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The effect of a textured shoe insert on running gait

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Abstract
The aim of this research was to determine the influence a shoe insert with a textured, thermos-plastic heel has on running gait. Sixteen (16) participants completed a three-stage protocol to assess step length, contact time and gait imbalance in barefoot, shod and shod with insert conditions. Results indicated significant correlations between the barefoot condition and shod with the insert condition for contact time ($r=0.773$, $p=0.015$), imbalance ($r=0.838$, $p=0.005$) and step length ($r=1.000$, $p=0.000$). Further analysis revealed no significant difference between the barefoot and shod with the insert conditions for contact time, imbalance and step length. Based upon these results, running with a textured, thermos-plastic insert may influence a runner's gait to more resemble that of a barefoot condition.

Keywords: Running, inserts, foot strike, injury, shod running

1. Introduction

Running has remained a popular exercise for decades, if not longer. In the United States of America alone, it is estimated that over 16 million people finished running races [1]. According to some experts, long-distance running was crucial in creating our current upright body form [2]. Humans are one of the few species who have mastered bipedal locomotion and their foot has evolved to be the basis for such a specialized gait [3]. The human foot alone comprises 26 bones, 33 joints and 19 muscles [3, 4]. The bones are arranged to form a medial longitudinal arch which makes it ideal for its function of supporting the weight of the body and spreading the forces experienced during gait [3, 5]. As mentioned by Altman and Davis[6] analysis of rear foot striking in a barefoot condition results in very high vertical ground reaction load rates. It has been suggested that the anatomy and small surface area of the heel is suited for the loads of walking, but not for attenuating the repeated impacts associated with running [6, 7]. Even with running shoe evolution, approximately 75% of shod runner's heel strike[6]. Interestingly, the percentage of runners reporting injury associated to running is at a similar value - up to 79% [7] Barefoot running, in contrast, is associated with a shorter stride length and higher cadence than in typical shod running with a rear foot strike pattern [6, 8-10]. Forefoot striking while running barefoot takes greater advantage of the energy-storing capacity of the arch, which is observed by the increased vertical arch motion during load acceptance [6, 11]. Additionally, being barefoot appears to allow for more sensory input to the neuromuscular system [6].

The human foot initiates and controls many movements a person performs. Shoe inserts and foot orthotics have been advocated and successfully used for many years for sports and other physically intensive activities. Shoe inserts, orthotics, and braces are used to reduce the loading in the structure of interest. They often attempt to reduce the loading in and around the ankle and the knee joint [12]. The nerves in our feet require texture, vibration, or shearing force to register important sensory feedback. Cutaneous feedback from the soles of the feet plays an important role in the control of gait and standing balance [7]. When foot sole cutaneous feedback is reduced experimentally through cooling or anaesthesia [13-17], impairments in postural control are observed. Additionally, enhancement of foot sole cutaneous feedback through applied vibration leads to alterations and illusions of whole body sway and reduced gait variability [18-20]. Facilitatory shoe insoles that employ subthreshold [20-22] and suprathreshold vibration [23], as well as static rigid support [24] have been shown to improve balance and gait parameters in older adults, and in patients with diabetes, stroke, and Parkinsons [12].

Based upon this knowledge, it is possible that a textured, thermoplastic heel-plate may stimulate an athletes' neuromuscular system in a manner more consistent with that of a barefoot condition. Closing this neural loop might allow for enhanced control and understanding of how we move. In real-time improvement in sensory awareness and proprioception might occur and manifest in a shift in gait. This shift in gait may be to a pattern of movement that is more biomechanically consistent with how the human machine is designed. To date, there are no published studies investigating shoe inserts designed specifically to influence gait in this manner. Therefore, the specific aim of this research were to determine if a thermoplastic heel-plate insert influences running gait.

2. Methods

2.1 Participants

Sixteen (16) healthy college aged volunteers to participate in this study. All participants were recreationally active (participating in light to moderately intense bouts of exercise 3 or more days per week for at least 6 months) prior to participating in this research. Before engaging in data collection, all participants read, signed and dated a consent form agreeing to participate in this study. This study was approved by the University of South Carolina Institutional Review Board.

2.2 Protocol

Once consent was obtained, participants proceeded to the initial phase of data collection. This included completing a health history questionnaire (PAR-Q) designed to determine if the participant could safely participate. If the participant answered affirmatively to any condition listed on the PAR-Q, they were excluded from the study. Additionally, to participate in this study, the participant had to be an appropriat age, not be pregnant, and have no orthopedic, cardiac or other medical problem to limit physical activity.

