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Design of Foot-Inserts Based on Foot Reflexology Study for the Design of Foot Inserts Based on Foot Reflexology

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ABSTRACT Human palms and feet have reflex points connecting to different organs of the body through a neurological network that stimulates the specific organs. Application of pressure on the reflex points helps rebalance, heal, and improve blood circulation. Footwear is designed to induce pressure through these reflex-points located over the plantar surface of feet. Five zones are identified to study projected inserts/designs to investigate acupuncture pressure reflexes for overall wellness and stress management. Several functional prototypes are developed to adopt pressure/sensational acupuncture therapy on different sensitive zones underneath the feet to study the performance of reflexology diagnosis. A customised reflex-foot-insert is designed to study specific performance towards relaxation/comfort of identified participants (7 samples) during their static standing phase. Varied densities of polyurethane are used in the design of reflex-inserts. D-120 has been found to provide more contact surface area resulting in less pressure for males whereas D-95 has imparted similar effects for females.

INTRODUCTION

One of the important objectives of footwear is to provide comfort. In the present context, the footwear signifies immense value of importance for therapeutic purposes. Foot reflexology is the practice of inducing the reflexes in the feet, which correspond to other organs or parts of the body for acquiring responses. Acupressure uses sustained or intermittent sequences of actions starting from locating a point, applying pressure, releasing and relaxing, to create a pulse of healing energy that continues to accentuate with intensity (Kim et al. 2017). As the application of pressure stops, the sensation also disappears. A strong sensation reflects an imbalance due to excess energy while a weak sensation suggests a deficiency leading to fatigue and aching (Embong et al. 2015). Reflexology is a natural healing technique by the application of pressure to stimulate nerves triggering a relaxation response throughout the body. In the long run, it results in good health, eases pain, prevents disease, and improves the quality of life. The benefits include reduction of stress and anxiety, body pain, mood swings, etc. Reflexologists believe that applying pressure to these points promotes blood circulation, relaxation, and healing in the body by liberating blocked energy (Murat-Ringot et al. 2020). The design of shoes must incorporate exertion of pressure through (innersole) reflex points of the foot to generate/stimulate sensation. These reflex points are energy junctions that relay and reinforce energy along meridian lines of the body, passing energy (Chi) toward the organs via the nervous system.

It can be seen from Figure 1 that there are five principal zones of the nervous system in the foot. Nerves from different organs of human body are ending at different zones of human feet as revealed from Figure 1. Zone 1 contains reflex points connecting through the thumb, arm, shoulders, neck and brain again down to the big toe. Zone 2 covers the region starting from the index finger, up the arm to the shoulder, neck and brain down the body to the second toe. Similarly, Zone 3 extends through similar regions and finally down to the body to the third toe, etc. The design of a footbed depends on seat length, wedge angle, and shank shape parameters so that the fit between the foot and footwear

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Fig. 1. A schematic of the bottom of the foot showing the reflex points

