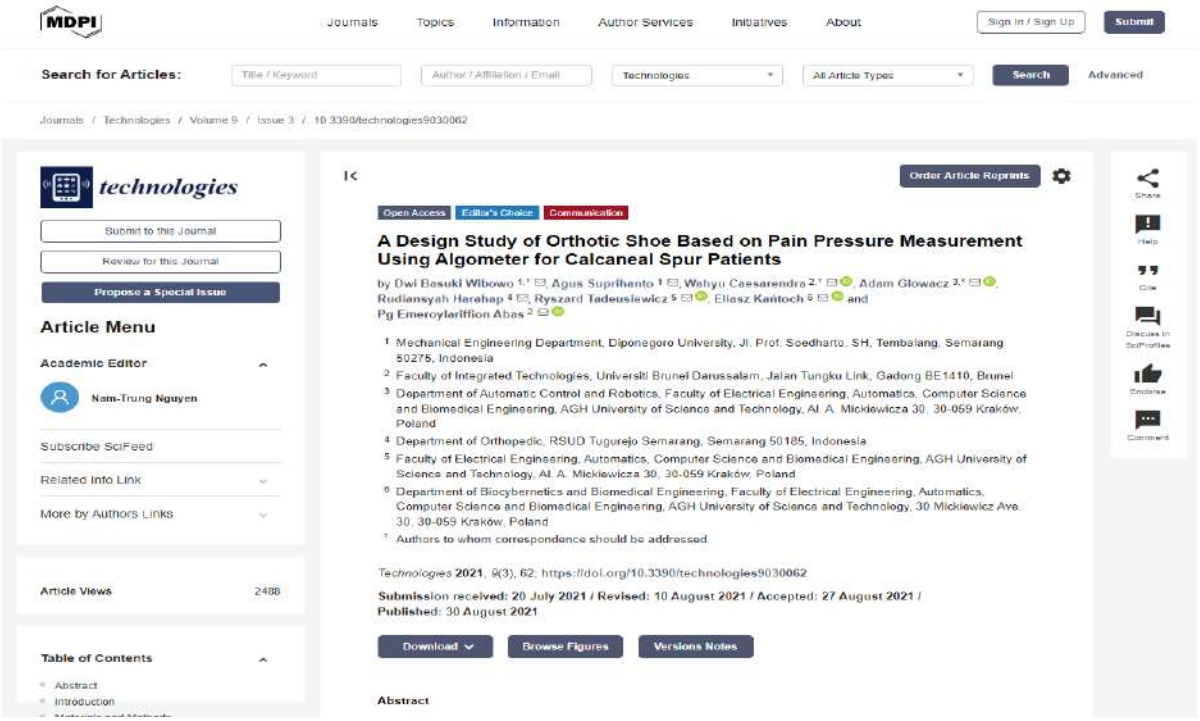
DAFTAR ISI KORESPONDENSI

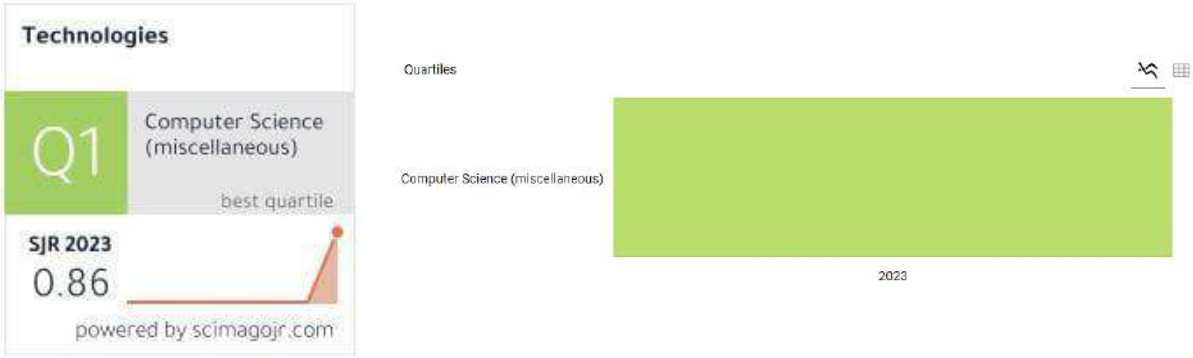
Judul : A Design Study of Orthotic Shoe Based on Pain Pressure Measurement Using Algometer for Calcaneal Spur Patients
Jurnal : Technologies
Publisher : MDPI

1. Artikel Technologies, Quartiles dan SJR, Submission Progress

- **Artikel Technologies**



- **Quartile dan SJR**



- **Submission Progress**

Submission received : 20 July 2021

Revised : 10 August 2021

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2. Submission Received (Email)

Dwi Basuki <rmt.bowo@gmail.com>

[Technologies] Manuscript ID: technologies-1327393 - Submission Received

1 pesan

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Received: 20 July 2021
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3. Assistant Editor Assigned (Email)

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Dear Dr. Wibowo,

Your manuscript has been assigned to Eva Zeng for further processing who will act as a point of contact for any questions related to your paper.

Journal: Technologies
Manuscript ID: technologies-1327393
Title: A Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients
Authors: Dwi Basuki Wibowo *, Agus Suprihanto, Wahyu Caesarendra *, Adam Glowacz *, Rudiansyah Harahap, Ryszard Tadeusiewicz, Eliasz Kańtoch, Pg Emeroylariffion Abas

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4. Major Revisions (Email)

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[Technologies] Manuscript ID: technologies-1327393 - Major Revisions

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Manuscript ID: technologies-1327393
Type of manuscript: Communication
Title: A Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients
Authors: Dwi Basuki Wibowo *, Agus Suprihanto, Wahyu Caesarendra *, Adam Glowacz *, Rudiansyah Harahap, Ryszard Tadeusiewicz, Eliasz Kańtoch, Pg Emeroylariffion Abas
Received: 20 July 2021
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Plants receives an increased IF of 2.762 and falls into the highest quartile (Q1) in the category 'Plant Sciences'.