When safe participation was determined, the participant's age, sex, height, and weight were recorded. Participant's age and sex were self-reported, while height and weight were determined using a validated measuring instruments and recorded to the nearest centimeter or tenth of kilogram, respectively.

Following the initial collection, the participant was offered approximately 10 minutes to become familiar with the experimental equipment (treadmill, gait analysis equipment, shoe insert) used for data collection. Once the familiarization period was completed, the participant was asked to complete a series of randomly assigned 4-minute bouts of treadmill running at a self-selected speed. The participant was asked to select a speed they believed best reflected their 'normal' running speed. This speed was maintained throughout each of the three running bouts.

Of these three bouts of running; one bout was completed barefoot, a second with the participants' usual running shoes, a third with a custom fitted shoe insert with a textured thermoplastic heel-plate to be placed in their usual running shoe. After completing each of the 4-minute bouts the participant was given 2 minutes to shift conditions. After the last 4-minute running bout, the participant was offered the opportunity to warm down on the treadmill with or without the insert for 10 minutes.

The running portion this visit mimicked the following:
10 minute familiarization period
4 minute treadmill run shod
2 minute rest
4 minute treadmill run barefoot
2 minute rest
4 minute treadmill run shod with the Shoe Cue insert
10 minute warm down period

2.3 Equipment

The Optogait system (OPTOGait, Microgate S.r.I, Italy, 2010) was used on the treadmill in the laboratory condition. This system consisted of two beams attached to the sides of the treadmill. The system uses a LED lighting system to precisely measure the variables of interest. The variables of interest for this research recorded by the Optogait system were contact time (the amount of time the participant's foot is in contact with the ground from foot strike to toe-off), step length (the distance between the tip (toe) of two subsequent feet or the distance between the heel of two subsequent feet) and imbalance (an indicator of running 'asymmetry' between the right and the left foot).

Variables measured with the Optogait system and associated units of measure included:

Contact time, measured in milliseconds; Imbalance, measured as a percentage indices between right and left; Step Length, measured in centimeters.

The ShoeCue ShoeCue, Boston, MA USA, 2017) insert was used in this research. The ShoeCue is a shoe insert with a textured, thermoplastic heel-plate.

2.4 Data Analysis

Statistical analyses were conducted to determine if a statistically significant correlation existed between the three conditions with respect to the three variables of interest. Further analyses were conducted to determine if a statistically significant difference existed between those variables and conditions with significant relationships. All calculations were performed using SPSS (Version 24) with an a priori level of significance set at $p \leq 0.05$. Pearson correlations were used to determine the relationship between the three conditions. Fisher's z transformation, 95% percentile confidence intervals (upper and lower limits), mean values, and standard deviations were determined. Independent sample t-tests were used to determine if there were significant differences between conditions

3. Results

3.1 Tables

Table 1. Reveals descriptive characteristics of the 16 study participants.

Table 1: Physical characteristics of female and male participants (Mean ± SD)

Characteristic	Pooled (N=16)	Female (n=10)	Male (n=6)
Age (y)	20.75±1.69	20.60±1.78	21.01±1.67
Height (cm)	172.33±7.17	167.28±5.17	178.22±3.74
Body Mass (kg)	69.08±11.14	64.93±9.38	75.99±11.05

Table 2 reveals the means values of the three conditions and the three variables of interest.

Table 2: Mean values of Barefoot, Shod and Shod with insert conditions.

Condition	Minimum	Maximum	Mean	Std. Deviation
Contact Barefoot[1]	0.03	0.09	0.057	0.021
Contact Shod[1]	0.02	0.09	0.065	0.025
Contact w/ Insert[1]	0.01	0.09	0. 060	0.030
Imbalance Barefoot[2]	-3.79	3.64	0.713	2.636
Imbalance Shod[2]	-8.28	6.41	-0.606	4.053
Imbalance w/ Insert[2]	-6.63	3.52	0.461	3.152
Step Length Barefoot[3]	49.02	94.23	68.19	14.55
Step Length Shod[3]	55.12	103.63	74.49	14.02
Step Length w/ Insert[3]	50.04	95.25	28.60	14.48

[1]Contact time–milliseconds; [2]Imbalance–indices in % between right and left; [3]Step Length-centimeters

Table 3 reveals Pearson correlation results, Fischer's z transformation, upper and lower limits of the 95% Confidence Interval.