becomes comfortable and suitable for the chosen activity. Many researchers have investigated different types of materials and shapes to relieve the high pressures linked to foot pain and discomfort (Godfrey et al. 1967; Silvino et al. 1980; Tsung et al. 2004). A study was performed to compare the effectiveness of reducing plantar pressure using seven different materials (Leber and Evanski 1986). However, with a change in material property, the pressure characteristics also change. Lower peak pressures can be achieved with conforming footbeds or through varying levels of cushioning. Materials with low stiffness provide adequate conformance to eliminate clearance between the foot and footbed. It was learnt that there is no reduction in vertical impact forces during running when viscoelastic insoles compared with conventional running shoe insoles, probably due to the bottoming-out of the insoles (Nigg et al. 1988). It was demonstrated that the impact force and loading rates depend on midsole construction (Aguinaldo and Mahar 2003). Customised modified insoles with an additional layer of cushioning provided comfort (Martinez et al. 2019). They were able to reduce pressure by up to 77 percent by using a metatarsal bar with ethyl vinyl acetate (EVA) and poron offloading material. A few biomechanical changes were suggested by adding additional pads to the insole. A metatarsal pad was added to the forefoot region to redistribute plantar pressure (Wright et al. 2002). A heel lift was also added to the posterior region of the insole to revise the discrepancy of anatomical leg length for Achilles, tendonitis, and ankle equinus. Insoles also serve as tools for odour and moisture control, arch support, and extra cushioning (Mientjesa and Shorten 2012). There are some conventional insoles made of foam, memory foam, gel, air cushion, cork and leather. Foot reflexology can be used as a tool for the treatment of some diseases. The effects of foot reflexology on chemotherapy-induced nausea and vomiting in patients with digestive system or lung cancer, and the protocol for a randomised controlled trial were studied (Goonetilleke 1999). Oral Aydan and Ayse (2013) reported reflexology studies in managing fatigue in multiple sclerosis and suggested rehabilitation means. Calvin et al. (2021) studied lateral shifts in plantar pressure distribution and reported that shifts in the foot centre of pressure may not be important to modify joint load distribution for knee osteoarthritis. James et al. (2020) considered 5 materials, ranging from 20 to 23, and found their quality index scores and concluded that orthotic materials can reduce plantar pressure. Juan et al. (2022) used 3D-printed insoles made of thermoplastic polyether and polyurethane to study plantar pressure distribution for diabetic-deformed feet. Judith et al. (2022) explained the mechanism behind reflexology as one therapeutic tool for preventive health benefits. Yeh et al. (2022) suggested wearable inertial sensors to observe characteristic differences in walking for older people. Bioimpedance study was conducted to find the effect of massage on foot reflexology (Saeed 2012) where the investigator found that the impedance, phase angle and resistance increase with massage.

Aim of the Study

As the foot surface profile and BMI vary for every individual, the design of the foot inserts to conform to the foot morphological parameters is the primary purpose of research. The design of the inserts should need to adapt the function and biomechanics of the foot, improper positioning of the foot during gait, or other discomforts caused by injury, overuse, or disease. The protruded designs created on varied pressure zones over the foot inserts with the top layer being the natural leather is the way-forward research initiative, as there is a lack of therapeutic foot inserts designed with reflex features using leather covering, which has been an encouraging move towards taking forward this research thereof.

Objectives

The objective of the present paper is to (i) design a footwear inserts using polyurethane foams at reflex-points, (ii) to make prototypes and use them through participants, and (iii) to study the efficacy of varied density polyurethane foams and their functional aspects over reflex-points to acquire foot-comfort advantages for beneficiaries The design of leather inserts with the provision of protruded surface profiles with the reference of reflex points of the foot using varied polyurethane foam density materials has been proposed to be developed in this research work to improve the blood circulation over the plantar region of foot to gain therapeutic advantages.

Organisation

Therefore, based on the current demands and requirements mentioned above, the present paper is organised such that the materials and methods are presented in section 2, experiments are described in section 3, results and discussions are summarized in section 4 and at the end, the conclusion is drawn.

MATERIAL AND METHODS

Four types of inserts, namely foam, gel, cork, and leather were procured from the local market. Different brands of foam, plastazote, Latex, dynafoam, ortho felt, Spenco and molo were collected from the local market. Foam works better for cushioning support and pressure relief gel was procured mainly for shock absorption, while cork was selected for support and leather was chosen for providing cushion, comfort, and feel. These materials possess one-eighth inch of thickness. Adhesive, EVA, and poron were procured from the local market. Three types of gel namely, Spenco gel insoles, New Balance Pro gel supportive insoles, and Orthaheel gel heel orthotic inserts were collected. Among other materials, felts (polyester), insole boards, and anti-slip materials were procured from the market. There were seven participants distributed over the age group of 30-55 years who were drawn for the study. The samples were selected based on Gaussian distribution as one sample aged 30 years, one at 55 years, one at 37 years, one with 49 years and another three in the range of 42-45 years of age. The mean age is estimated to be 43 years. The participants possessing normal foot morphological characteristics and leading a healthy lifestyle were called on for the experimentation procedures. The participants' Body Mass Index and associated foot parameters were observed prior to seeking their consent for participation in the study. People with this average age group are found to be witnessing malfunctioning of organs and are in dire need of nerve stimulation or reflex-excitation (Goonetilleke 1999).

