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Original Research

The Effect of Using Air Brace on the Ground Reaction Force Component in People with Ankle Sprain

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ABSTRACT

The components of the Ground reaction force are of clinical importance. The use of braces can be effective in reducing harmful factors. Therefore, this study aims to investigate the effect of the using air braces on the variables of the ground reaction force in people with ankle sprain. Material and methods:10 female with ankle sprain complication participated in this study. Using a force plate (1000 Hz), the components of the ground reaction force were measured when walking in two conditions with and without braces. Then, the peak variables of the ground reaction forces, impulse, and loading rate were extracted. Repeated measure ANOVA was used to analyze the data (α=0.05). Results: The results showed that there was a significant difference between the two conditions in the synchronized reaction force in the direction of Fx1 ($p = 0.03$), Fx2 ($p = 0.008$) and Fy1 ($p = 0.02$), but in the other components there was no difference between the two conditions. Conclusion: The increase in horizontal ground reaction force as a result of the use of air braces indicates greater instability. Also, increasing the posterior reaction force of the ground due to the use of braces is one of the risk factors for knee injury. It seems that the use or non-use of this type of brace depends on future research.

Keywords: Air brace, Walking, Ground Reaction Force, Ankle sprain

Introduction

Ankle sprain is one of the most common injuries in sports [1]. Researchers have shown that extra ankle inversion during plantar flexion of the ankle increases the likelihood of ankle sprain [2]. The most common type of ankle injury is an external sprain ligament [3]. More than one-fifth of people with ankle sprain have symptoms such as pain, swelling, recurrent sprain, a feeling of emptiness, and ankle instability [4]. Using a brace can prevent re-sprain, increases people's balance and reduce muscle activity in people with functional ankle instability [5-7]. Passive stiffness of the ankle braces is a very important factor in limiting ankle inversion [8]. Previous research has examined the effect of braces on the range of motion [9]. The researchers found that braces reduced the rotation of the hindfoot on the frontal and sagittal plates [10]. Various studies have shown that different braces limit the range of motion of the joints and reduce the activity of the muscles involved [11-13]. ankle braces restrict normal ankle motion, specifically ankle dorsiflexion and plantar flexion, they may have a detrimental effect on the lower extremity's ability to attenuate vertical ground reaction forces [14].

Increasing the components of the ground reaction forces are associated with injuries from overwork and expose the individual to injuries such as fracture stress, patellar pain, and the complication of plantar fasciitis [15-17]. Reaserchers demonstrated that the use of the ankle brace reduces the time to reach the peak of vertical impact of the ground reaction force [18]. While other study did not show any alterations in GRF after using ankle brace [14]. Therefore, researchers are looking to maintain external support as well as control the extra movement of the ankle and in addition, it does not reduce the range of motion, which is why one of the braces recommended by orthopedists today is air braces. In addition to providing external support, these braces prevent additional joint movement. But so far no research has been done on the effect of using air braces on the three-dimensional distribution of the components of the ground reaction force in these people with functional ankle instability. Since the three-dimensional distribution of the ground reaction forces is of clinical importance and will help therapists in determining the appropriate treatment strategies, in this study we intend to examine the effect of air brace on the ground reaction forces and also, the related components to gain an understanding of the forces applied to the body in these people. We hypothesized that air braces reduced the components of the ground reaction force

Material and Methods

Participants

The present study is of quasi-experimental and laboratory type. 10 women with ankle instability were participant in this study. G* Power software was used to select the number of subjects in the present study. The mean and standard deviation of the age, height and mass of the subjects were equal to (30.87 ± 5.05 year), (166 ± 7 cm), and (71.6 + 15.2 kg), respectively. The criteria for subjects to enter the study were: obtaining a score above 26 from the ankle performance evaluation questionnaire, a history of severe external ankle sprains, a history of ankle instability in the last 6 months .Also, the exclusion criteria from the study were the difference of more than 3 mm between the length of the two lower extremities, the history of surgery, and skeletal abnormalities. All subjects were right-handed and right-footed, which was measured by hand throwing test and foot kick. Subjects were advised not to engage in strenuous physical activity for 48 hours prior to the test. Prior to the test, the objectives and the study method were described to the subjects. Subjects signed a written consent to participate in the study.

Instruments and Procedure

Air brace used in this research was of model (Elife-AN055) made in China (Fig1.)

Figure 2. Air Brace

Using two force plates of Kistler (Kistler AG, Winterthur, Switzerland) of dimensions 600 mm 400 mm, the ground reaction forces (GRF) in the vertical (Fz), anterior-posterior (Fy) and mediolateral directions (Fx) were measured while walking. The sampling frequency was set to Hz1000. The two force plates were placed along each other, apart 1 cm from each other in the middle of a 20-meter path, so that the subject would take at least 5 steps before reaching the force plate. The force plates were first calibrated before the data was recorded.

