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A Case Study Comparing Minimalist Design Running Shoes with Traditional Motion Control Foam Core Running Shoes

Patricia D Christie[1]*, Ryan W Jackson[1], Christopher T Carper[1], Melissa Gymrek[1], Jimmy Riccitello[1] and Stephen J Lyons[1]

Abstract

The purpose of this study was to examine and compare the relative benefits of traditional motion-control running shoe design and the contemporary trend toward a minimalist shoe. Proponents of minimalist design claim that the lower heel and freedom of movement inherent in its lighter design promotes proper biomechanics and results in greater efficiency while advocates of the more traditional motion control foam core running shoe point to the advantages of greater stability and cushioning to prevent injury. The study consisted of a total of four phases where the subjects first ran in traditional motion control foam core shoes over a given distance and at a constant perceived level of effort and then were switched to minimalist shoes. Each phase consisted of a set of at least 9 different workouts distributedover a three-week period of time. Each workout consisted of the participant running 4 intervals of either 800 meter or 1600 meter distances. Phase One was an adjustment to the study protocol. In Phase Two the subjects ran in their usual foam core running shoes. Phase Three was an adjustment to the minimalist shoes done through alternating foam core and minimalist shoes. Phase Four consisted of running solely in the minimalist shoe. The 29 runners measured in the study were all able to demonstrate that they ran faster using the minimalist running shoes when compared to their traditional foam core shoes. These results confirm that at a comparable perceived effort, when the performance of athletes using a minimalist shoe was compared with the performance of the same athlete using tradition motion control foam core shoes, the performance measured in minimalist running shoes demonstrated greater speed and efficiency.

Keywords

Minimalist running shoes; Running; Training improvement

Introduction

Innovation is the cornerstone of the running shoe industry. Proponents of minimalist running shoes claim that the lower heel and freedom of movement inherent in its lighter design promotes proper biomechanics and results in greater efficiency while advocates of the more traditional motion control foam core running shoe point to the advantages of greater stability and cushioning to prevent injury. This debate over the relative benefits of traditional motion-control running shoe design and the contemporary trend toward a minimalist shoe design is reflected in the history of the running shoe itself.

Since 1832 when Wait Webster patented a process for adhering rubber soles to leather shoes and boots to the development of vulcanization which led to the creation of Keds, the first rubber and canvas athletic shoe in 1892 by Goodyear, designers have constantly tinkered with the design of the running shoe in an effort to optimize function and performance [1] Adolph Dassler, who many consider the father of the modern running shoe and who in 1948 founded Addas the company which would later become Adidas and Puma, began making spiked running shoes in 1920 [1]. Each shoe he designed was specially made to optimize performance over a certain running distance by varying the number and length of the running spikes added to the sole of the shoe. In 1936, the year that Adolph Dassler's running shoe was worn by Jessie Owens in the Olympics, Converse produced the first official athletic shoe of the United States basketball team [2].

In 1960, New Balance introduced the "Trackster", the world's first running shoe made with a ripple sole. It was also the first running shoe to come in varying widths [3]. The Trackster was given a big boost when it was adopted by colleges around the country including the Massachusetts Institute of Technology for their cross-country teams [2]. It weighed in at about 3 ounces-more than twice its modern counterpart. In the 1960's, Phil Knight, a miler on the University of Oregon track team, and his coach Bill Bowerman were disenchanted with the quality of running shoes available on the market and decided to create their own running shoe based on a design by Bowerman and founded a company called Nike. Originally known as Tiger Shoes, the defining characteristic of their shoe design was a cushioned heel wedge [4].

The running craze of the 70's and the demand for running shoes that followed led to further innovation. In 1972, Bowerman produced the first waffle sole when he poured rubber into a waffle iron in his kitchen [4]. Even NASA got into the act when it helped to develop the first air-cushioned running shoe by inserting small bags of pressurized gas into the soles and heels of a running shoe to absorb shock and cushion the foot [2]. Later, manufacturers began designing running shoes based not only on the type of running the athlete did but on their running style as determined by the degree of movement in the foot during the push-off phase of the running gait. The three running shoes styles that were developed included neutral, supination and pronation [2].

Thereafter, most running shoe design was focused upon promoting stability of the foot during the act of running and achieving, to the extent possible, a neutral foot position. Some designs focused on neutralizing the runner's pronation while others focused on eliminating pronation. This was accomplished through various forms of stability control technology built into the design of the soles, heels and upper portions of the running shoe [2]. In the 1970's manufacturers began using ethylene vinyl acetate to provide runners with additional cushioning and shock absorption [2]. During the 80's

***Corresponding author:** Patricia D Christie, Massachusetts Institute of Technology, Building 24, Room 604, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, USA, Fax: 617-258-9500; Tel: 617-324-1945; E-mail: patti@mit.edu

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and 90's there was little to distinguish one fundamentally identical running shoe from another.