The method includes a collection of samples, identification of reflex-zones beneath the foot, identification of organs prone to malfunction for the participants, selection of insert materials, design and optimisation of sizes for foot-inserts, and experimentation on reflex inserts with participants on P-walker for pressure measurement and analysis of data. The idea of designing protrusion over-pressure zones on reflex foot inserts using varied polyurethane foam densities has been primarily to investigate the efficacy of the foam cushioning and resiliency behaviours at the designated pressure zones of the foot and thereby influencing improved foot comfort advantages to the beneficiaries. After revealing the findings on acquiring foot comfort benefits from the study, the usefulness and the efficacy of reflex inserts would be suggested and recommendable for the well-being of the common people for experiencing foot comfort at ease.

Participants

Participants possessing normal foot parameters and leading healthy lifestyles from the locality in the age group of 30-55 years were encouraged to participate and registered accordingly for the research study. The participants expressed enthusiasm and involvement to render support in the study and extended cooperation for the successful conduct of the procedures.

Experimental Procedure

Foot inserts constructed with multilayers were laminated conforming the plantar surface of the foot with the protrusions designed at designated pressure zones and would be placed inwards of the footwear. The laminate consists of a central spongy core made of a foamed plastic material. A thin layer of fibrous paper is layered on the upper surface of the central core. The side view of the object displays three raised portions extending upwardly from the upper surface of the laminate. The first raised portion is visible near proximate to the inner peripheral edge of the insert, which extends longitudinally to provide support for the person's arch. The second raised portion is oval-shaped to support the metatarsal portion of the person, and the third raised portion supports the person's phalanges. This lamination is 0.25 inches in thickness. Further, a reflexology leather insert was constructed by combining polymeric foam of varied densities with the protruded contours at the desired pressure zones. The reflexology insert material was evaluated on mechanical characteristics and compression and resiliency properties were recorded and further compared with similar conventional inserts. Finally, the leather reflex insert was placed inside a shoe. The sequences of operations pertaining to the development of the insert prototype and the tests performed are given in Figure 2a.

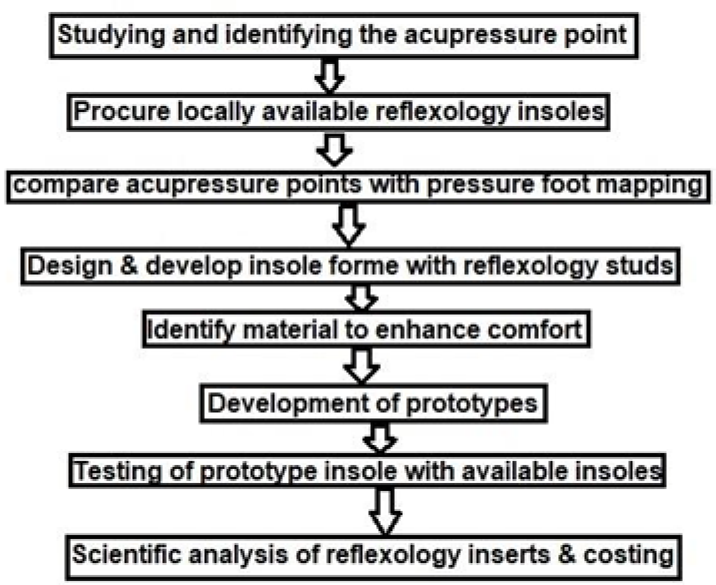

Fig. 2a. Image of foot inserts made with layered with polymeric foams at reflex points based on reflexology study

Initially, basic acupressure points on the plantar region of the foot were identified. Then the reflexology inserts were (following the method as described above) employed for experimental analysis. Pressure mapping tests were carried out with the due consent of the participants. The protruded contours were designed and developed using varied-density polyurethane foams especially on the pressure zones of the foot for the development of reflex inserts. The physical tests on developed insert samples of both flat and reflex were carried out to analyse their mechanical behaviours to ascertain the foot comfort parameters of the beneficiaries. The procedure of the experiment has been enumerated in a sequential manner shown in Figure 2(a). Figure 2(B) exhibits the combined reflexology leather inserts having leather as the first layer and polymeric foams as the underneath layer.

