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Research Article | Journal of Exercise, Sports & Orthopedics | Open Access

Can Cushioned Shoes with Anatomical Insole Correct the Impact in Runners with Recurring Shin Splint?

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Received: October 18, 2014; Accepted: January 09, 2015; Published: February 05, 2015

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Abstract

Shin splint injury usually takes several weeks to recover. We determine the effect of cushioned shoes with anatomical insole on impact, over pronation and mechanical strategy to impact during running in 10 k runners, over pronators, rear foot initial contact and unilateral recurrent shin splint respect bare foot running before sport return.

Fourteen runners with recurrent shin splint who underwent standardized physical therapy were included. We compared by one tailed paired t-test the variables impact, rear foot over pronation angle in midstance and mechanical strategy to impact during barefoot running condition with anatomical insole and cushioned shoes running condition (α=0.05 and 1-β=80%).

The impact was reduced from 6.893 g to 6.600 g (95% CI: 6.513 g-6.686 g, *p<0.001*) using cushioned shoes with anatomical insole condition respect barefoot running condition. The over pronation angle in midstance was reduced from 18.50° to 16.21° (95% CI: 14.29°-18.13°, *p = 0.011*) using cushioned shoes with anatomical insole condition respect barefoot running condition. The mechanical strategy to impact analyzed by cross correlation coefficient between cushioned shoes with anatomical insole condition with barefoot running condition was 0.77 (95% CI: 0.74-0.81, p<0.001). Running with cushioned shoes with anatomical insole in subjects with unilateral recurrent shin splint before return sport attenuates the impact and reduces over pronation. But, doesn´t change the mechanical strategy to impact.

Keywords: Shin splint; Running, Impact, Iso-inertial accelerometer

Introduction

Detmer [1] in 1986 includes shin splint, tibial stress fracture and periostitis as Medial Tibial Stress Syndrome (MTSS). This involves a progression from acute inflammation to local anabolic bone reaction [2-4] that ends in structural bone damage [4,5]. Although primary cause of MTSS is unknown [3,6,7], radiology findings show a progressive bone reaction [6] related to impact and running [8,9]. Related risk factors are over pronation, initial rear foot contact, muscle fatigue or previous MTSS.

The impact (i.e. "the collision between two objects" [10]), is habitually associated with MTSS [6,8]. Tibial impact during running occurs 150 milliseconds after heel contact [11], with potential harmful effects in runners [8,12]. Low cost accelerometers can be used to assess impact in running [13-15] and helps to study mechanical patterns [15-18]. Heel contact has a correlation coefficient of 87% with ground reaction force [18].

Recently, 10 kilometers (10 k) running are massive and inexpensive [19]. Unfortunately, between 27 to 70% of 10k runners may develop MTSS [20,21]. Recovery of 18 minutes of asymptomatic running may take more than 100 days to return to sport after MTSS [6]. Today, there is not enough information related to recovery or MTSS re-injury process, but physicians and physical therapist usually recommends changing footwear and use an orthopedics insole [3] in order to reduce impact. However, it is not know if this therapeutic management positively affects the mechanical characteristics of impact during running [6].

Therefore, our research aim was to determine the effect of cushioned shoes with anatomical insole on impact, over pronation and mechanical strategy to impact during running in 10 k runners, over pronators, rear foot initial contact and unilateral recurrent shin splint respect barefoot running before sport return.

We hypothesized that:

1. Impact during running is lower using anatomical insole with cushioning shoes compared to bare foot running.

2. The over pronation angle in midstance is lower using anatomical insole with cushioned shoes compared to barefoot running.

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3. Exist a change of mechanical strategy to impact using anatomical insole with cushioned shoes respect to barefoot running (cross-correlation coefficient < 70%).

Methods

Study design

This prospective, single-blind trial and analytic observational study was conducted in Instituto Traumatológico "Teodoro Gebauer Weisser" (Santiago, Chile).

Subjects

Fourteen consecutive male rear foot runners and over pronators with recurrent unilateral shin splint diagnosis (Table 1) who underwent a physical therapy process (Table 2) were incorporated into the study during June 2013 to September 2014. No patient was excluded or lost during the study. A priori, the sample size necessary to obtain a statistical power of 80% with 5% of type I error in difference between two dependent means (matched pairs) of one tail, was twelve subjects being developed by G*Power 3.1.9.2 (Kiel University, Germany).

The inclusion criteria was men between 20 and 45 years of age, diagnosis of recurrent shin splint disorder (posteromedial pain of distal tibial portion during exercises), at least 2 episodes of shin splint in the last year, 10 k runners, rear foot initial contact runner, barefoot over pronation over 15° during midstance running [22] and asymptomatic running of 20 minutes at seventh week of physical therapy. The exclusion criteria was any lower limb musculoskeletal injury, pain at moment of running analysis, cognitive impairments or any other conditions that alter the running analysis. All subjects gave their consent to the study. This was approved by IRB of Instituto Traumatológico "Teodoro Gebauer Weisser" (Santiago, Chile) according to the principles of Helsinki declaration. Written informed consent was obtained from all participants.