During walking, the GRF of both legs was recorded and the results of the dominant leg were used for analysis. Before the test, each subject would walk in the lab for about 5 minutes to adjust to the test conditions. Then, each subject walked 6 times with "shoes" and 6 times with "shoes + braces" and their kinetic information was recorded. In the present study, the type of shoes (ASICS design) was the same for all subjects and selected according to their foot size.

Data Processing

The resulting force plate signals were fitted using fourth-order low-pass Butterworth filter with a 10 Hz cutoff frequency [19]. Peak variables of ground reaction forces, impulse and loading rate were measured. For the GRF variables, three vertical components, five mediolateral components and two anterior-posterior components were extracted. For ground reaction forces, the 3-point vertical line includes the value of the vertical force peak at the moment of initial contact (FzI.C), the mid-stance phase (FzM.S), and the push off (FzP.O), in the anterior-posterior direction of the two peak points (FyP.O) and brake (FyI.C), and in the mediolateral direction of the 5 peaks (FxI.C, FxF.F FxM.S, FxH.O and FxP.O) were calculated. All GRF forces were normalized according to individual weight and analyzed at the dominant foot.

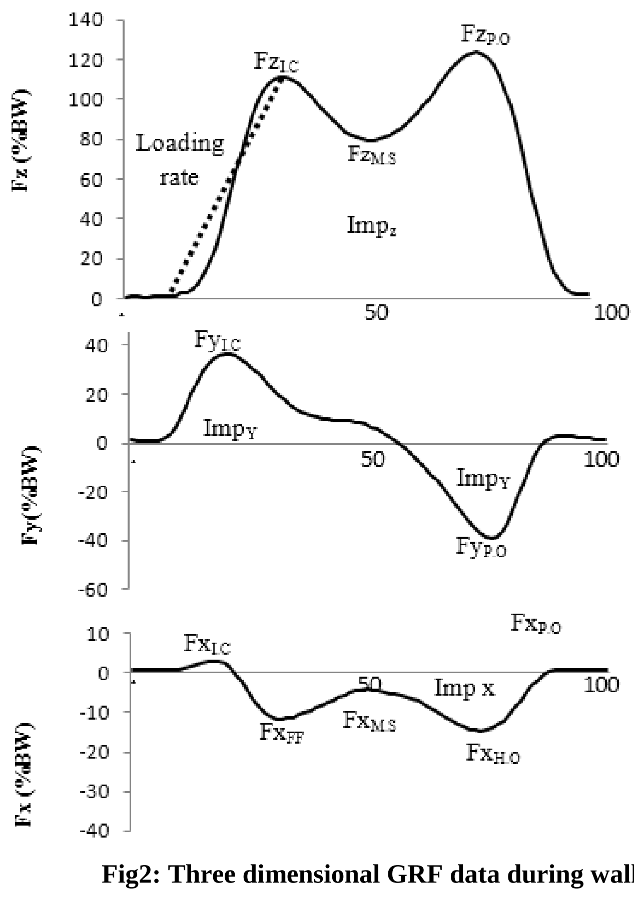

Fig2: Three dimensional GRF data during walking

Impulse was also measured in three directions: x (Impx), y (Impy), and z (Impz). To calculate the impulse size, the method Trapezoidal integration was used [20].

$$\text{impulse} = \Delta t\left(\left(\frac{F1 + Fn}{2}\right) + \sum_{i=2}^{n-1} Fi\right)$$

Vertical loading rate is defined as the initial section slope between heel contact moment to the first peak of ground rea ction vertical force [16].

$$\text{Loading rate} = \left[\!\left[\frac{\text{peak Fz(N)/body weight(N)}}{\text{time to peak Fz}}\right]\!\right]$$

Statistical Analyses

To statistically analyze the data, the Shapiro-wilk test was first used to test the natural distribution of the data. Due to the natural distribution of the data, the repeated measure ANOVA test was used to make the intragroup comparison at the significance level of $p < 0.05$.

Results

Table 1 (1) shows the average peak components of the Fx, Fy, and Fz- normalized ground reaction forces in both conditions with and without using an air brace. The components of Fx1 and Fx2 of the ground reaction force with brace worn on increased by 28% and 27%, respectively, compared to the conditions without using it ($p = 0.036$). Also, the values of the Fy1 component increased significantly after using the brace ($p = 0.02$). In other components of the reaction force, wearing insoles did not have a significant effect ($p > 0.05$).