Fig. 2b. Image of foot inserts made with layered with polymeric foams at reflex points based on reflexology study

Mathematical Analysis

The body can be thought of as a cylinder inside which the movement of water and salts induces impedance across the body, which can be measurable. If Z be the impedance, □is the average density of body fluid, L be length and A be cross-sectional area, then,

$$Z = \rangle (L/A) \quad (1)$$

When a person walks, the force applied on the ground is F, the Achilles tendon muscles contract or expand with a distance x, the force on the contractile elements is F_{CE}, the force on damping is F_b, and the force on the elastic elements is F_k. The mechanical balance of total force around the ankle becomes:

$$F = F_{CE} + F_b + F_k \quad (2)$$

The kinetics of motion becomes:

$$F = F_{CE} - b\,(dx/dt) - k(x) = k_1\,(dx)^a \quad (3)$$

The value of exponent 'a' becomes (1, 2 or 3). k_1 is the spring constant, k_2 is the stiffness constant and b is damping coefficient. Muscle works as a spring. Generally, $dx = x_2 - x_1$, where x_1 is the initial position of spring and x_2 becomes the final position of the spring movement. With initial conditions of $x1(0) = x2(0) = 0$, the equation (3) can be solved as:

$$F_{CE}(s) = [(k_1 + k_2 + bs) / k_1]\, F(s) + (k_2 + bs)\, X_1(s) \quad (4)$$ or

$$X_1(s) = F_{CE}(s) / (k_2+bs) - [(k_1+k_2+bs) / (k_1(k_2+bs))]\, F(s) \quad (5)$$

If $x1(0) = 0$, then a unit step change on equation (4) leads to

$$F(t) = [F_{CE}\, k_1 / (k_1+k_2)]\, [\, 1-\exp(-((k_1+k_2)/b)\, t)] \quad (6)$$

Wherein equation 6 represents the kinematic mechanism of foot muscles for movement.

RESULTS

Reflexology is a natural healing process that facilitates and accelerates acupressure exertion located under the feet, in the hands and on inside ears that are connected to certain organs of the body. Light touch or massage is put forward through acupressure energy points to stimulate the nerve endings for the revival of functionalities of affected organs in the body. In the acupressure practices, the patients were subjected to the application of pressure starting from a lower degree of pressure to a firm degree of pressure over different pressure points that were held steadily for a certain time and later subjected to gradual release of pressure. Keeping this concept in mind, the reflexology inserts have been designed and engineered using varied density characteristics of polyurethane foam materials ranging from lower, medium and higher range physical properties with the protrusion contours on the acupressure zones of the plantar region of the foot. The cushion energy over the acupressure zones of the foot received by the body helps in the healing process.

The polyurethane foam materials for the prototype of reflex inserts were chosen being soft but firm enough to withstand the pressure and transmit the energy to the body of the participant. Four reflex zones were identified under the feet, (i) underside of toes (ii) heel area, (iii) little toe, and (iv) adrenal area. The first zone covering the underside of the toes was chosen as nerves of the under-toes area, which are linked to the head and brain and the participants are likely to have symptoms of headaches/migraines. Hence, the application of pressure will be transmitted to release the muscle tension around the cervical spine resulting in the reduction of stress and tension, improving nerve function, and maintaining homeostasis. The second zone was chosen specific to the heel region as the pressure points are connected to the sciatic nerve (the longest and widest in the human body). The application of light to moderate pressure helps reduce lower back pain, spinal disc herniation, and spinal stenosis. The third region was chosen as some participants experience symptoms of shoulder and arm pain. Nerves from this region are responsible for tension in arms. The pressure applied by the reflex insert helps in treating insomnia, headaches, and stress. The fourth zone was chosen since the probable occurrence of some health consequences was possibly due to the disc-functioning of the adrenal gland. Stress hormones namely, adrenaline and noradrenaline are released from the medulla to trigger a fight or flight response. Hence, an application of pressure at this reflexology point (a finger distance under the ball of the foot) helps in relieving stress and tension. Reflexology wooden sticks were used to apply pressure within a 5-10 mm diameter region around the point. The pressure was applied at a 90-degree angle using a rack and pinion type of reflexology stick. The duration of holding pressure was 30 seconds per minute, and each participant was treated for a duration of 45-60 minutes. The reflex inserts designed are primarily aimed at rendering cushion energy induced from varied polyurethane foam materials over the different pressure zones of the foot to provide foot comfort benefits and thereby improve the overall well-being of the participants.

