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The Effect of Barefoot Running Using Two Running Styles on Lower Extremity Joint Reaction Forces

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Abstract

Introduction: As running is a popular worldwide pastime, it is beneficial to investigate potential differences in joint forces in order to determine whether or not there is a superior biomechanical running pattern. **Methods**: Research was conducted on twenty runners to observe the differences in internal joint reaction forces at the hip, knee, and ankle. Ten male and ten female participants who all naturally run with the same initial foot contact pattern (rearfoot runners) were included in this study. Each subject ran barefoot on an instrumented treadmill under the following conditions: two trials with a natural rearfoot initial contact and two trials with an induced forefoot strike. Peak joint reaction force data were averaged from five strides during both conditions to determine the peak forces experienced at the ankle, knee, and hip in each X, Y, and Z plane. **Results**: The paired samples t-test was utilized for data analysis comparing running styles for each subject. Significance was set a p<.05. Statistical analysis of the results revealed no significant difference between rearfoot and forefoot running patterns when comparing all subjects or males and females alone as all p values were greater than .05. **Conclusions**: The results of this study suggest that there may be no superior foot initial contact pattern to reduce joint reaction forces in the lower extremity. Findings from other studies in the literature support the conclusions of this current study. It is recommended that additional research be conducted in order to gain more insight as to whether or not a superior running pattern does indeed exist. If so, this would aid in helping runners improve their biomechanical efficiency and potentially reduce the possibility of overuse injuries.

Introduction

It is beneficial to investigate potential differences in joint forces in order to determine whether or not a superior biomechanical running pattern exists. The trend in recent years has been for runners to transition from a natural rearfoot strike pattern toward a midfoot or forefoot strike to increase running performance or decreasing potential injury (Fredericks et al., 2015; Kuhman, Melcher, & Paquette, 2015; Stearne, Alderson, Green, Donnelly, & Rubenson, 2014). However, there has not yet been a significant decrease in injuries for runners (Valenzuela, Lynn, Mikelson, Noffal, & Judelson, 2015) based on this change. There is a weakness in current research on the observations of internal joint forces and the effects produced due to foot strike pattern as most research in the past has focused mainly on the GRFs observed in runners with respect to strike pattern . However, the direct observation into what the joints are experiencing may help create a direct line for future conclusions on injury prevention (Rooney & Derrick, 2013). The purpose of the current study was to observe and compare joint reaction forces between rearfoot and forefoot strike patterns to determine if any consistency exists in the force loading patterns within each running style, with the hope of determining if a connection can be made between forces observed and initial contact pattern.

Methods

Each participant met the following requirements: running bouts of 3-10 miles on at least 2 days of the week, between 18 and 50 years of age, run with a heel strike, and free from any injury that could affect running performance. Each participant performed four barefoot running trials on an instrumented AMTI (Watertown, MA) treadmill (1000 Hz downsampled to 100 Hz): two with a natural rearfoot strike and two with an imposed forefoot strike. As different running speeds have been thought to cause variable forces in runners due to altering the joint kinematics, and possibly influencing the strike pattern (Fredricks et al., 2015), running velocity of each subject was standardized at five miles per hour. Subjects utilized a barefoot condition.

Five complete strides were recorded for each trial utilizing three-dimensional optical motion analysis with 10 Vicon (Oxford, UK) cameras and video capture from 2 Bonita high speed cameras (all cameras exhibited a 200 Hz capture rate) integrated by Vicon Nexus software. Three-dimensional joint reaction forces of each subject's left and right hip, knee, and ankle joints during the trials were graphed using Vicon Polygon software. Five highest peaks were recorded and averaged for each joint based on the direction with the highest forces observed in the joint to determine the peak force observed in five strides. Data were then exported into SPSS statistical software to compare intrasubject data of the forces at all major lower extremity joints between the rearfoot and forefoot strike pattern. The paired samples t-test was utilized for data analysis comparing running styles for each subject. Significance was set a P>.05.

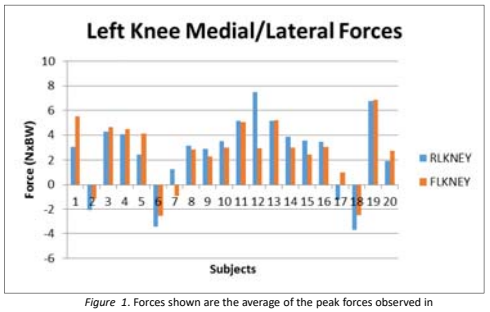

Figure 1. Forces shown are the average of the peak forces observed in five steps and demonstrates forces observed in the left knee . Positive values designate forces in the anterior direction and negative values designate forces in the posterior direction.