Then in 2007, Boulder Colorado-based Newton Shoe Company produced the first minimalist running shoe to be mass marketed [5]. Co-founded by ultra-marathoner, Danny Abshire, the Newton shoe departed from traditional running shoe design in that it incorporated less cushioning, thinner soles and is made of lighter weight materials than other running shoes allowing for greater proprioception while simultaneously providing the foot with minimal stability and protection [5]. A benefit of using the minimalist shoe is that it encourages the fore-foot or mid-foot strike running pattern [6]. When this type of running was analyzed, it was shown that type of gait will protect the runner from some of the impact related injuries that runners experience annually [7]. Newton Running shoes have been designed to promote this type of foot strike pattern to reduce those injuries [6]. They are intended to closely approximate barefoot running conditions.

Following the trend, by 2011, minimalist running shoes have been made available by most of the major shoe manufacturers. The Vibram FiveFingers has separate slots for each toe and no cushioning [8]. Traditional racing flats are fairly minimal; offering good ground feel and control. Conversely, the Nike Free line of footwear features a segmented sole which provides greater flexibility while still having an amount of cushioning [9]. Saucony introduced the Kinvara line of shoes which feature a dropped sole, which halves the thickness of the sole and removes much of the heel cushioning, to encourage more of a midfoot strike for the foot [10]. Hollander et al. [11] have shown that excessive cushioning inhibits natural running kinematics.

A claim associated with barefoot running is that there is a reduced oxygen cost. It has been shown that barefoot running is more economical than running in a shoe at 70 % VO_2 while maintaining a specific heart rate [12]. It has also been suggested that the higher oxygen consumption associated with wearing shoes is related to the mass of the shoes. Divert et al [13] showed that the main effect of wearing shoes was its influence on the way that the foot interacted with the ground through the impact of damping material present in the shoes [13]. Newton Running shoes claim to capture and optimize the return of energy to the runner so they can run faster [14].

The purpose of this study is to compare the exercise physiologic based performance differences measured in runners wearing traditional motion control foam core running shoes versus the minimalist design. In our study, the Newton running shoe was selected because it was the first mass produced minimalist running shoe to be offered for sale to the public and, despite certain proprietary design characteristics such as the actuator lugs located in the forefoot of the sole which are unique to the Newton shoe design, is typical of the contemporary minimalist design subsequently offered by most of the major running shoe manufacturers in that it incorporates lower heels, less cushioning, thinner flexible soles and is made of lighter weight materials than traditional motion control foam core running shoes.

Materials and Methods

Subjects

Healthy participants were recruited from campus through a seminar class, Chemistry of Sports (SP.235, ES.010) and through word of mouth. Subjects gave their informed consent and the study was approved by the Massachusetts Institute of Technology (MIT) Committee on the Use of Humans as Experimental Subjects (COUHES Number 0901003076). After being informed of the nature of the study, participants gave their written consent to participate in this study. To be included in the study, the participants had to complete all four phases of the study.

Study design: The study was undertaken to examine if a runner is able to run faster in a minimalist shoe when compared to a traditional foam core shoe. The participants were expected to complete the four phases of the study within a 12-week period. To have the participant's data included in the analysis, completion of the protocol was expected within that time period. To examine if the participants were able to run faster using the minimalist shoes, a comparison between the time interval taken to cover either 800 m or 1600 m in either the foam core shoes or the minimalist shoe at a pre-determined heart rate zone wasf recorded. Statistical analysis using a t-test was used to compare if a participant's times were statistically different.

Training protocol: Running was performed on an indoor track (to minimize variability by keeping environmental conditions such as wind, temperature, humidity, lighting, precipitation, etc., constant) or on an indoor treadmill set at a 1 % inclines. Participants ran the measured distance at a predetermined steady heart rate and recorded the elapsed time. During phase one of the study, participants were supervised to ensure that the protocol was followed.

The participants ran to achieve a specific target heart rate, (dependent on the age and physical fitness of the individual, FS1 monitors supplied from Polar Electro Inc. Lake Success, NY) and then measured how long it took to run the given interval. The aerobic threshold was calculated as 15 beats per minute below 220 minus the age of the participant. This was the heart rate at which the running test was conducted throughout the study. Participants began each running test by a warm up period followed by the completion of one of the intervals and a cool down where the heart rate was at the end of warm up period and then repeated until the intervals were all completed. The running test distance was either of 1600 m or 800 m.

