide more insight to the ongoing research of which running style is better and less likely to produce injury.

In the first experimental article reviewed, "Orthotic Intervention in forefoot and rearfoot strike running patterns", the objective of the study was to compare the two foot strike running patterns: forefoot vs. rearfoot. The experimental design consisted of fifteen subjects than ran with both a forefoot and a rearfoot strike pattern. Also, the subjects ran with and without braces (orthotic devices). In this experiment, five trials were collected for each condition. Between conditions, the following were compared: peak rearfoot eversion, eversion excursion, eversion velocity, peak inversion moment, and inversion work. The results that were found in this experiment were that increased rearfoot excursions and velocities and decreased peak eversion were noted in the forefoot strike pattern compared to the rearfoot strike pattern. However, orthotic interventions, such as braces, did not significantly change rearfoot motion in either of the foot strike patterns. It was also noted that there were reductions in the internal rotation and abduction of the knee. The article concluded with the thought that braces or orthotic devices do not differentially affect rearfoot motion of a rearfoot strike and a forefoot strike running pattern. Braces or orthotic devices do have a larger and more systematic effect on rearfoot kinetics compared to rearfoot kinematics. (Stackhouse, C. L., I. M. Davis, and J. Hamill, 2012)

To sum the first article up, it was found that while the subject was using the forefoot strike pattern, there was an increase in the heel deviating from its normal position, and there was also an increase in the speed at which the subject was running. However, it was also found that while the subject was using the forefoot strike pattern, they had a decrease in eversion, where the heel bends away from the midline of the foot. It was also found that braces did not significantly change the motion of the heel during running in either of the foot strike patterns.

The second article, "Forefoot Running Improves Pain and Disability Associated Witch Chronic Exertional Compartment Syndrome", hypothesized that adopting a forefoot strike running technique will lead to decreased pain and disability associated with chronic exertional compartment syndrome (CECS). The experiment methods consisted of ten patients with CECS enrolled in their experiment. During a 6-week forefoot running intervention, the following were taken for all patients at baseline and upon completion of the intervention: resting and post-running compartment pressures, kinematic and kinetic measurements, and self-report questionnaires. In the questionnaires, the run distance and pain levels were recorded. In order to

measure the perceived change after the 6-week intervention, a 15-point global rating of change (GROC) scale was used. The results that the experimenters found were that the mean post-run anterior compartment pressures significantly decreased. The vertical ground-reaction force and impulse values were significantly reduced. The distance that the subjects ran slightly increased, and the pain reported by the subjects significantly decreased. In conclusion, the experimenters found that the 6-week forefoot running intervention led to decreased post-running lower leg intracompartmental pressures. Also, not only was surgical intervention avoided for all patients, but also pain and disability typically associated with CECS was greatly reduced. (Diebal, Angela R., Robert Gregory, Curtis Altiz, and J. Parry Gerber, 2012)

To sum the second article up, the researches believed that using the forefoot running strike during running would decrease pain and the risk of acquiring an injury. This experiment was focused around patients who had chronic exertional compartment syndrome (CECS). According to the Mayo Clinic, "Chronic exertional compartment syndrome is an exercise-induced muscle and nerve condition that causes pain, swelling and sometimes even disability in affected muscles of your legs or arms. Anyone can develop chronic exertional compartment syndrome, but it's more common in athletes who participate in sports that involve repetitive impact exercise, such as running and fast walking" (Staff, Mayo Clinic, 2013). The results that were found in this experiment were that the front compartments of the leg had decreased pressures, the force from the ground that was exerted on the subjects while running was reduced, pain felt by the subjects was decreased, and distance ran by the subjects was increased. Overall, it seems that by utilizing the forefoot strike, people may be less likely to experience pain and decrease their risk of injury if they have CECS.

"Effect of Strike Pattern and Orthotic Intervention on Tibial Shock during Running" was the third article that I reviewed. In this article I found that the main purpose of the study was to compare forefoot and rearfoot strike patterns and orthotic interventions effect on shock to the joints in the leg. In the experiment, semi-rigid devices were constructed for fifteen runners that were injury-free. The data that was recorded four separate times (forefoot strike, rearfoot strike, with orthotic, without orthotic) was the following: tibial accelerometry, ground reaction force, and 3D kinematic data. The experimenters found that there was a significant increase in tibilial acceleration for the forefoot strike pattern compared to the rearfoot strike pattern. The experiments believed it was because of the greater peak vertical ground reaction force, peak

anteroposterior ground reaction force, anteroposterior ground reaction force load rates, knee stiffness, and leg stiffness found in forefoot strike pattern runners. Also, it was found that with an orthotic, there was decreased dorsiflexion excursion and knee stiffness was slightly increased. Overall, the article stated that "no significant interactions were found between strike pattern and orthotic condition for any variables assessed" (Laughton, Carrie A., Irene M. Davis, and Joseph Hamill, 2003).