Table 3: Correlational data between Shod and Insert conditions to Barefoot.

Condition	Correlation	Significance	Upper Limit	Lower Limit
Contact Shod	0.608	0.082	0.848	0.161
Contact w/ Insert	0.773	0.015*	0.917	0.45
Imbalance Shod	0.086	0.825	0.557	-0.427
Imbalance w/ Insert	0.838	0.005*	0.942	0.586
Step Length Shod	0.124	0.75	0.583	-0.396
Step Length w/ Insert	1.000	0.000*	1.000	0.998

Table 4 reveals t-test results of significantly correlated conditions to Barefoot condition.

Table 4: T-test results of significantly correlated conditions to Barefoot condition

Condition	Significance
Contact w/ Insert	0.172
Imbalance w/ insert	0.000
Step Length w/ Insert	0.124

4. Discussion

The aim of this study was to observe the time of contact, step length and imbalance during barefoot, shod and shod with a sole insert conditions at a self-selected speed in recreationally trained runners. Results revealed the condition of shod with a sole insert displayed significant correlational relationships to the barefoot condition for the variables of contact time and step length. Additionally, the shod condition and barefoot condition were found to be significantly correlated in step length. Upon further analysis, no statistically significant difference was observed between contact time and step length between the barefoot condition and the shod with insert condition. There was a statistically significant difference observed between the shod condition and barefoot condition when examining step length. These results demonstrate that the insert condition leads to a shift in shod running gait spatial and temporal characteristics to be more similar to a barefoot running condition.

In this research contact time was defined as the amount of time the participant's foot is in contact with the ground from foot strike to toe-off. Research has indicated contact time as a variable of significant interest when examining running gait. Traditionally running athletes have been labeled as one of two types of foot strikers, which is how their feet contact the ground. Either the athlete is a forefoot striker (FFS) or a rear foot striker (RFS). Peters [25] articulates the difference between FFS and RFS well in the following: The primary differences between these two approaches are the force of the impact, the transference of energy, and the duration of ground contact. In each of these categories, FFS is superior to RFS [26]. Ardigo *et al*. compared speed, step frequency, step length and oxygen consumption in 8 active male runners using either FFS or RFS [26], Hayes *et. al*. evaluated by video 181 runners in competition [31], and Cavanagh *et. al*. and Lieberman *et. al*. performed biomechanical comparisons of the two techniques [2, 32]. In short summation, when the heel hits the ground first, there is a brake-like effect, and a greater collision and contact time between the leg and the ground. Alternatively, a forefoot impact induces a more rounded and rolling motion, reducing recoil from hitting the ground as well as actual ground contact time, and thus friction. An important caveat for this comparison is that, at slower speeds, FFS is less biomechanically fluid and efficient than RFS [26]. This may induce novice runners to prefer RFS, as it is initially less exhausting and more similar to the familiar motion of walking. Peters [25]. The results of this research indicate that with the use of a textured heel-plate insert athletes run at self-selected speeds with a contact time more like that of a barefoot condition (forefoot strike).

A reduction in stride length, although it would appear smaller in trained runners, may be advantageous as it has been shown to reduce impact peaks [34-36] and loading rates [33, 36] experienced by runners. A shorter stride length means the heel is located more underneath the center of mass (COM) which reduces the amount of hip and knee flexion required[38]. Compared to shod running, barefoot running leads to a reduction in stride length by 6 – 8% in inexperienced and those with a long history of barefoot running [33-35, 37]. Schubert [38] indicated that increased stride rate (decreased stride length) affects impact peak, kinematics, and kinetics and therefore may be considered as a mechanism with which to influence injury risk and recovery of a runner. Specifically, similarities are seen across all studies, with decreased center of mass vertical excursion, ground reaction force, impact shock and attenuation, and energy absorbed at the hip, knee, and ankle as step rate is increased or step length is decreased at a constant speed [38].

Although analysis of imbalance did not yield statistical significance, it may be worth noting that the shod with insert and barefoot conditions, observationally, were more similar. A lack of symmetry, that is relative differences in muscle strength, motion, flexibility, balance, and mechanics between sides of the body, is one element often highlighted as a risk factor for injury. The Imbalance measure used in this research is an indicator of running 'asymmetry' between the right and the left foot. A more symmetric running gait would indicate a more balanced athlete, thus a more efficient athlete [39].

Limitations associated with this research project include. Respectively, a difference in shoe may reflect a difference in cushioning which in turn may influence the sensory impact of the insert. The drop angle of the shoe worn may influence a runner's gait as well.