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5. Revision Reminder (Email)

Dwi Basuki <rmt.bowo@gmail.com>

[Technologies] Manuscript ID: technologies-1327393 - Revision Reminder

3 pesan

Technologies Editorial Office <technologies@mdpi.com> 6 Agustus 2021 pukul 16.03
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Cc: Dwi Basuki Wibowo <rmt.bowo@gmail.com>, Agus Suprihanto <agusm90@yahoo.com>, Wahyu Caesarendra <wahyu.caesarendra@ubd.edu.bn>, Adam Glowacz <adglow@agh.edu.pl>, Rudiansyah Harahap <rudiansyahrsutugurejo@gmail.com>, Ryszard Tadeusiewicz <rtad@agh.edu.pl>, Eliasz Kańtoch <kantoch@agh.edu.pl>, Pg Emeroylariffion Abas <emeroylariffion@ubd.edu.bn>, Technologies Editorial Office <technologies@mdpi.com>

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We sent a revision request for the following manuscript on 31 July 2021.

Manuscript ID: technologies-1327393
Type of manuscript: Communication
Title: A Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients
Authors: Dwi Basuki Wibowo *, Agus Suprihanto, Wahyu Caesarendra *, Adam Glowacz *, Rudiansyah Harahap, Ryszard Tadeusiewicz, Eliasz Kańtoch, Pg Emeroylariffion Abas
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May we kindly ask you to update us on the progress of your revisions? If you have finished your revisions, please upload the revised version together with your responses to the reviewers as soon as possible.

You can find your manuscript and review reports at this link:
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Thank you in advance for your kind cooperation and we look forward to hearing from you soon.

Kind regards,
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E-Mail: eva.zeng@mdpi.com

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Dwi Basuki Wibowo <rmt.bowo@gmail.com> 7 Agustus 2021 pukul 06.07
Kepada: Dwi Basuki Wibowo <rmt.bowo@gmail.com>, "eva.zeng@mdpi.com" <eva.zeng@mdpi.com>
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Dear Eva Zeng,

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Dear Dr. Wibowo,

Thanks for your kind reply. We usually give authors 10 days to revise the manuscript. Your deadline is on 10 August. We just send a gentle reminder to you and hope you could submit your revised manuscript on your due date.

Have a nice day.

Best regards,
Ms. Eva Zeng/MDPI
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[Technologies] Manuscript ID: technologies-1327393 - Revision Reminder

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Cc: Dwi Basuki Wibowo <rmt.bowo@gmail.com>, Agus Suprihanto <agusm90@yahoo.com>, Adam Glowacz <adglow@agh.edu.pl>

Dear Eva Zeng,

I tried to submit the revised paper and respond to the reviewers' comments, however, the link does not work.
I attached the revised paper and 3 documents for Reviewers. Please kindly help me upload these files into the system.

Thank you.

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6. Revised Article

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Communication

A Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients

DwiBasuki Wibowo[1,*], Agus Suprihanto[1], Wahyu Caesarendra[2,*], Adam Glowacz[3,*], Rudiansyah Harahap[4], Ryszard Tadeusiewicz[5], Eliasz Kańtoch[6] and Pg Emeroylariffion Abas[2]

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[3] Department of Automatic Control and Robotics, Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering, AGH University of Science and Technology, al. A. Mickiewicza 30, 30-059 Kraków, Poland
[4] Department of Orthopedic, RSUD Tugurejo Semarang, Indonesia; rudiansyahrsutugurejo@gmail.com
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* Correspondence: rmt.bowo@gmail.com; wahyu.caesarendra@ubd.edu.bn; adglow@agh.edu.pl

Abstract: Pressure pain threshold (PPT) is a useful tool for evaluating mechanical sensitivity in individuals suffering from various musculoskeletal disorders. The aim of this study is to investigate PPT at the heel area, in order to assist in the design of orthotic shoes for sufferers of heel pain due to calcaneal spur. The size and location of calcaneal spur was determined by x-ray images, with PPT data measured around the spur at 5 points by using algometer FDIX 25. Pain test experiment was conducted by pressing each point, to obtain the pain minimum compressive pressure (PMCP) and its location. The information of shoe size, spur location and dimensions, and the PMCP location of each individual, are used to obtain the exact point location for applying a softer material to the shoe in-sole, in order to reduce heel pain. The results are significant as it can be used by designer to design appropriate shoe in-sole to individuals from heel pain.

Keywords: calcaneal spur; pain minimum compressive pressure; algometer; orthotic shoe.

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Technologies* **2021**, *9*, x. https://doi.org/10.3390/xxxxx

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Accepted: date
Published: date

1. Introduction

Calcaneal/heel spur is a small bone that grows on the inferior side of the heel bone and can be seen with an x-ray examination [1]. Calcaneal spurs, as a cause of plantar fasciitis (PF), are currently debatable [2], however, it has a strong correlation with PF {3-4]. The disease can cause pain in the heel and tenderness beneath, which is typically severe in the morning, and improve only after a routine daily weight bearing activity [5]. Obese people who has to stand or walk for a long time, and people with diabetes are most vulnerable to this disease [6]. The most common treatments for individuals with heel spur syndrome, are through intake of a nonsteroidal anti-inflammatory drug or corticosteroid injections, however these treatments should not be administered continuously for a long duration time, due to their side effects on the kidney, and liver, and may also lead to high blood pressure, and stroke [7]. Another treatment that has relatively little effect to the human body, is by reducing pressure on the heel through the use of orthotic shoes [8-9].

The sole of the human foot, particularly, at the heel area, carries a weight of about 69% of the body weight (BW) when standing [10], whilst when walking or running, the heel strike phase ranges from 2.0-5.4 BW [11]. This large amount of load on the heel may cause heel pain and plantar fasciitis, especially if there is a spur present on the heel bone. Orthotic shoes are designed to reduce pressure in the heel area, and its design requires knowledge on the location and dimensions of the spur, as well as the pressure threshold that can cause pain. Previous studies have reported that plantar heel pain caused by heel spur, generally increases in intensity with age and weight of the person. In some of these researches, spurs have been classified into three categories: small (1–2 mm), medium (3–5 mm) and large (≥6 mm), to determine the relationship between spurs dimension and pain intensity. However, the level of pain of each individual has been estimated from a telephone survey, and hence, definitely subjective and qualitative [12]. To obtain a quantitative level of pain, an algometer may be used, which needs to be applied to the tissues via a small rubber tip. The measurement may be taken by pressing each region using the algometer probe (Algomed, Medoc Ltd, Israel), with the minimum pressure that is causing pain (in kg/cm2), or the pressure pain threshold (PPT), recorded.