To sum the third article up, the experimenters found that there was an increase in tibilial acceleration when the subject landed on their forefoot during running. With the use of a brace, the subject faced an increase in knee stiffness, but a decrease in deviation. Ultimately, it was found that between the variables that were measured, there was no significant difference in the running foot strike pattern that was used.

The last article I reviewed was, "Changes in Lower Extremity Movement and Power Absorption during Forefoot Striking and Barefoot Running". The main purpose of this article was to compare a forefoot strike with a barefoot strike, and ultimately compare those two foot strikes with a rearfoot strike. The way in which the researchers carried out their experiment was 20 subjects (10 male and 10 female). All of the runners were rearfoot strikers that completed a 3-step analysis that consisted of 3 conditions: rearfoot strike, forefoot strike, and barefoot strike. The results that the experimenters found were that "running with a forefoot strike pattern and barefoot resulted in significantly greater plantar flexion and significantly less negative knee power (absorption) when compared to rearfoot strike condition. Forefoot strike condition runners landed in the most plantar flexion and demonstrated the most peak ankle power absorption and lowest knee power absorption between the 3 conditions. Barefoot and forefoot strike conditions demonstrated decreased total lower extremity power absorption compared to the rearfoot strike condition but did not differ from one another" (Williams, B., DH Green, and B. Wurzinger, 2012).

To sum the fourth article up, the experimenters found that there was less shock on the knee when the runner was using the forefoot strike pattern. The experimenters also noted that most of the shock from running was being absorbed by the runner's ankle, rather than their knee. Ultimately, the experimenters found that there was not a significant difference between barefoot running and using the forefoot strike.

To easily compare and contrast the four articles reviewed, the following is a table listing the article and the results from the experiment:

Article	Results

Article #1:
Orthotic Intervention in forefoot and rearfoot strike running patterns
	• Forefoot strike pattern
	  • Increase in heel deviating from its normal position
	  • Increase in speed
	  • Decrease in eversion (heel bends away from the midline of the foot)
	• Braces
	  • Did not significantly change the motion of the heel in either of the foot strike patterns

Article #2:
Forefoot Running Improves Pain and Disability Associated Witch Chronic Exertional Compartment Syndrome
	• Forefoot strike pattern
	  • Front compartments of the leg had decreased pressures
	  • Force from the ground that was exerted on the subjects was running was reduced
	  • Pain was reduced
	  • Distance ran was increased
	  • People may be less likely to experience pain and decrease their risk of injury if they have chronic exertional compartment syndrome (CECS)

Article #3:
Effect of Strike Pattern and Orthotic Intervention on Tibial Shock During Running
	• Forefoot strike pattern
	  • Increase in tibilial acceleration
	• Brace
	  • Increase in knee stiffness
	  • Decrease in deviation
	• Ultimately, no significant difference in the running foot strike pattern that was used

Article #4:
Changes in Lower Extremity Movement and Power Absorption during Forefoot Striking and Barefoot Running
	• Forefoot strike pattern
	  • Less shock on the knee
	  • Shock is absorbed by runner's ankle
	• Ultimately, no significant difference between barefoot running and using the forefoot strike

Table 1: Comparison of Final Results of 4 Articles Reviewed

After viewing the table above, it is noted that all four articles had similar results. All four articles found that runners that use the forefoot strike pattern have a decrease in pain, increase in speed/distance, and less shock is delivered. Also, article #1 and article #3 both included the use

of braces in their experiments. Article #1 stated that there was no significant change to the motion of the heel; however, in article #3 the experimenters found that there was an increase in knee stiffness and also a decrease in deviation. Article #3 and article #4 were also similar because they both concluded with stating that ultimately, there was no significant difference between the foot strike pattern used by a runner. On the contrary, article #2 states that pain and risk of injury decreases when runners who have CECS use the forefoot strike pattern.

After thoroughly reading through all four articles and comparing and contrasting them, I have noticed that there is a pattern among the four articles; the pattern is that all of them have pointed out the benefits that forefoot running has on a runner's body. Even though I chose only four articles to review, I have looked through many databases and read many articles to make sure I have a well-rounded literature review. I found it very hard to find an article that focused on the rearfoot strike pattern and it was especially hard to find an article that stated that the rearfoot strike pattern would reduce the risk of injury. Through the examining of the articles results, and hypothesizing myself, I believe that using the forefoot strike pattern while running would be most beneficial to runners to use.