Scientific Analysis

A total of seven participants were enrolled and subjected to scientific analysis to ascertain the maximum pressure, average pressure and surface area of contact being exerted by the participants. P-walk tests were conducted on static positions as well as on dynamic movement for the participants in the Gait laboratory. Variables like max pressure, average pressure and surface area were measured, recorded and collected. Barefoot experiments were conducted on varied density flat inserts and reflex inserts on categories of surface area, average pressure and maximum pressure and the data pertaining to these experiments are drawn in detail as under.

A P-Walk analysis has been performed to understand the plantar pressure evaluation in static and dynamic conditions and to treat pathologies related to balance and gait disorders. A single platform was used for both static and dynamic analysis. The static analysis has been employed to ascertain the plantar pressure distribution when a participant is in a standing position. Figure (3a) illustrates the static position of participants on the platform for plantar pressure distribution.

Fig (3a). Static position of participants on platform for plantar pressure distribution

Table 1 illustrates the surface area values on varied density parameters of flat inserts. It is observed from the Table that the surface area values are higher in the case of FD 95 and FD 120 while comparing the other variables. Out of these, FD 95 and FD 120 possess the higher values of surface area majorly being of their lowest compression set in percentage value when comparable with other lower as well as higher density inserts.

Table 2 illustrates the surface area values on varied density parameters of reflex inserts. It is observed from the Table that the surface area values are highest, especially for RD 120 amongst all other variables. Further to add, the values of RD 120 are higher than the values of FD 120 in regard to the surface area parameter.

Table 3 describes the average pressure values on varied density parameters of flat inserts. It is

Table 1: Surface area on varied densities of flat inserts (cm²)

Person	Gender	Bare foot	FD 55	FD 75	FD 95	FD 120	FD 140
1	Female	210	244	247	260	262	240
2	Female	186	218	220	226	214	213
3	Male	213	233	241	250	261	247
4	Female	195	234	229	237	226	230
5	Male	232	260	261	262	256	261
6	Male	255	269	260	277	268	271
7	Male	190	211	228	236	232	226

Table 2: Surface area on varied densities of reflex inserts (in cm²)

Person	Gender	Bare foot	FD 55	FD 75	FD 95	FD 120	FD 140
1	Female	210	236	251	262	250	235
2	Female	186	218	225	220	241	216
3	Male	213	240	264	258	262	251
4	Female	195	216	220	230	241	230
5	Male	232	256	267	276	274	271
6	Male	255	267	282	291	292	225
7	Male	190	228	230	227	230	226

Table 3: Average pressure on varied densities of flat inserts (in kPa)

Person	Gender	Bare foot	FD 55	FD 75	FD 95	FD 120	FD 140
1	Female	64.6	53.6	52.6	50.7	51.9	55.3
2	Female	80.1	67.6	64.1	64.7	69	66.8
3	Male	75.8	66.8	67.7	68.4	66.8	68.3
4	Female	69	57.8	56.3	59.4	60.2	61.1
5	Male	62.9	57.2	57.4	54.9	60.2	57.9
6	Male	58	48.5	48.5	47.8	46.4	47.1
7	Male	69.9	61.3	63.1	61.1	60.3	61.3

observed that the average pressure values are lesser for FD 95 and FD 120 than the other lower and higher density inserts. The decreased pressure values of FD 95 and FD 120 are mainly owing to compression as well as the cushioning characteristics of the inserts.

Table 4 describes the average pressure values on varied density parameters of reflex inserts. It is observed that the average pressure values are lesser for RD 95 and RD 120 than the other lower and higher density inserts. The decreased pressure values of RD 95 and RD 120 are mainly owing to compression as well as cushioning characteristics of the inserts.