The use of algometer has been widely used by researchers to study trochanteric pain [13], musculoskeletal pain [14], neck pain [15], myofascial pain [16], low back pain [17], and knee osteoarthritis [18]. An algometer has been used to determine PPT value on the heel of individuals experiencing plantar heel pain syndrome [19]. To measure PPT, the heel regions has been divided into 5 regions: (1) the medial posterior, (2) the medial anterior, (3) the lateral posterior, (4) the lateral anterior, and (5) central site.

In this paper, a study has been performed to investigate PPT measurements at the heel area, to assist in the design of proper orthotic shoes, in order to reduce pain pressure for individuals with calcaneal spur. These orthotic shoes cannot be mass produced [8] as the location and dimensions of spur, and shoe sizes of every individual may be different. Hence, each orthotic shoe must be specially tailored for each individual. The pain minimum compressive pressure (PMCP), and its location on a particular individual, are used as a basis for determining the material hardness of the shoe in-sole at the smallest PPT location as measured using an algometer [20-21]. Previous researches have shown that reducing pressure in the heel area can be achieved by raising the heel height of the shoe, whereby shoes with heel height of 2-cm and 3-cm for men and women, respectively, have been shown to be sufficient to decrease calcaneal pain [21]. Combining the shoe insole material with the appropriate hardness and increasing the heel height of the shoe, greatly reduces the pressure in the heel area.

2. Materials and Methods

Thirteen (13) volunteers, who suffer from calcaneal spur and had been carefully selected by an orthopedic specialist at RSUD, a local public hospital in Tugurejo Semarang, were involved in this study. Each of the individuals had signed a consent form related to the study of Calcaneal spur. Location and dimension of the calcaneal spur of each individual was determined using X-Ray, with S and L denoting the distance from the tip of the heel to the base of the spur growth, and the length of spur, respectively, as shown in Figure 1a. To observe the location and dimension of the spur in plantar view, the X-Ray image was plotted by using digital footprint, which also displays foot length (FL), foot width (FW), shoe size, and foot type [21-22]. In this study, the base of spur is assumed to be located in the heel center line, which is a line drawn from the center of the heel to the tip of the second toe, as shown in Figure 1b [21-22]. Table 1 shows the spur location and dimension for the 13 volunteers, with their details.

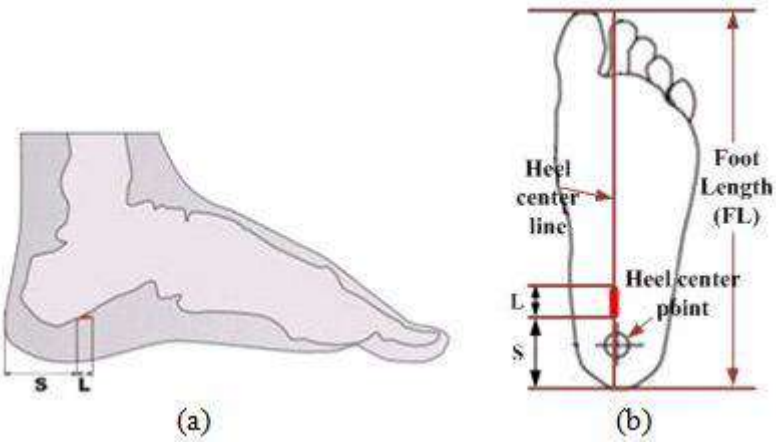


Figure 1. Determination of spur location and dimension in plantar view.

Table 1. Subject characteristics.

Subj. No.	Gender	Age (years)	Weight (kg)	Height (cm)	Occupation	S dimension (mm)		L dimension (mm)	
						Left foot	Right foot	Left foot	Right foot
1	Female	68	59.4	149	Housewife	38.0	-	5.0	-
2	Male	73	49.4	145	Unemployed	34.0	34.0	4.0	3.5
3	Female	60	49.3	157	Housewife	-	36.0	-	1.5
4	Female	65	50.3	153	Housewife	-	38.0	-	4.0
5	Male	47	57.5	152	Factory worker	39.0	-	5.0	-
6	Male	47	55.4	150	Unemployed	41.0	42.0	3.0	2.0
7	Male	50	56.2	157	Factory worker	36.0	35.0	2.0	4.0
8	Male	63	65.6	151	Public servant	39.0	-	7.0	-
9	Female	54	61.6	167	Public servant	-	30.0	-	6.0
10	Female	56	66.1	148	Factory worker	38.0	39.0	7.0	4.0
11	Female	38	51.3	152	Unemployed	34.0	34.0	1.5	2.0
12	Female	63	66.3	163	Public servant	35.0	34.0	2.0	4.0
13	Female	50	60.7	159	Factory worker	35.0	36.0	5.0	6.0

The volunteers consist of 5 males and 8 females, with mean age of 56.5 years. 3 of the volunteers are public servants, whose activities require them to stand and walk for a long duration of time during the day. The other volunteers consist of 4 factory workers, 3 unemployed persons and 3 housewives, all of whom are required to stand often. These volunteers have been suffering from heel pain due to calcaneal spur since, on average, 1.5 years ago, and have been prescribed nonsteroidal anti-inflammatory drug and/or corticosteroid injections, for treatment. Surgery procedure was never done since the last 10 years because the individual before complained that their foot could not be used to walk after the surgery and an infection happened because individuals' living environment was not clean.

Research ethics committee guidelines, relating to volunteers of RSUD Tugurejo for research purposes were duly followed. Pain in the heel area of each volunteer was inspected, giving emphasis around the area of the spur growth. All subjects had experienced no pain in the foot other than calcaneal spur. Pain test was done by pressing certain points

on the heel area by using a rigid stick with diameter of 1.0 cm or more, and prior to the test being done, the volunteers were instructed not to consume any anti-inflammatory drug. The purpose of inspection is to determine the pain minimum compressive pressure (PMCP) and its associated location in the heel area, with pain known from the volunteer's facial expression (qualitatively rated on a scale of 0 to 10) [23].

The pain test has been conducted using algometer FDIX 25 (Wagner Instruments, Greenwich CT, USA), as shown in Figure 2a [24]. This device consists of a flat rubber tip probe of 1.0 cm in diameter, which is applied perpendicular to the skin, with the pressure transmitted to a load cell to produce a voltage output. The signal is transduced and amplified, and subsequently, the output is displayed in Newton or Kilogram (pressure is equal to force divided by the probe area).