Table 1. Mean and standard deviation of the normalized ground reaction force during walking

BW%		Without orthoses	With orthoses	P value
Fz	Fz_1	1.05±0.056	1.079±0.07	0.255
	Fz_2	0.75±0.06	0.74±0.06	0.848
	Fz_3	1.08±0.06	1.07±0.06	0.310
Fx	Fx_1	0.025±0.011	0.032±0.015	0.036
	Fx_2	-0.043±0.007	-0.055±0.017	0.008
	Fx_3	-0.021±0.009	-0.027±0.014	0.18
	Fx_4	-0.037±0.013	-0.042±0.02	0.19
	Fx_5	0.004±0.007	0.0088±0.006	0.14
Fy	Fy_1	-0.15±0.027	-0.17±0.04	0.02
	Fy_2	0.20±0.025	0.18±0.03	0.09

Fig 3 shows the results of Impx, Impy, and Impz with two conditions with and without braces. The results showed that when using the brace, the values related to the Impx Impy Impz when wearing the brace did not change significantly compared to the conditions of not using the brace (p >0.05).

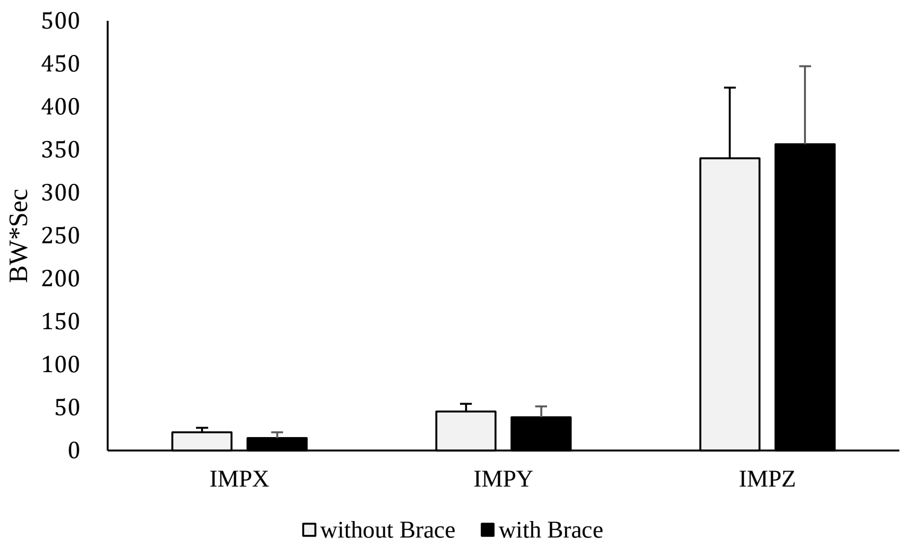

Fig 3. Impulse value in stance phase of gait for tow condition (with and without brace)

Fig 4 shows the vertical force loading rate in two conditions of with and without brace during walking. As seen, using the brace did not any difference in loading rate (p >0.05).

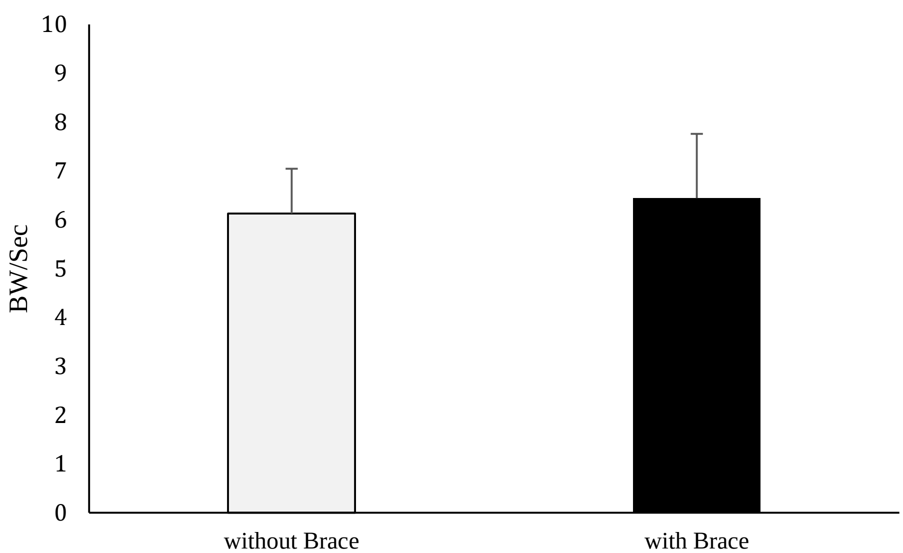

Fig 4. Loading rate in stance phase of gait for tow condition (with and without brace)