It can be observed from Table 5 that the maximum pressure values on the varied density of flat

Table 4: Average pressure on varied densities of reflex inserts (in kPa)

Person	Gender	Bare foot	FD 55	FD 75	FD 95	FD 120	FD 140
1	Female	64.6	55.4	54.1	52.1	52.4	56
2	Female	80.1	68.2	68.2	71.9	67.8	74.9
3	Male	75.8	67.1	65.7	62.4	63.7	64.7
4	Female	69	59.4	56.3	53.8	54.3	61.8
5	Male	62.9	53.2	54.9	55.6	55.6	56.1
6	Male	58	48.2	48.7	47.8	46.2	50
7	Male	69.9	56.7	57.4	57.3	56.3	60.7

Table 5: Maximum pressure on varied densities of flat inserts (in kPa)

Person	*Gender*	*Bare foot*	*FD 55*	*FD 75*	*FD 95*	*FD 120*	*FD 140*
1	Female	174	132	121	124	125	122
2	Female	209	176	160	198	236	184
3	Male	157	170	172	175	169	158
4	Female	172	186	175	202	219	172
5	Male	158	164	176	143	158	155
6	Male	130	162	174	127	173	145
7	Male	170	193	178	174	170	138

inserts are found with significant differences in the comparison of barefoot data. It is revealed from the Table that the maximum pressure values with respect to FD 120 is higher than the values of barefoot. The trend in the case of FD 95 appears higher in maximum pressure values than in barefoot predominantly.

It can be observed from Table 6 that the maximum pressure values on the varied density of reflex inserts are significant differences in the comparison of barefoot data. It is revealed from the Table that the maximum pressure values with respect to RD 120 are higher than the values of barefoot. While comparing the maximum pressure data obtained between FD 120 and RD 120 inserts, RD 120 possesses lower pressure values and it is evident that RD 120 insert deserves to support the beneficiaries with therapeutic advantages. The trend in the case of FD 95 appears higher in maximum pressure values than barefoot predominantly.

Table 7 furnishes the comparison of maximum pressure versus surface area between FD 120 and RD 120 inserts. It compares the maximum pressure exerted and the surface area used by persons in barefoot conditions, with normal footwear (FD) and with reflex inserts (RD) conditions. It is clearly understood that the values listed under maximum pressures of reflex inserts RD 120 are lesser than those of flat inserts FD 120 and the surface area values of RD 120 are higher than FD 120 inserts. Hence, RD 120 inserts are considered scientifically superior in physical characteristics than FD 120 inserts and are advantageous for the beneficiaries primarily due to lesser pressure values over higher surface

Table 6: Maximum pressure on varied densities of reflex inserts (in kPa)

Person	*Gender*	*Bare Foot*	*FD 55*	*FD 75*	*FD 95*	*FD 120*	*FD 140*
1	Female	174	131	146	133	127	135
2	Female	209	191	210	210	184	214
3	Male	157	185	183	168	174	149
4	Female	172	181	199	195	195	172
5	Male	158	160	141	149	149	169
6	Male	130	113	141	138	158	202
7	Male	170	124	140	159	150	161

Table 7: Comparison of max pressure versus surface area of FD 120 and RD 120

Barefoot max-pressure surface area		*Flat insert D120 max-pressure surface area*		*Reflex insert D120 max-pressure surface area*	
(kPa)	*(cm^2)*	*(kPa)*	*(cm^2)*	*(kPa)*	*(cm^2)*
174	210	262	125	250	127
209	186	214	236	241	184
157	213	250	169	258	174
172	195	237	219	230	195
158	232	256	158	274	149
130	255	268	173	292	158
170	190	232	170	230	150

area. These physical characteristics are the scientific evidence proving RD 120 inserts are the pressure-relieving foot comfort component recommendable for the therapeutic benefits of the participants.