There are five pain compressive points specified in this study. The 5th point is set at the base of the spur, the 4th point is set at the end of the spur add 1.0 cm, and another 3 points are set around the spur with the radius equal to spur length added with 1.0 cm, as shown in Figure 2b [22]. The procedure of pain test are as follows: 1) mark the 5 pressure points around the spur growth with a marker, 2) press the skin at 5th point, 3) increase the pressure gradually and stop until the volunteer screams "ouch", 4) take a note on the pressure value, 5) apply the same pressuring procedure at point 4, point 3, point 2 and point 1. From the record of quantitative data of the pain test, the PMCP and its associated point location on the heel of each individual can be determined. This PPT measurement procedure is represented as a flowchart, in Figure 3.

(a) (b)

Figure 2. Pain test in the heel region using algometer FDIX 25.

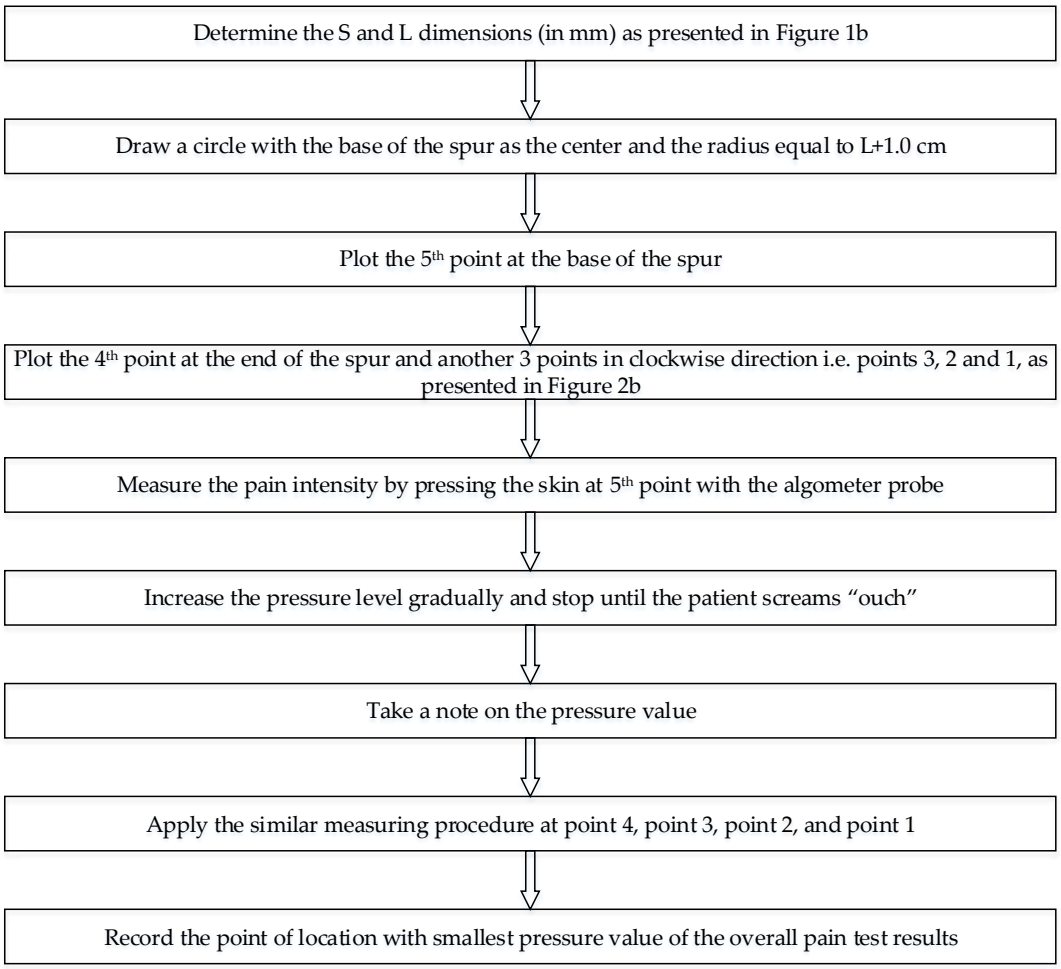


Figure 3. The PPT measurement procedure.

3. Results

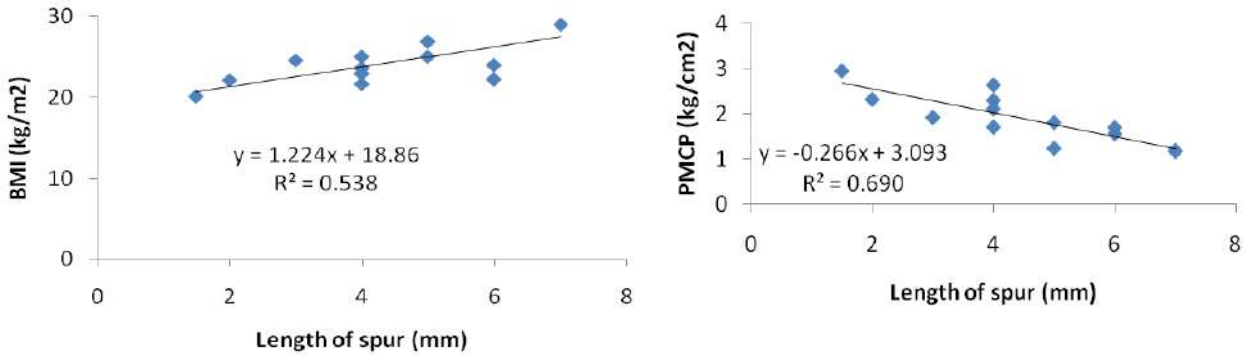
From the 13 volunteers, 7 volunteers suffer calcaneal spur on both feet, as shown in Table 1. Testing pressure of pain on these volunteers, was done on both their right and left foot, such that a total of 20 sets of testing were performed. Only the smallest recorded pressure pain from the volunteers, who suffer calcaneal spur on both feet, was used as the basis for the evaluation of pain, and only the longest spur was recorded. Table 2 shows PMCP test results sorted by the volunteers' occupation. Body mass index (BMI) can be calculated by dividing the body weight (in kg) to the squared height (in m^2), and used to classify the volunteers 3 groups: normal weight with BMI value between 18.5–24.9 kg/m^2, overweight with BMI value between 25.0–29.9 kg/m^2, and obese with BMI≥30 kg/m^2 [25]. Consequently, 8 volunteers had been as normal weight, 4 volunteers as overweight, and 1 volunteer as obese.