With the information that I have gathered through this literature review, I plan to take further steps to continue research on this topic in the future. My plan is to conduct a research experiment that answers the following question: Are injuries less likely to occur when landing on the mid-foot while jogging, as opposed to landing on the hind-foot, as measured by counting the number of injuries that occur in two groups of individuals participating in an 8-week jogging program? The objective of this study is to compare running foot strike patterns (forefoot and rear) and find which one is least likely to produce injury. The target populations for this study are individuals between the ages of 18-25 years, who do not have any injuries present. Anyone who does not fall in the specified age range will not be considered. Anyone who has an injury already present will not be considered. This is to ensure that the data obtained from the individuals is not a reflection of a previous injury and to prevent accidentally misconstrued interpretations.

The method of sampling for this study would be stratified random sampling because the study aims to have twenty females and twenty males in each group, but the members of each group are randomly selected. Because this study involves performing a physical activity three times a week for eight weeks, the participants will be volunteers as well. It would be unethical to force participants to perform exercise if they absolutely would not want to do that. People who

fit the criteria of the study will volunteer their participation, and then participants will be randomly assigned to a group.

Eighty individuals between the ages of 18 to 25 years who attend Northern Illinois University in DeKalb, Illinois will be selected for this study and a pre-test/post-test control group design will be used. Also, it will be necessary to obtain an equal number of males and females to allow for more comparison of the results. Therefore, forty individuals will be male and forty will be female. A qualitative approach would first involve an evaluation of each individual by a certified physical therapist. The physical therapist would do an initial evaluation on the person's lower extremities, making sure to check for any form of pre-existing injury. Once each individual is completely evaluated, the group of eighty will be divided in half – each group will have twenty females and twenty males. One group will be designated FFR (forefoot runner) and the other, RFR (rear foot runner). After each group is properly assigned, the investigator will teach and explain, to each group separately, the form in which they are to use while jogging (landing on forefoot vs. landing on rear foot).

The research will take place over an eight week course. The course will consist of running three times a week for thirty minutes using either the forefoot strike or the heel strike. Each participant will be given a log in which they will note the time, day, pace, and distance. They will also note any pain they will have during or after running each day. This log will be submitted at the conclusion of the eight weeks and evaluated to compare the two groups. Once the course is completed, the participants will then participate in a post-evaluation. The post-evaluation will include each participant receiving the same assessment they received during the pre-evaluation, from the same physical therapist that first assessed them. The point of the second assessment is to see if there have been any changes in the participant's body since the first time they were assessed. The pre-evaluation and post-evaluation information will also be compared to confirm if any injuries developed based on the foot strike style. I believe that the expected outcome after obtaining the data will be that more injuries will be present in the participants who were in the rear foot running group. If that is the case, then what can be concluded from the data is that it is more likely that a person will not obtain an injury if they land on their forefoot while jogging.

The variables controlled by the researcher would include: age (specified age range), primary diagnosis of being injury-free, means to evaluate effect of running style (injury present

vs. no injury present), and the length of time of treatment (8-weeks). The participants should be between the ages of 18-25 years because that is the age range in which I am interested in studying. Each participant must be injury-free; otherwise the resulting data could be misconstrued. The way in which the running style will be evaluated will be from comparing data from a physical therapist's assessment before and after the program. Finally, the time of the program is set to 8 weeks to allow for effective results.

In order to see if the 8-week jogging programs (group 1 and group 2) had any effect on the participant's joints/muscles, one main factor is incorporated – the assessment of each participant provided by a certified physical therapist. A bar graph can be used to present the data of the number of injuries present in each group. Using a bar graph is the best option because it will visually display the data the best. The two groups will be represented by two different color bars. There will be only one section which will represent the number of injuries that occurred after the program was completed; there will most likely be two bars in this section to represent injury in both groups. The bar graph will serve as a form of descriptive statistics. Because the results in this study will be generalized to a wider population, there will be inferential statistics. Because the scale of the study is ratio and the two groups involved are independent of one another, the test of significant would be the *t* test (independent groups). The type of hypothesis that will be proposed would be a research hypothesis. A two-tailed test will be used to analyze the data that is collected. This research experiment is projected to occur sometime during the next three years while I am in Doctorate school for Physical Therapy at Northern Illinois University.

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