5. Conclusion

Each area assessed in this research (contact time, step length and imbalance) is known to be associated with running gait. These results indicate that the use of a shoe insert with a thermoplastic heel may influence the gait of a runner to the point of resembling that of a barefoot condition (less contact time, shorter step length and less imbalance). This may reduce the likelihood of injury, while increasing the efficiency of movement. The use of a shoe insert with a textured thermoplastic heel-plate may lead to a modified gait pattern in recreational runners more closely resembling a barefoot condition when compared to a purely shod condition. Further research should be conducted to account for the limitations mentioned above and in athletes of different training volumes, goals and experience.

6. Reference

1. United States Running Event Finishers 1990-2015. Running USA. http://www.runningusa.org/statistics Accessed: 6.29.17
2. Hopkins M. Distance running shaped human evolution. Nature, 2004. doi:10.1038/news041115-9
3. Franklin S, Grey M, Heneghan N, Bowen L, Francois-Xavier L. Barefoot vs common footwear: A systematic review of the kinematic, kinetic and muscle activity differences during walking. Gait & Posture, 2015; 42:(3)230-239. https://doi.org/10.1016/j.gaitpost.2015.05.019
4. Theodore D. Anatomy of the moving body: a basic course in bones, muscles, and joints (2nd ed.), North Atlantic Books, Berkeley, CA, 2015, 280.
5. McKeon P, Hertel J, Bramble D, Davis I. The foot core system: a new paradigm for understanding intrinsic foot muscle function Br J Sports Med. 2015; 49:290.
6. Altman AR, Davis IS. Barefoot Running: Biomechanics and Implications for Running Injuries. Current Sports Medicine Reports. 2015; 11(5):244-250.
7. Van Gent RN, Siem D, van Middelkoop M, van Os AG, Bierma-Zeinstra SMA, Koes BW. Incidence and determinants of lower extremity running injuries in long distance runners: a systematic review. British Journal of Sports Medicine. 2007; 41(8):469-480.
8. Robbins SE, Hanna AM. Running-related injury prevention through bare- foot adaptations. Med Sci Sports Exerc. 1987; 19:148Y56.
9. De Wit B, De Clercq D, Aerts P. Biomechanical analysis of the stance phase during barefoot and shod running. J Biomech. 2000, 33:269Y78.
10. Divert C, Mornieux G, Baur H *et al*. Mechanical comparison of barefoot and shod running. Int J Sports Med. 2005, 26:593Y8.
11. Hamill J, Russell EM, Gruber AH, Miller R. Impact characteristics in shod and barefoot running. Footwear Sci. 2011; 3:33Y40.
12. Nigg B, Nurse M, Stefanyshyn D. Shoe inserts and orthotics for sport and physical activities. Medicine and Science in Sport and Exercise. 1999; 3(17):S421-8.
13. Strzalkowski NDJ, Triano JJ, Lam CK, Templeton CA, Bent LR. Thresholds of skin sensitivity are partially influenced by mechanical properties of the skin on the foot sole. Physiological Reports, 2015; *3*(6):e12425. http://doi.org/10.14814/phy2.12425
14. Perry SD, McIlroy WE, Maki BE. The role of plantar cutaneous mechanoreceptors in the control of compensatory stepping reactions evoked by unpredictable, multi-directional perturbation. Brain Res. 2000; 877:401-406.
15. Perry SD, Santos LC, Patla AE. Contribution of vision and cutaneous sensation to the control of centre of mass (COM) during gait termination. Brain Res. 2001; 913:27-34.
16. Nurse MA, Nigg BM. The effect of changes in foot sensation on plantar pressure and muscle activity. Clin. Biomech. (Bristol, Avon). 2001; 16:719-727.
17. Eils E, Nolte S, Tewes M, Thorwesten L, Völker K, Rosenbaum D. Modified pressure distribution patterns in walking following reduction of plantar sensation. J. Biomech. 2002, 35:1307–1313.
18. Meyer PF, Oddsson LIE, De Luca CJ. Reduced plantar sensitivity alters postural responses to lateral perturbations of balance. Exp. Brain Res. 2004; 157:526-536.
19. Kavounoudias A, Roll R, Roll JP. Specific whole-body shifts induced by frequency-modulated vibrations of human plantar soles. Neurosci. Lett. 1999; 266:181-184.
20. Roll RR, Kavounoudias AA, J-PJ R. Cutaneous afferents from human plantar sole contribute to body posture awareness. Neuro Report. 2002; 13:1957-1961.
21. Galica AM, Kang HG, Priplata AA, D'Andrea SE, Starobinets OV, Sorond FA *et al*. Subsensory vibrations to the feet reduce gait variability in elderly fallers. Gait Posture. 2009; 30:383-387.
22. Priplata AA, Niemi JB, Harry JD, Lipsitz LA, Collins JJ. Vibrating insoles and balance control in elderly people. The Lancet. 2003; 362:1123-1124.
23. Novak P, Novak V. Effect of step-synchronized vibration stimulation of soles on gait in Parkinson's disease: A pilot study. J. Neuroeng. Rehabil. 2006; 3:9.
24. Perry SD, Radtke A, McIlroy WE, Fernie GR, Maki BE. Efficacy and effectiveness of a balance-enhancing insole. J. Gerontol. A Biol. Sci. Med. Sci. 2008; 63:595-602.
25. Peters M. An Evaluation of Basic Running Techniques: A Guide for Health Practitioners and the Novice Runner. Clinical Correlations, 2017.
26. Divert C, Mornieux G, Baur H, Mayer F, Belli A. Mechanical comparison of barefoot and shod running. International Journal of Sports Medicine. 2005; 26:593-8.
27. Lieberman DE, Venkadesan M, Werbel WA *et al*. Foot strike patterns and collision forces in habitually barefoot versus shod runners. Nature. 2010; 463(7280):531-5. http://www.ncbi.nlm.nih.gov/pubmed/20111000
28. Cheung RT, Davis IS. Landing pattern modification to improve patellofemoral pain in runners: a case series. J Orthop Sports Phys Ther. 2011; 41(12):914-9. http://www.ncbi.nlm.nih.gov/pubmed/22031595
29. Daoud AI, Geissler GJ, Wang F *et al*. Foot strike and injury rates in endurance runners: a retrospective study.