The average length of spur of all volunteers is 4.5 mm. There are 2 volunteers whose spur lengths are classified as small, 7 volunteers as medium, and 4 volunteers as large. PMCPs for the volunteers vary between 1.17 to 2.95 kg/cm^2, with an average of 1.89 kg/cm^2. The average PMCP of adults (age between 18-50 years old), and elderly (age between 51-75 years old), are 1.93 kg/cm^2, and 1.83 kg/cm^2, respectively, whilst the average PMCP of males and females are 1.99 kg/cm^2 and 1.75 kg/cm^2, respectively. Averages for occupational groups are 2.64 kg/cm^2, 2.18 kg/cm^2, and 1.58 kg/cm^2, for housewife, unemployed, and working volunteers, respectively. For different points on the heel, the average PMCP at point 1 is 1.82 kg/cm2 (4 subjects), point 2 is 1.17 kg/cm2 (1 subject), point 4 is 2.01 kg/cm2 (6 subjects), and point 5 is 2.06 kg/cm2 (2 subjects). No PMCP point has been identified at point 3.

The correlations between length of spur and BMI; and between length of spur and PMCP, can be presented as linear regressions with correlation coefficients of 0.73 and 0.83, as shown in Fig. 4a and Fig. 4b, respectively. Fig. 5 shows the correlation between BW and PMCP; and between BMI and PMCP, which can also be presented with linear regressions with correlation coefficients of 0.85 and 0.82, as shown in Fig. 5a and Fig. 5b, respectively. The relation between age and PMCP shows an inverse relationship, but is very insignificant as shown by the correlation coefficient of only 0.14.

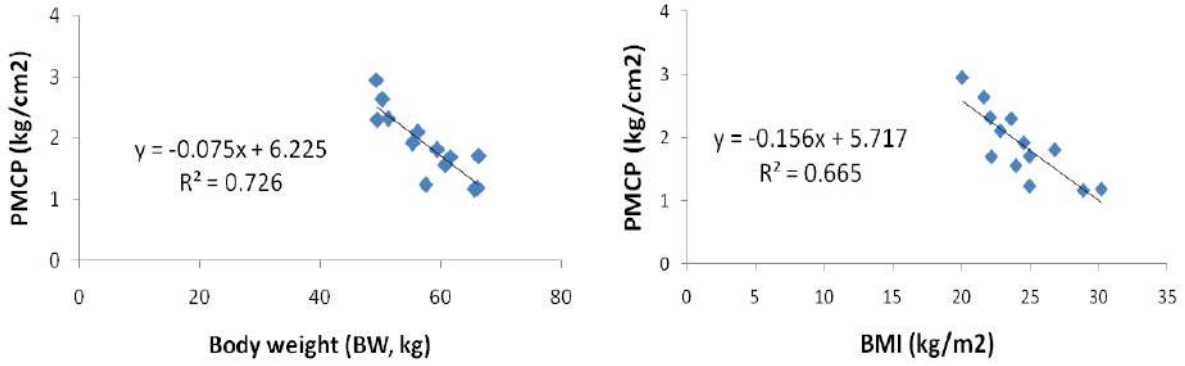
Table 2. PMCP test results

Subject No.	BMI (kg/m²)	Occupation	Length of spur (mm)	PMCP test		
				Value (kg/cm²)	Foot Tested	Point test location
1	26.81	Housewife	5	1.81	Left	5
3	20.06		1.5	2.95	Right	4
4	21.64		4	2.64	Right	4
2	23.64	Unemployed	4	2.3	Left	5
6	24.56		3	1.92	Left	4
11	22.1		2	2.32	Right	1
5	24.97	Worker	5	1.24	Left	4
7	22.85		4	2.11	Right	4
8	28.89		7	1.17	Left	2
9	22.19		6	1.7	Right	1
10	30.21		7	1.19	Left	4
12	24.97		4	1.71	Right	1
13	23.98		6	1.56	Right	1



(**a**) (**b**)

Figure 4. The correlation between lengths of spur with: (**a**) Body mass index (BMI); and (**b**) Pain minimum compressive pressure (PMCP).



(**a**) (**b**)

Figure 5. (**a**) The correlation between body weight (BW) with pain minimum compressive pressure (PMCP);(**b**) The correlation between body mass index (BMI) with pain minimum compressive pressure (PMCP).

Figure 6 shows the correlation between the classifications of gender, age, occupation, and spur location, and the average PMCPs. Low PMCP value indicates that light/low pressure has caused the volunteer to scream in pain. From the results, it can be concluded that generally female felt more pain than male, elderly felt more pain than adult, and volunteers who worked felt more pain than those who did not work and housewife. Also, the average PMCP at point 1 is lower than in points 4 and 5.

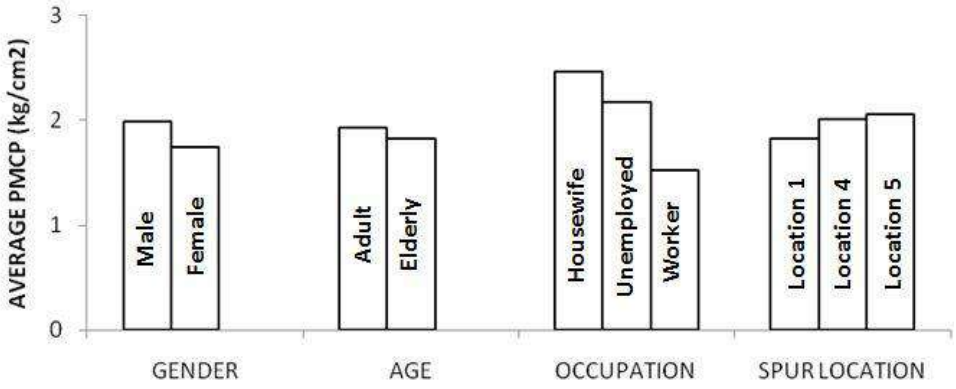


Figure 6. The correlation between the classification of gender, age, occupation, and spur location to the average pain minimum compressive pressure (PMCP).

4. Discussion

Figure 4b shows that the longer the spur, the more painful it is. This is consistent with reality, whereby the longer the spur, the greater the bending moment occurring at the base of the spur, and consequently, the more painful it is. The pain at the spur and the length of the spur, are also related to BW. It can be seen from Figure 4a and Figure 5a, that the weight of the volunteers not only significantly increases the length of the spur but also heel pain [6-8]. In addition, obese volunteers generally experience more pain than volunteers with normal BMI, as can be seen in Figure 5b [6].