The study consisted of four phases:

Phase 1: running the intervals in foam core running shoes under supervision of one of the study authors.

Phase II: running the intervals in foam core shoes after attending a running clinic on Mid-sole running.

Phase III: running the intervals alternating between foam core shoes and minimalist running shoes (Newton Running Shoe, Boulder, CO).

Phase IV: running all the intervals in minimals shoes. The subjects were required to run at least 9 times in each of the Phase II, III and IV of the study. The participants in the study were given the use of a Polar FS1 Heart monitor (either purchased from a commercial supplier or donated by Polar Electro Inc., Lake Success, NY and a pair of properly fitted Newton shoes (donated by Newton Running Shoe, Boulder, CO). The foam core shoes that the participants used were the shoes that the participants had been previously training with.

Data collection: Each participant recorded the date, time, place, beginning heart rate, aerobic threshold heart rate at which the running test was conducted, the distance covered and the timed results of each test for each interval on an on-line website.

Data analysis: Once the subjects completed the study, the data was downloaded from the website and imported into an Excel spreadsheet. The statistical tests were made for the following samples:

foam core shoes in phase II vs. minimalist shoes in phase IV and direct comparison between the two shoe types in phase III. Two tailed T-tests were performed using the standard statistical package available in Excel (Microsoft Corporation, Redmond, WA) for phase II and phase IV comparisons and two-tailed T-tests were done on the Phase III data. Averages and standard deviations for results of each participant were calculated using the standard Excel statistical packages.

Results

The participants for the study were self-selected and interested in participating in a running program. Twenty-nine participants were able to complete the entire study protocol out of 53 who enrolled. A complete data set consisted of completion of all four phases of the protocol. The rest of the information about the study population will only include information about the participants who completed the entire study protocol. Since participants in the study were largely recruited from the student populations, this resulted in some incomplete data sets due to academic demands and not the result of injury.

The age range of the participants was 19 to 51 with an average age of 26.5 years. There were 14 female and 15 males in the study. There were 22 experienced runners and 7 recreational/inexperienced runners. For analysis purposes, the participants have been assigned a participant number from 1 to 29 inclusive. Participants 1-13 did 800 m intervals and participants 14-29 did 1600 m intervals. There were no injuries reported by the study participants during any point of the study.

All of the participants in the study ran faster when they used the minimalist running shoes when compared to the foam core shoes (Figures 1-4). In terms of statistical significance ($p<0.05$ %, meaning that there is a 5 % chance that the intervals are the same), all 29 participants had at least one interval statistically significant, and 19 out of 29 ran statistically faster in the minimalist shoes in all four intervals than in the their foam core shoes. There were 76 % (22 out of 29) of the participants that had at least 3 intervals statistically faster in the minimalist shoes than the foam core shoes. 93 % (27 out of 29) of the participants had at least 2 intervals statistically faster in the minimalist shoes than the foam core shoes.

To account for the increased fitness level of the participants, the participants were asked during phase III of the study to alternate the foam core shoes and the minimalist shoes during the same workout on the same day. Participants 1, 15, 17 and 18 instead of alternating shoes on the same day, did different days, different shoes, so their interval data was not included in this analysis. With the exception of participant 22, everyone ran faster in the minimalist shoes than the foam core shoes. Participant 22 had difficulty adjusting to running in the minimalist shoes during phase III of the study, but was able adjust during phase IV. In fact for participant 22, all intervals in the minimalist shoes were faster and intervals 2 and 4 were statistically different. Of those 25 participants, 58 % showed a statistical difference (at least 95 % confidence level) between the two shoes. If the statistical confidence level is decreased to 75 %, then 83 % of the participants were able to complete the distance faster in the minimalist shoe when compared to the foam core shoes for Phase III of the study (Figure 5).

Discussion

When we look at the history of running, we started by running barefoot. Our species, like others, ran to be able to hunt protein rich sources of food, but now many choose running as a regular exercise and lifestyle choice in order to take advantage of the significant health benefits that have been well documented in medical literature [15]. Recently there has been a popularization of barefoot running. Running barefoot in an urban setting is typically not a safe choice. The development of the minimalist shoe is the industry's solution to this dilemma.