Table 1: Subject characteristics.

Total subject, n= 14	Mean	S.D
Age (years)	31.7	(10.3)
Height (m)	1.74	(0.04)
Weight (Kg)	72.8	(6.2)
Body mass index (Kg/m2)	23.8	(2.2)
Initial contact frequency (Initial contact/s)	0.76	(0.12)

S.D. = standard deviation

Table 2: Physical therapy treatment.

Period	Therapeutic principles
Week 1	-Sport rest -Control of inflammatory reaction (Compression bandages) -Control of pain (cryotherapy and TENS) -Plantar flexion flexibilization (superficial thermotherapy and PNF)
Week 2 to 5	- Maintence control of inflammatory reaction and pain - Improve ankle muscle flexibility - Isometric strengthening - Start excursion training - Progression of isometric strengthening to eccentric strengthening
Week 6	-Maintence flexibilization improved -Aerobic reconditioning -Footwear modification (footprint analysis) -Eccentric strengthening (emphasis on inverter group) -Start of the running on treadmill Add 5 minutes per session Cryotheraphy after running training
Week 7	-Achieve 20 minutes of running without presence of pain -Running analysis -Advance towards to the sport return stage

TENS = Transcutaneous Electrical Nerve Stimulation; PNF = Propioceptive Neuromuscular Facilitation.

Intervention

Medical diagnosis was developed by two senior foot and ankle orthopedic surgeons. After medical diagnosis, all subject received 400 mg every 8 hours during first 5 days to reduce the acute symptoms with non steroidal anti-inflammatory drug (2-(4-isobutylphenyl) propionic acid) by oral way. The last two days, in all subjects it was indicated progressively reduce the frequency of drug administration.

Each subject completed a physical therapy process for 7 weeks developed by the same therapist (CD), by attending sessions of 1.5 hours 3 times a week.

A footprint correction was done with neutral cushioned shoes (Asics America Corp., USA) with anatomic insole (Foot Solution, Chile). The insole was designed using pedobarography data (RScan international NV, Belgium), aimed at diminish pressure in footprint (Figure 1) with wedges and arches. The insole was created by a senior foot specialist (Foot Solution, Chile) with the same materials. Seven days before the evaluation, all subjects used the anatomic insole for least two hours every day.

Assessment

A running analysis with accelerometer and video-photogrammetry by Matlab 7.0.1 (Mathworks inc., USA) was done in the Biomechanics unit of Centro de Investigaciones Medicas del Instituto Traumatológico "Teodoro Gebauer Weisser" (Santiago, Chile) by the same evaluator (CD). Each subject ran with cushioned shoes with anatomical insole and barefoot. They started with a 2 minute warm up at 3.0 m/s. If they needed more time to get used to the treadmill (Techno gym Spa, Italy) they practiced more time. Once the warm up was over, they selected their own speed to run. The speed was similar to the speed they used to practice before the shin injury. Randomly they were allocated to either start running with cushioned shoes with anatomic insole condition or running barefoot condition. Each condition was 5 minutes of time duration. The subjects had 10 minutes of rest between conditions. A triaxial accelerometer ADXL 345 (Analog Devices Inc., USA) with 16 g, 3.9 mg/LSB of resolution, wireless connection and amplified by a factor of 10 [9] was used. The accelerometer was fixed to the calcaneus in bipedal posture respect its medio-lateral axis and cephalo-caudal axis. In a static way the sensor was calibrated by the action of the gravity force in X, Y and Z versors. In a dynamic way each signal was taken in a sample frequency of 1000 Hz.

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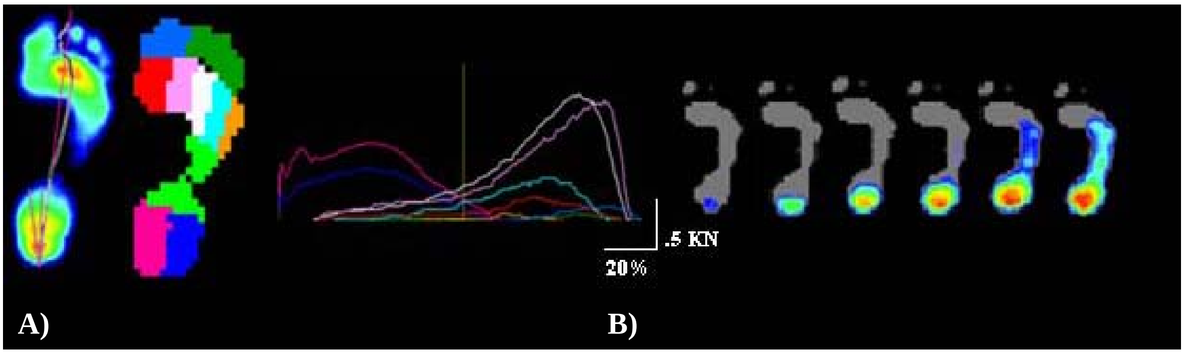