Figure 6 show that PMCP of elderly is less than adult. It indicates that elderly felt more pain than adult. Therefore, calcaneal spurs as form of foot disorder can negatively influence elderly people. Another researcher reported that foot disorders can negatively influence elderly people, thus affecting their condition of frailty [26]. This is in contrast to the conclusions reached from another research work based on telephone survey in relation to daily weight-bearing activity, which concludes that adults feel more pain than elderly [12]. These differences may be due to the differences in the methods of inspection of pain. In reference [12], qualitative and subjective method of measuring pain was used, without

giving detail relationship between pain levels and their daily activities. On the other hand, the level of pain was obtained from the pain test using algometer in this study, and hence, is quantitative in nature. Figure 6 also demonstrates that volunteers who actively engage in work feel more pain than those who do not work [5]. This is because pain in the heel would need to be withstand whilst working, causing the heel conditions to deteriorate even further, and consequently, making the pain threshold to be even lower. The condition is different on volunteers who do not work; they can sit or lie down to rest their heel, when they feel the pain. Figure 6 also shows that females with plantar heel pain syndrome demonstrate significantly lower PPTs than males [5].

The results of pain pressure tests on the 13 volunteers demonstrates that a large portion of the volunteers (46%) experience pain on the tip of the spur (point 4). 31% and 15% of the volunteers experience pain on the lateral side (point 1), and central or base of the spur (point 5), respectively. However, the average PMCP on the lateral side (point 1) is relatively lower than on points 4 and 5. This result is consistent with the reality that the compressive force on the end of spur produces the lowest PPT. Another group of researchers has also reported that PPT levels at medial and central sites are lower than at sites lateral, from subjects with plantar heel pain syndrome, who are not specifically due to calcaneal spurs [19]. In this study, the locations of the probe of the algometer on the calcaneal spur sufferers, have been placed strategically around the spur growth, and results have indicated that areas around the spur end give lower PMCP value as compared to the spur base.

Pain suffered by calcaneal spur volunteers whilst standing or walking is generally caused by the improper distribution of large pressure in the calcaneus region. This is consistent with the measurement obtained using a foot plantar measurement system [10-11]. To correct the distribution, orthotic shoes with increased heel height can be used [21], however, this may be impractical for the subject populations, especially male volunteers who work as public servants. Alternatively, a flat heel height shoe but with a softer material in the heel area of the in-sole, as shown in Figure 7 [27], may be used. Similar shoe-insoles in the form of inserts have been sold in the market, but they are not effective in reducing pain in volunteers with calcaneal spur, as the insertion area, which is made of soft silicone rubber, does not properly support the area with the smallest PPT.

Figure 7. Soft shoe in-sole insert material in the heel for people with calcaneal spur.

Foot pain can be minimized by redistributing pressure from the affected area for example using shoe in-sole [28]. Accurate foot pressure distribution measurements can be obtained using foot scanner [29], however this method is in many ways less practical. PMCP measurement using an algometer offers a simpler technique for detecting heel pain. So that appropriate treatment for each patient can be given, therefore no large patient samples are needed. Another example of foot pain measurement based on visual analogic scale is presented in [30].

In this study, PMCP measurement method using an algometer intends to guide and assist orthotic shoe designer by placing a softer material in the heel area where the PMCP of patient is the smallest. As the exact location is person specific, large samples are not

necessarily needed. Details of each individual, including age, gender, occupation, shoe size, the distance from the tip of the heel to the base of the spur (S); length of spur (L); and PMCP location of left and/or right foot, need to be recorded. Age, gender, and occupation are required to determine the appropriate type and model of shoes, whilst shoe size, the distance from the tip of the heel to the base of the spur (S); length of spur (L), and the PMCP location, are required to design a proper shoe in-sole material with a certain hardness [20].

Figure 8 illustrates an example of a shoe in-insole with a softer material in the heel area, of the right foot of volunteer #9. The location of PMCP is at point 1, with the distance from the heel tip equal to S=30 mm and from the heel center line the length of spur, L=6 mm plus the diameter of the algometer tip probe 10 mm. Putting a softer material in the right location and slightly raising the heel height of the shoe (especially for female volunteers) or alternatively, slightly enlarging the contour area in the heel region of the shoe in-sole [21], significantly reduce the pressure in that area.

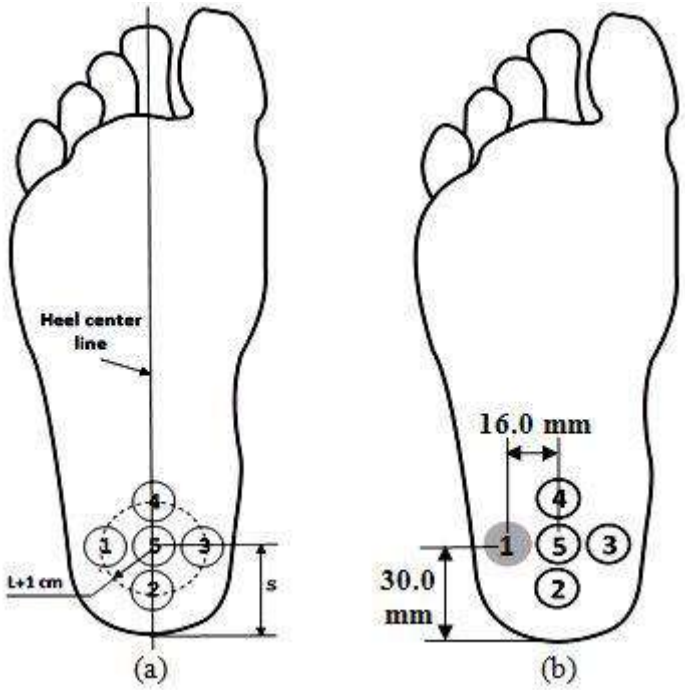


Figure 8. Soft shoe in-sole insert material in the heel area for volunteer #9: (**a**) Definition and notation; (**b**) The dimensions of the distances for soft material laying.