This study has shown that at a specific heart rate, that wearing the a minimalist running shoe allows the runner to travel a given distance faster when compared to the same runner wearing a pair of foam core shoes. Having the participants maintain a constant heart rate throughout the study allows the perceived effort to be the same. Hanson et al. [16] have shown that running barefoot is more economical than running with shoes. When Liberman's group examined the running economy in minimal shoes versus foam core

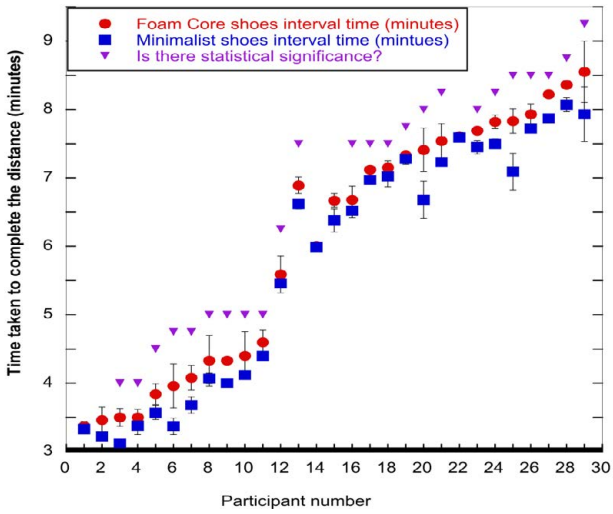

Figure 1: Comparison between foam core shoes and minimalist shoes for the first of four intervals.

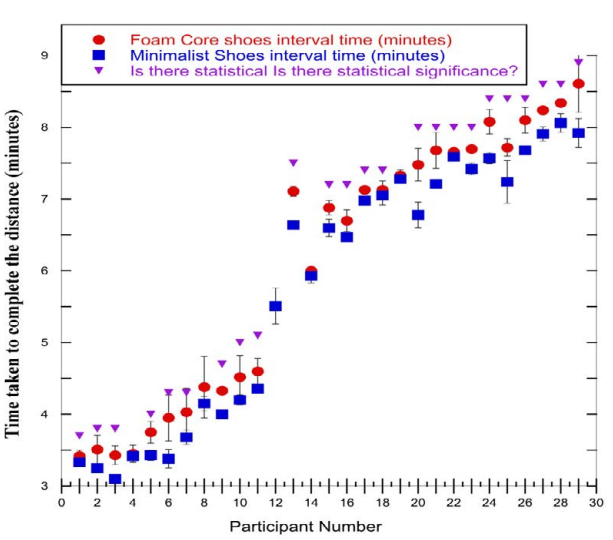

Figure 2: Comparison between foam core shoes and minimalist shoes for the second of four intervals.

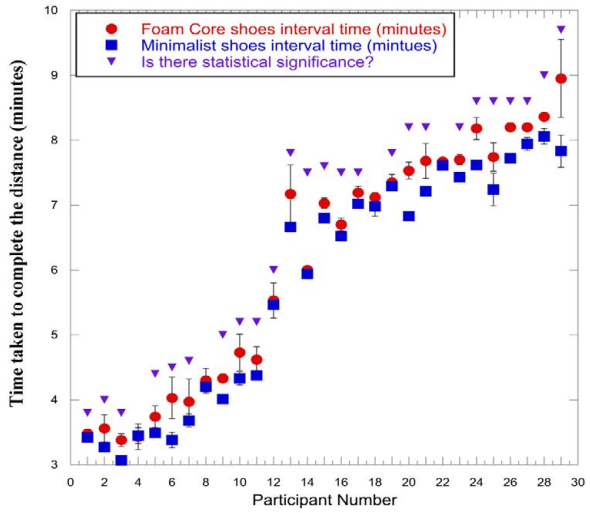

Figure 3: Comparison between foam core shoes and minimalist shoes for the third of four intervals.

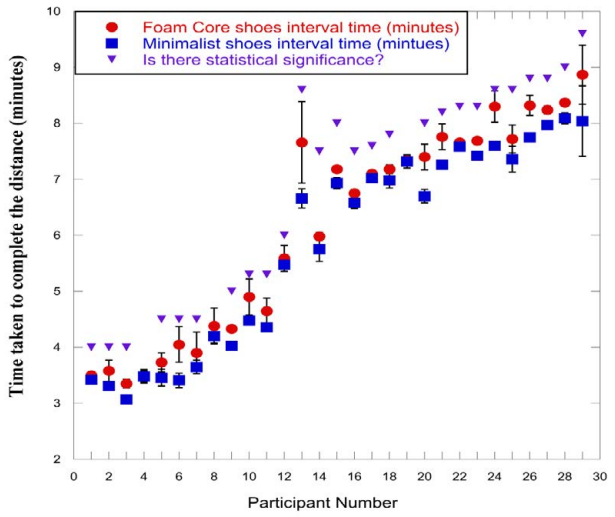

Figure 4: Comparison between foam core shoes and minimalist shoes for the third of four intervals.

shoes (which they refer to as standard running shoes), they concluded that minimally shod shoe runners are statistically more economical than the traditionally shoe runners after controlling for the shoe mass and stride frequency [12]. They concluded that this is due to the more elastic energy storage and release in the lower extremity while running in the minimalist shoes [12] Franz and coworkers [16] concluded in their study that there is no metabolic advantage to running barefoot over running in minimalist shoes. Bell and Judge [17] have shown that after an initial period of adjustment, running in minimalist shoes reduced oxygen consumption at similar workload when compared to traditional running shoes.