Med Sci Sports Exerc. 2012; 44(7):1325-34. http://www.ncbi.nlm.nih.gov/pubmed/22217561

30. Diebal AR, Gregory R, Alitz C, Gerber JP. Forefoot running improves pain and disability associated with chronic exertional compartment syndrome. Am J Sports Med. 2012; 40(5):1060-7. http://www.ncbi.nlm.nih.gov/pubmed/22427621
31. Ardigo LP, Lafortuna C, Minetti AE, Mognoni P, Saibene F. Metabolic and mechanical aspects of foot landing type, forefoot and rearfoot strike, in human running. Acta Physiol Scand. 1995; 155(1):17. http://www.ncbi.nlm.nih.gov/pubmed/8553873
32. Hayes P, Caplan N. Foot strike patterns and ground contact times during high-calibre middle-distance races. J Sports Sci. 2012; 30(12):1275-83. http://www.ncbi.nlm.nih.gov/pubmed/22857152
33. Cavanagh PR, Lafortune MA. Ground reaction forces in distance running. J Biomech. 1980; 13(5):397-406. http://www.ncbi.nlm.nih.gov/pubmed/7400169
34. Thompson M, Lee S, Seegmiller J, McGowan C. Kinematic and kinetic comparison of barefoot and shod running in mid/forefoot and rearfoot strike runners. Gait & Posture. 2015; 41:957-959.
35. Hall JP, Barton C, Jones PR, Morrissey D. The biomechanical differences between barefoot and shod distance running: a systematic review and preliminary meta-analysis. Sports Medicine. 2013; 43:1335-1353.
36. Heiderscheit BC, Chumanov ES, Michalski MP, Wille CM, Ryan MB. Effects of step rate manipulation on joint mechanics during running. Medicine & Science in Sports & Exercise. 2011; 43:296.
37. Squadrone R, Gallozzi C. Biomechanical and physiological comparison of barefoot and two shod conditions in experienced barefoot runners. Journal of Sports Medicine and Physical Fitness. 2009; 49:6-13.
38. Schubert AG, Kempf J, Heiderscheit BC. Influence of Stride Frequency and Length on Running Mechanics: A Systematic Review. Sports Health. 2014; 6(3):210-217. doi:10.1177/1941738113508544.
39. McMahan I. The Effect of Asymmetry On Running Performance and Injury Prevention, 2016. Accessed: 7.01.2017 at: http://running.competitor.com/2016/01/injury-prevention/symmetry-and-running_144007#f44klTSzv0XmbYTx.99