5. Conclusions

Pressure algometry can be used to objectively and quantitatively determine the best heel location, such that optimal improvement towards the relief of pain can be achieved using orthotic shoe. The information on shoe size, spur location and dimensions, and the PMCP location of each individual, are essential to obtain the exact point location, in order to apply a softer material in the heel area of the shoe in-sole. Putting a softer material in the right location plus slightly raising the heel height of the shoe, especially for female, significantly reduces the pressure in that area. It has also been shown that the level of pain increases with increasing weight; another incentive for individual to reduce body weight, in order to reduce pain in the heel area. An alternative method to detect the presence or absence of calcanea spurs on the heel using algometer is presented. Algometer is able to show quantitatively the amount of pressure applied. The magnitude of the pressure and the response of the sample to pain can be used to determine PMCP. Therefore, the small number of samples in our opinion is sufficient to obtain the PMCP value.

Future work: the results of this research will be used to design shoe in-sole according to PMCP measurement data and the effectiveness of these shoe in-sole in minimizing pain in the sample.

Author Contributions: Conceptualization, D.B.W.; methodology, D.B.W. and A.S.; software, W.C.; validation, D.B.W.; A.S.; and W.C.; formal analysis, W.C.; investigation, R.H.; resources, A.S.; data curation, R.H.; writing—original draft preparation, D.B.W.; writing—review and editing, W.C., A.G. and P.E.A.; visualization, A.S.; supervision, R.H.; project administration, D.B.W. funding acquisition, A.G., R.T. and E.K.

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7. Response to Reviewer 1

Reviewer 1

This study suggested interesting results and experimental suggestions.

Also, this paper is well written with logical flow.

However, I found some major limitations and suggest revision related these issues.

This paper deserves to be reject and invite resubmission.

There were a total of 13 subjects, 5 males and 8 females.

Divided into 3 groups by age group, 10 people aged 18-29, 15 people aged 30-49, and 5 people aged 50 and over participated. For reliability verification, the sample size is so small that I agree to increase the number of subjects and conduct the study again.

In my opinion, the study should be re-proposed with increased sample size to allow normative data on the newly developed test battery AND when the inter-rater reliability is verified.

Author response:

Thank you for the reviewer's comment. This study aims to determine whether the algometer can be used as an alternative method to detect the presence or absence of calcanea spurs on the heel. Algometer is able to show quantitatively the amount of pressure applied. The magnitude of the pressure and the response of the sample to pain can be used to determine PMCP. Therefore, the small number of samples in our opinion is sufficient to obtain the PMCP value.

We have added above statement in Abstract and Conclusions to avoid misinterpretation of the reader regarding a number of samples used in this study.

Abstract: Pressure pain threshold (PPT) is a useful tool for evaluating mechanical sensitivity in individuals suffering from various musculoskeletal disorders. The aim of this study is to investigate PPT at the heel area, in order to assist in the design of orthotic shoes for sufferers of heel pain due to calcaneal spur. The size and location of calcaneal spur was determined by x-ray images, with PPT data measured around the spur at 5 points by using algometer FDIX 25. Pain test experiment was conducted by pressing each point, to obtain the pain minimum compressive pressure (PMCP) and its location. The information of shoe size, spur location and dimensions, and the PMCP location of each individual, are used to obtain the exact point location for applying a softer material to the shoe in-sole, in order to reduce heel pain. The results are significant as it can be used by designer to design appropriate shoe in-sole to individuals from heel pain.

5. Conclusions

Pressure algometry can be used to objectively and quantitatively determine the best heel location, such that optimal improvement towards the

relief of pain can be achieved using orthotic shoe. The information on shoe size, spur location and dimensions, and the PMCP location of each individual, are essential to obtain the exact point location, in order to apply a softer material in the heel area of the shoe in-sole. Putting a softer material in the right location plus slightly raising the heel height of the shoe, especially for female, significantly reduces the pressure in that area. It has also been shown that the level of pain increases with increasing weight; another incentive for individual to reduce body weight, in order to reduce pain in the heel area. An alternative method to detect the presence or absence of calcanea spurs on the heel using algometer is presented. Algometer is able to show quantitatively the amount of pressure applied. The magnitude of the pressure and the response of the sample to pain can be used to determine PMCP. Therefore, the small number of samples in our opinion is sufficient to obtain the PMCP value.

8. Response to Reviewer 2

Reviewer 2

This manuscript is well written. The authors have considerably improved the quality of this research following the suggestions of reviewers. Therefore, it is recommended to be accepted for publication on Technologies. Please see below for some minor comments.

The writing professionalism still can be improved to avoid grammatical errors. For example, "are the used to..." in Line 28.

Author response:

Thank you for the reviewer's comment. We have revised the sentenced as highlighted in yellow.

"The information of shoe size, spur location and dimensions, and the PMCP location of each individual, are used to obtain the exact point location …"

As mentioned in the replies to Reviewer 2 (in the last review round), this is a preliminary study and there will be following studies. In this case, it is recommended to outline the future work in the Conclusions section.

Author response:

Thank you for the reviewer's comment. We have added the future work in the Conclusions:

5. Conclusions

Pressure algometry can be used to objectively and quantitatively determine the best heel location, such that optimal improvement towards the relief of pain can be achieved using orthotic shoe. The information on shoe size, spur location and dimensions, and the PMCP location of each individual, are essential to obtain the exact point location, in order to apply a softer material in the heel area of the shoe in-sole. Putting a softer material in the right location plus slightly raising the heel height of the shoe, especially for female, significantly reduces the pressure in that area. It has also been shown that the level of pain increases with increasing weight; another incentive for individual to reduce body weight, in order to reduce pain in the heel area. An alternative method to detect the presence or absence of calcanea spurs on the heel using algometer is presented. Algometer is able to show quantitatively the amount of pressure applied. The magnitude of the pressure and the response of the sample to pain can be used to determine PMCP. Therefore, the small number of samples in our opinion is sufficient to obtain the PMCP value.

Future work: the results of this research will be used to design shoe in-sole according to PMCP measurement data and the effectiveness of these shoe in-sole in minimizing pain in the sample.

Please consider increasing the resolution of figures. For example, the schematics in Figure 1 are not very clear; the photo in Figure 2 (a) is a little blurred.

Author response:

We have removed Figure 2 with a better image.

(a) (b)

Figure 2. Pain test in the heel region using algometer FDIX 25.

9. Response to Reviewer 3

Reviewer 3

In this manuscript, researched about Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients

However the research could be improved, in order to be of interest to journal readers.

This research showed Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients

From my humble point of view this research was well-organized and show precise results.

However,I recommend review carefully and accurately this manuscript after major revision because of the following issues.