Using a heart rate monitor is a more accurate way to measure heart rate when compared to manual palpation. It was shown by Greer and Hatch [18] that it was best to use a heart rate monitor instead of manually counting heart rate through palpation. Since the heart rate was the basis of perceived effort, the use of a heart rate monitor was a valid choice. It has previously been shown that with trained mid-forefront runners there is not a significant difference in metabolic outputs (rate of oxygen consumption, energy cost, fuel consumption, or heart rate) between running barefoot and running in a minimalist shoe [19].

The data was analyzed using a statistical student t-test. The student t -test assesses whether the means of two samples are *statistically* different from each other [20]. The study design allowed for pairs of data to be analyzed together. For this reason, the simple t-test was an appropriate statistical test. An ANOVA (analysis of variance) tests whether there are differences between three or more unrelated groups [21]. This was inapplicable to our study analysis.

The participants in this study were able to maintain a specific heart rate while running intervals. When the participants were wearing minimalist shoes they ran the distance in a shorter time period than when they ran in motion control foam core shoes. One might argue that the study participants were able to run faster in minimalist shoes due to participating in a consistent physical exercise program over the course of 8 weeks. By having the subjects alternate their shoes on a given day (Phase III of the study), the improvement in fitness levels was accounted for. The study participants were all able to run faster in minimalist shoes than motion control foam core shoes. This supports our hypothesis that running in a minimalist shoe allows the runner to traverse distances faster than when they are using traditional foam core shoes.

One participant (participant 22) exhibited difficulty adjusting to the minimalist running style of shorter strides and midfoot/forefoot strike. This highlights the importance of using caution when transitioning to minimalist shoes from traditional motion control foam core shoes. It should be noted that after the three-week transition of phase III, participant 22 was able to inprovements in speed and running efficiency. Fuller et al. [22] have shown that transitioning to minimalist shoes from traditional foam core running shoes must be done gradually to avoid injury. Their meta-analysis of the current literature showed that there was no standard protocol for transitioning [22]. In our study we chose a 3-week transition where the participants alternated their shoes after the participants

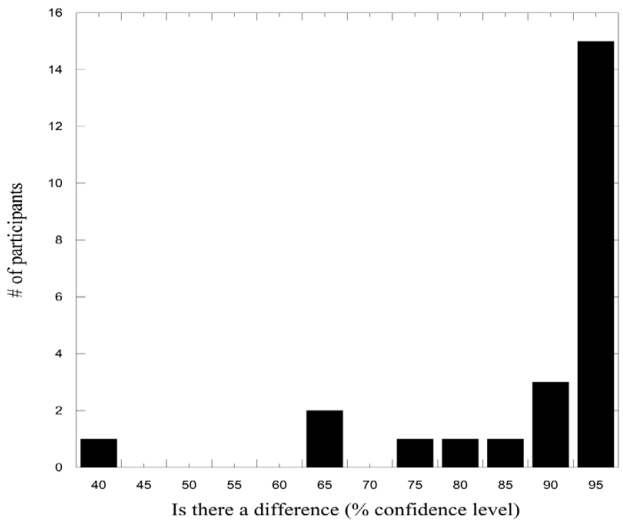

Figure 5: Direct comparison between interval time between the foam core shoes and the minimalist shoe.

attended a clinic on running form and proper biomechanics. The authors believe this resulted in no injuries being reported after the complete transition to minimalist shoes was achieved. In a survey of Chicago area runners, the fear of developing an injury was given as the main reason for not transitioning to a minimalist-type running shoe [23]. After a review of the literature by Perkins et al. [24], the authors concluded that no conclusions can be drawn regarding specific risks or benefits to running barefoot, shod, or in minimalist shoes due to the lack of what the authors defined as high-quality evidence.

This study confirms that at comparable perceived effort when the performance of athletes using minimalist shoes was compared with the performance of the same athletes using tradition motion control foam core shoes, the performance measured in minimalist running shoes demonstrated greater speed and efficiency.

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Author Affiliation

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[1]Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, USA