Figure 1: Pedobarography assessment. Two subjects during pedobarography assessment, (A) a rearfoot overpronation (Pink line) with cavus footprint impression (false cavus) during pedobarography at left and ground reaction force by footprint area at right, (B) a medial impact during rearfoot overpronation into the first 150 miliseconds of running. KN = Kilo Newton.

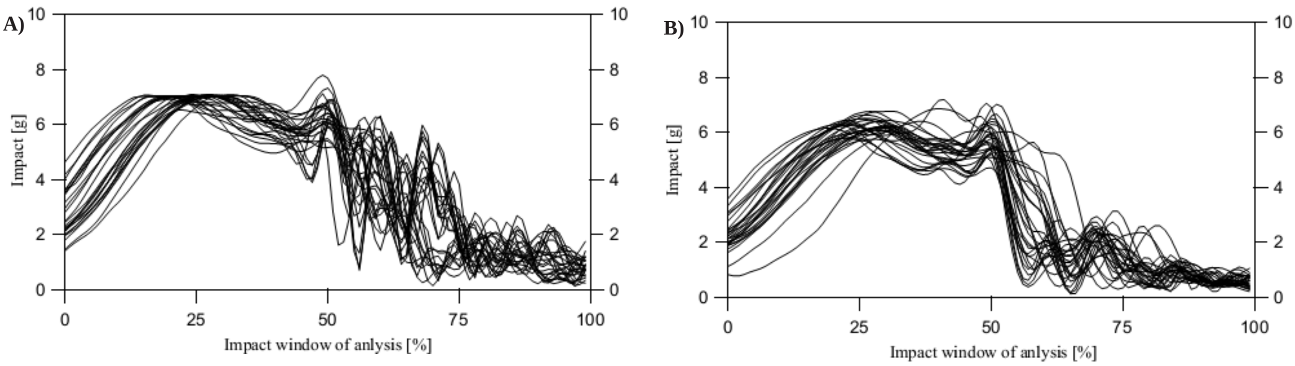

Figure 2: Impact signal. Impact signal of one subject, (A) barefoot condition. (B) cushioned shoes with anatomical insole condition.

Outcomes

Thirty consecutive initial contacts were identified from a frequency analysis using a wavelet transform described by Aung et al. [15] in relation to the accelerometer signal using a Daubechies 4 by Mat lab 7.0.1 (Mathworksinc, USA). After that, to create the impact signal from the initial contact we made a normalized analysis (second/second) at 100% of the 150 milliseconds starting at the initial contact of the isoinertial signal (Figure 2). The maximum value of the impact signal (equation 1) was used to obtain the impact variable for cushioned shoes with anatomic insole and barefoot condition.

To quantify the mechanical strategy change during impact, each impact signal of two conditions was cross-correlated (equation 2) [23] to obtain a mechanical strategy to impact variable. A correlation coefficient of 0.7-1.0 was considered as a strong correlation [24].

Thirty over pronation rare foot angles in midstance by two dimensional methods as described by Nigg [22] were averaged to obtain the over pronation angle in midstance variable for cushioned shoes with anatomical insole condition and bare foot condition.

$$\mathbf{Impact[T]} = \sqrt[2]{a_x[\mathbf{T}]^2 + a_y[\mathbf{T}]^2 + a_z[\mathbf{T}]^2} \qquad (1)$$

$$\mathbf{r}_{\mathbf{XY}}[\mathbf{T}] = \frac{\int_0^T \mathbf{X}[\mathbf{T}]\mathbf{Y}[\mathbf{T}+\tau]\mathbf{dt}}{\mathbf{T} * \sqrt{\int \mathbf{X}[0]\mathbf{X}[\tau]\mathbf{dt} * \int \mathbf{Y}[0]\mathbf{Y}[\tau]\mathbf{dt}}} \qquad (2)$$

Where Impact [T] is the isoinertial accelerometer signal, a_x[T] is the cephalo-caudal rear foot signal, a_y[T] is the medio-lateral rear foot signal, a_z[T] is the antero-posterior rear foot signal, X[T] is the barefoot condition, Y[T] is the cushioned shoes with anatomical insole condition and T is time.