1.) Introduction

This section shows clear structure with progression on importance of heel pain, as a condition frequently described in the literature. Within these sections it was highlighted that prevalence in the population. This led nicely to the purpose of the study.

Them authors need discuss this later on in the discussion portion and highlight the findings in the conclusion and abstract.

Besides Introduction may be improved adding new information in order to provide an adequate state-of-the-art including some references. I suggest to include this reference to complete this requirement related to foot pain and elderly complications that authors do not included – López López et al.

doi: 10.1590/1516-3180.2020.0492.R1.0802021.

Author response:

Thank you for the reviewer's comment. We have added the suggested paper in the Reference and the a brief explanation presented in Section 4 Discussion.

4. Discussion

Figure 4b shows that the longer the spur, the more painful it is. This is consistent with reality, whereby the longer the spur, the greater the bending moment occurring at the base of the spur, and consequently, the more painful it is. The pain at the spur and the length of the spur, are also related to BW. It can be seen from Figure 4a and Figure 5a, that the weight of the volunteers not only significantly increases the length of the spur but also heel pain [6-8]. In addition, obese volunteers generally experience more pain than volunteers with normal BMI, as can be seen in Figure 5b [6].

Figure 6 show that PMCP of elderly is less than adult. It indicates that elderly felt more pain than adult. Therefore, calcaneal spurs as form of foot disorder can negatively influence elderly people. Another researcher reported that foot disorders can negatively influence elderly people, thus affecting their condition of frailty [26].

26. Navarro-Flores E, Becerro-de-Bengoa-Vallejo R, Calvo-Lobo C, Losa-Iglesias ME, Palomo-López P, Mazoteras-Pardo V, Romero-Morales C, López-López D., Influence of foot pain on frailty symptoms in an elderly population: a case-control study, Sao Paulo Med J. 139(4):319-24, 2021

2 .) Materials and methods

Methods should be improved in order to increase how was conducted the study. Due to the fact that sample size is not enough to conclude. Beside I recommend to author improve the statistics in order to compare and correlate their achievement.

Author response:

Thank you for the reviewer's comment. This study aims to determine whether the algometer can be used as an alternative method to detect the presence or absence of calcanea spurs on the heel. Algometer is able to show quantitatively the amount of pressure applied. The magnitude of the pressure and the response of the sample to pain can be used to determine PMCP. Therefore, the small number of samples in our opinion is sufficient to obtain the PMCP value.

We have added above statement in Abstract and Conclusions to avoid misinterpretation of the reader regarding a number of samples used in this study.

Abstract: Pressure pain threshold (PPT) is a useful tool for evaluating mechanical sensitivity in individuals suffering from various musculoskeletal disorders. The aim of this study is to investigate PPT at the heel area, in order to assist in the design of orthotic shoes for sufferers of heel pain due to calcaneal spur. The size and location of calcaneal spur was determined by x-ray images, with PPT data measured around the spur at 5 points by using algometer FDIX 25. Pain test experiment was conducted by pressing each point, to obtain the pain minimum compressive pressure (PMCP) and its location. The information of shoe size, spur location and dimensions, and the PMCP location of each individual, are used to obtain the exact point location for applying a softer material to the shoe in-sole, in order to reduce heel pain. The results are significant as it can be used by designer to design appropriate shoe in-sole to individuals from heel pain.

5. Conclusions

Pressure algometry can be used to objectively and quantitatively determine the best heel location, such that optimal improvement towards the relief of pain can be achieved using orthotic shoe. The information on shoe size, spur location and dimensions, and the PMCP location of each individual, are essential to obtain the exact point location, in order to apply a softer material in the heel area of the shoe in-sole. Putting a softer material in the right location plus slightly raising the heel height of the shoe, especially for female, significantly reduces the pressure in that area. It has also been shown that the level of pain increases with increasing weight; another incentive for individual to reduce body weight, in order to reduce pain in the heel area. An alternative method to detect the presence or absence of calcanea

spurs on the heel using algometer is presented. Algometer is able to show quantitatively the amount of pressure applied. The magnitude of the pressure and the response of the sample to pain can be used to determine PMCP. Therefore, the small number of samples in our opinion is sufficient to obtain the PMCP value.

3.) Results

Moving to next point, according to methods comments.The results section is enough appropriate according to the developed methods and the journal´s scope.

Author response:

Thank you for the positive comment that the result section is enough appropriate according to the developed methods and the journal's scope.

4.) Discussion.

This section needs to be improves in order to understanding of the results section comparing with novel and adequate studies. I would suggest to include information related to foot pain for example authors should discuss their result with the achivements of the research Losa Iglesias , et al. with regard to another foot pain measurement as the case of Visual Analogic Scale doi: 10.3390/ijerph15102205.

Author response:

Thank you for the reviewer's comment. We have included the suggested paper in the Discussion and Reference.

Foot pain can be minimized by redistributing pressure from the affected area for example using shoe in-sole [28]. Accurate foot pressure distribution measurements can be obtained using foot scanner [29], however this method is in many ways less practical. PMCP measurement using an algometer offers a simpler technique for detecting heel pain. So that appropriate treatment for each patient can be given, therefore no large patient samples are needed. Another example of foot pain measurement based on visual analogic scale is presented in [30].

30. Emmanuel Navarro-Flores, Marta Elena Losa-Iglesias, Ricardo Becerro-de-Bengoa-Vallejo, Daniel López-López, David Rodríguez-Sanz, Patricia Palomo-López and César Calvo-Lobo. Translation and Test–Retest of the Spanish Podiatry Health Questionnaire (PHQ-S). *Int. J. Environment Research and Public Health* **2018**, 15, 2205

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Thank you very much for resubmitting the modified version of the following manuscript:

Manuscript ID: technologies-1327393
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Title: A Design Study of Orthotic Shoe based on Pain Pressure Measurement using Algometer for Calcaneal Spur Patients
Authors: Dwi Basuki Wibowo *, Agus Suprihanto, Wahyu Caesarendra *, Adam Glowacz *, Rudiansyah Harahap, Ryszard Tadeusiewicz, Eliasz Kańtoch, Pg Emeroylariffion Abas
Received: 20 July 2021
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Authors: Dwi Basuki Wibowo *, Agus Suprihanto, Wahyu Caesarendra *, Adam Glowacz *, Rudiansyah Harahap, Ryszard Tadeusiewicz, Eliasz Kańtoch, Pg Emeroylariffion Abas
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