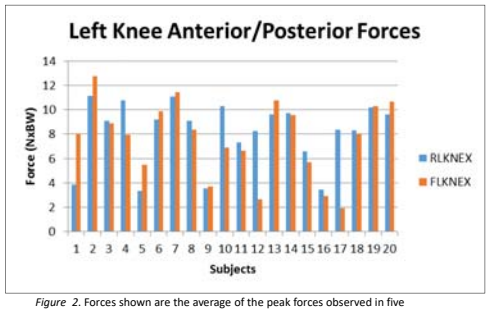

Figure 2. Forces shown are the average of the peak forces observed in five steps and demonstrates forces observed in the left knee. Positive values for (a) designate forces in the lateral direction and negative values for (a) designate forces in the medial direction. Positive values for (b) designate forces in the medial direction and negative values for (b) designate forces in the lateral direction.

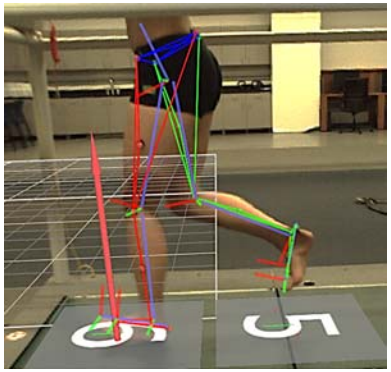

Figure 3. Rearfoot strike video capture with 3-D overlay as viewed in the Vicon Nexus program.

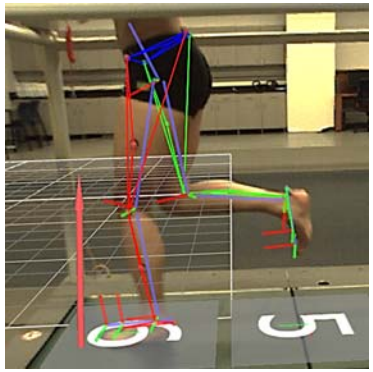

Figure 4. Forefoot strike video capture with 3-D overlay as viewed in the Vicon Nexus program

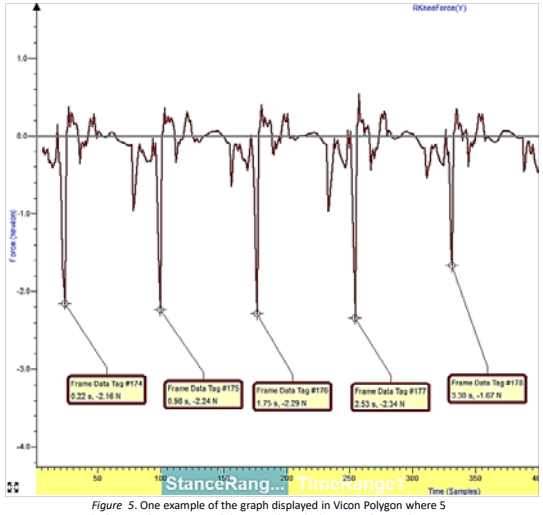

Figure 5. One example of the graph displayed in Vicon Polygon where 5 highest peaks were tagged during each trial. This particular graph is from 1 subject's forefoot trial of their right knee in the Y plane.

Results and Conclusion

There was no statistically significant finding when comparing all subjects together, or with a gender-specific analysis of the results. All comparisons resulted in p values > .05.

Conclusions

The results of the current study imply that foot strike patterns do not produce consistent force production at the lower extremity joints; therefore demonstrating that foot strike pattern produces variable force effects amongst individuals. As we know from other research, GRF increases with barefoot rearfoot strike patterning as compared to barefoot forefoot running (Almeida, Davis, & Lopes, 2015). However, the results of this study demonstrate no significant difference when directly observing joint forces during barefoot rearfoot and forefoot running, therefore suggesting GRF does not directly link to internal joint forces.

The results of this study suggest there is no implication of a superior strike pattern, which is in agreement with other current research (Stearne et al., 2014). The implication of this finding supports the ideology of runner individuality and variability in which force patterns cannot be predicted in all runners and therefore supporting the multifactorial and individualistic nature of repetitive injury development. The assumption of a variety of factors contributing to injury risk does coincide with a concurrent review of the literature studying strike patterns, as there are no clear conclusions of a superior strike pattern as a way to decrease the potential for injury.

Future Work

Future research needs to continue to observe kinetic and kinematic data during running to expand the data on this current issue. There is little significant research to make a definite conclusion about the best running strike pattern (Almeida et al., 2015). Suggestions are to build on the previous acute study with observations of long-term bouts of running or faster velocities to determine the joint forces observed between the foot strikes with new variables involved. Also, it would be beneficial to repeat this study with similar footwear provided to subjects. This would conclude if the forces observed were only in the barefoot condition or related to the strike pattern itself. More importantly, it is essential to continue to observe the effects other variables might have for forces observed at the major lower extremity joints and how they might contribute to potential injury as well.

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