Discussion

The aim of the present study was to investigate the effect of instantaneous use of air braces on the peak of the ground reaction forces, impulse and loading rate when walking in people with ankle sprain. At the moment of contact of the heel with the ground while walking, various factors such as surface material, type of shoe, muscle activity, range of motion of the joints, etc. affect the amount of force acting on the ground [21]. Since in this study both the surface on which the running was performed and the type of shoes were considered the same for both groups, the cause of the difference in the components of the ground reaction force can be considered as a result of using air braces [22]. It is clinically important to examine the ground reaction forces in all three dimensions. Various studies have shown that in the early stance phase (0-6% gait cycle) the horizontal reaction forces towards the outside, in the early single support phase (14-30% gait cycle) the horizontal reaction forces to the inside [23]. In the present study, it was observed that when using braces, the horizontal reaction force is towards the inside and outside is significantly increased. Research has shown that changes in the ground horizontal reaction force are related to those in the center of gravity, so an increase in the internal and external force of the horizontal ground reaction force indicates more changes in the center of gravity and therefore more instability in individuals [24].

In various studies, the posterior reaction force is referred to as the braking force. The increase in the posterior reaction force is related to the anterior shear force in the knee, so increasing this force is one of the risk factors for knee injuries [25]. On the other hand, increasing posterior force is one of the compensatory strategies to maintain balance and prevent slipping. People with ankle sprains appear to use a conservative walking strategy which increases the ground reaction force at the posterior surface. The results of this study showed that in neither of the components of the vertical force there is not a difference in the ground reaction force between the two different conditions. Previous research has suggested that the loading rate is one of the causes of injury [26-35], so that an increase in the loading rate is associated with injury caused by overwork. In the present study, it was observed that there is not seen to be any difference in loading rate between two conditions with and without braces. Since the brace used in this study plays a supportive role in the ankle, it seems quite logical that this brace does not increase or decrease the loading rate because the change in loading rate is usually due to a change in movement strategy or a change in the shoe insole. One of the limitations of this study was that the woman subjects were not included in the study, and due to differences in anthropometric characteristics, the generalization of the results of this study to the whole population would bear problems.

Conclusion

The results of the present research has shown that the using an air brace increases the horizontal reaction force and increases the posterior ground reaction force. The increase in horizontal reaction force indicates an increase in postural fluctuations, and on the other hand, an increase in posterior reaction force increases the risk of knee injury. It is very necessary to have further study to determine the precise effects of using brace.

Acknowledgement

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چکیده فارسی

تاثیر استفاده از بریس بادی بر متغییرهای نیروی عکس العمل زمین در افرادی با عارضه اسپرین مچ پا

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مولفه‌های نیروی عکس العمل زمین دارای اهمیت کلینیکی هستند. استفاده از بریس می تواند در کاهش فاکتورهای آسیب زا موثر باشد. لذا هدف از این تحقیق بررسی تاثیر استفاده از ارتز بادی بر متغییرهای نیروی عکس العمل زمین در افرادی با عارضه اسپرین مچ پا بود. ۱۰ زن با عارضه اسپرین مچ پا در این مطالعه شرکت نمودند. با استفاده از یک صفحه نیرو (۱۰۰۰ هرتز) مولفه‌های نیروی عکس‌العمل زمین هنگام راه رفتن در دو شرایط با و بدون بریس اندازه‌گیری شد. سپس متغیرهای اوج نیروهای عکس‌العمل زمین، ایمپالس، و نرخ بارگذاری استخراج شدند. آزمون آماری Repeated mesure با سطح معناداری (P<۰/۰۵) جهت تحلیل آماری مورد استفاده قرار گرفت. نتایج نشان داد در نیروی عکس‌العمل همسان‌سازی‌شده در جهت Fx1، Fx2 و Fy2 بین دو گروه اختلاف معناداری وجود دارد (P=۰/۰۴)، اما در سایر مولفه‌ها اختلافی بین دو شرایط مشاهده نشد. نتیجه نهایی: افزایش نیروی عکس العمل افقی در نتیجه استفاده از بریس بادی نشان دهنده ناپایداری بیشتر می‌باشد همچنین افزایش نیروی عکس العمل خلفی زمین در اثر استفاده از بریس یکی از ریسک فاکتورهای آسیب زانو به شمار می‌رود. به نظر می رسد با توجه به تحقیق حاضر استفاده و یا عدم استفاده از این نوع بریس به تحقیقات آینده بستگی دارد.

واژه های کلیدی: بریس بادی، راه رفتن، نیروی عکس العمل زمین، اسپرین مچ پا