Statistical analysis

In total, 2520 impact signals (14 runners x 2 conditions x 3 channels x 30 running cycles) were analyzed by STATA 12.0 (Stata Corp., EEUU). We used the Shapiro Wilk test to see if there was a normal distribution of the variables. After that, we studied if there was equal or different variance between groups. As data were normally distributed and with equal variance we used one tailed paired t-test with I type error of 5%, to compare the cushioned shoe with anatomical insole condition and barefoot condition.

Results

Impact was reduced from 6.893 g to 6.600 g (95% CI: 6.513 g-6.686 g) using cushioned shoes with anatomical insole (Table 2) with $p<0.001$, accepting our null hypothesis (1). Over pronation angle in midstance was reduced from 18.50° to 16.21°

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(95% CI: 14.29°-18.13°) using cushioned shoes with anatomical insole (Table 2) with p=0.011, accepting our null hypothesis (2). We found a correlation coefficient of 0.77 using cushioned shoe with anatomical insole (Table 2) with p<0.001, rejecting our null hypothesis (3).

Discussion

Correcting the impact is essential to avoid a new shin splint injury [25]. Rest and using insole are common ways of treating MTSS, but they have not shown to be too successful [26,27]. It is not known if anatomical insole can correct the impact during running and actually there is not enough scientific evidence available to support the prescription of using cushioned shoes, anatomical insole or their combination [28]. The objective of our research was to determine the effect of cushioned shoes with anatomical insole on impact, over pronation and mechanical strategy to impact during running in 10 k runners, over pronators, rear foot initial contact and unilateral recurrent shin splint, respect barefoot running, before sports return.

We acknowledge the limitations of our study. First, we used a two dimensional video photogrammetry method to obtain over pronation angle, but we could have created sensor with inclinometer and magnetometer to obtain directly the over pronation angle without video photogrammetry analysis. Second, we could have attached multiples sensors on bony segments calculated the attenuation phenomena arisen from rear foot to tibia with elastic wave propagation principles. Third, we could describe the pathological kinematic pattern of lower limb to know more details of pathological motion. Fourth, our physical therapy intervention had general principles to treat MTSS.

We found it is possible reduce impact and the over pronation angle using cushioned shoes with anatomical insole while running compared to running barefoot condition, after shin splint injury. But, the cushioned shoes with anatomical insole were not capable of changing the mechanical strategy to impact.

Increased over pronation angle was described by Gallant et al. [7] as a risk factor for shin splint. Stacoff et al. [29] published that foot orthesis could reduce only 1 to 4° of the over pronation angle with a small kinematic effect, showing similar results with us. By the way, Lafortune et al. [30] and Akins et al. [31] published that impact was reduced using insole, which agree with our findings and suggest the use of proper insole for running reduce risk factors of a new MTSS compared to barefoot condition after the rehabilitation of shin splint injury. In our case, the appropriate insole design was made with a pedobarography analysis.

Nevertheless, a mechanical strategy to impact is not changed during running while using cushioned shoes with anatomic insole after our physical therapy intervention (Table 3 and Figure 2).This warms that maintaining mechanical behavior from impact was not different to obtained during barefoot condition. This agrees with the report of Nigg et al. [32], who found that anatomic insoles had an influence on the magnitude of impact, but not in its loading rate. This also agrees with Davies et al. [33], who reporting that runners that produced tibial stress fractures had an increase load of vertical force.

In contrast to our physical therapy intervention, Crowell et al. [25] in 2010 & Crowell et al. [34] in 2011 demonstrated that a physical therapy with emphasis on changing kinematic strategy through real-time visual feedback with accelerometers reduce the magnitude and change in the mechanical strategy to impact, reducing the risk of tibial overload. Therefore a specific physical therapy is needed regarding the impact during running. Unfortunately, there is no accord in which is the best way to treat medically and with physical therapy, and future research in this areas are recommended to reduce risk factor of new shin splint injury after their rehabilitation. Because as we found, cushioned shoes with anatomical insole alone with our physical therapy intervention (unspecific physical therapy) for impact are insufficient to protect against tibial overload.

Conclusion

In anatomical insole design with cushioned shoes after physical therapy in subjects with unilateral recurrent shin splint before sport return, attenuate the impact and reduce over pronation angle of rear foot during running. Nonetheless, the mechanical strategy to impact does not change respect barefoot condition. This suggests only management with cushioned shoes and anatomical insole design with unspecific physical therapy can creates a mechanical risk of developing a new shin splint injury and progression to stress fracture in distance runners. We suggest create new therapeutic management with cushioned shoes with anatomical insole in recurring shin splint with specific impact running training to decrease the risk of developing new tibial lesions.

Ethical board review statement

This study was approved by Instituto Traumatológico Institutional Review Board (IRB).

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