DISCUSSION

In this section, the results were analysed. The participants enrolled were subjected to scientific analysis to ascertain maximum pressure, average pressure and surface area of contact. The P-Walk tests were conducted under static and dynamic analysis for the participants wherein RD 120 reflexology polyurethane foam material possesses maximum contact surface area. As pressure varies inversely with the area, it is inferred that RD120 material gets less pressure. The decreased pressure values of RD 120 are mainly owing to compression as well as cushioning characteristics of the inserts. It eventually signifies a lesser degree of pressure data while comparing other PU materials of varied density characteristics. Hence, the density characteristics play a crucial role in respect to the mechanical characteristics of the foam material. From the results, it can be observed that the present material polyurethane is suitable in reducing plantar pressure as also suggested by other researchers (James et al. 2020).

The compression set values of D55, D75, D95 and D120 with respect to static condition resulted in values of 12.0, 9.33, 6.74 and 6.17 respectively, wherein D120 has the lowest value of 6.17 amongst the foam materials assessed in the laboratory. The resilience property of RD 120 insert is the primary factor to conform the plantar surface profile of feet as well as the area of contact between feet and reflexology inserts. The recovery behaviour is very much needed for the insert materials to render the desirable foot-comfort requirements to the needy. The higher density, hardness and resilience characteristics of the RD 120 insert would help lessen the pressures underneath the plantar surface of the feet. This would further aid in lessening the impact and reducing the stress of the participants. The resilience/buoyancy behaviour of RD 120 insert would intend to act as a shock absorber to help remedy the pain and discomfort of the participants. It is revealed that the contact area of the foot exhibits increased value in the case of reflexology inserts while comparing flat inserts under experimentation analysis. Thus, in most cases, the contact surface area shows the increased value of trend with respect to reflexology inserts. The optimal (maximum) area is obtained in the case of the density material of RD-120 (polyurethane). Studies of Juan et al. (2022) also confirm the use of polyurethane in making customised insoles where their product may be helpful for other patients with deformed feet.

The higher cushion values of the RD 120 insert would help in cushioning the excessive plantar pressure distribution generated by the participants, thus, lowering the pressures on the entire region of the feet. The higher cushion values of RD 120 insert assist in absorbing energy to render foot comfort benefits to the participants. It is clearly understood that the maximum pressure data of reflex inserts RD 120 are lesser than that of flat inserts FD 120 and the surface area values of RD 120 are higher than FD 120 inserts. Hence, RD 120 inserts are considered scientifically superior in physical characteristics to FD 120 inserts and are advantageous for the beneficiaries primarily due to lesser pressure values over the surface area. The innovation of protruded design created on the varied pressure zones of RD 120 inserts is evidenced by proving the pressure relieving foot comfort component recommendable for therapeutic benefits of the participants. From the results obtained, it is understood that RD 120 PU insert represents meritorious features to provide therapeutic benefits, especially on the plantar region of the feet. Hence, based on the current research findings, RD 120 insert is recommended as one of the appropriate choices of foot comfort component for rendering therapeutic benefits to the participants. These findings are in close resemblance with the studies of Mathivanan et al.(2016) that investigated that D120 polyurethane foam possessed superior energy behaviour and acceptable cushioning performance in footwear applications.

CONCLUSION

The design of foot inserts based on foot reflexology has been attempted in this study. There are some sensitive reflex zones under the feet, namely, (i) underside of toes, (ii) heel area, (iii) little toe mound, and (iv) adrenal area, connected to organs forming neural or nerve network circles. On stimulating the reflex points by acupuncture/pressure, chemical messengers emit endorphins in the brain, which helps in suppressing the pain by blocking the transmission of pain impulses from neurons. Based on foot reflexology, protruding design protocols have been made on foot inserts using polyurethane materials of different density parameters. Participants identified experiments on varied reflex density inserts following the scientific analysis of P-walks on static and dynamic phases. It is revealed that the contact area of the foot exhibits increased value in the case of reflexology inserts while comparing flat inserts under experimentation analysis. Thus, in most cases, the contact surface area shows the increased value of trend concerning reflexology inserts. The optimal (maximum) area is obtained in the case of the density material of RD-120 (polyurethane).

The innovation of protruded design created on the varied pressure zones of RD 120 inserts is proven as the pressure relieving foot comfort component recommendable for therapeutic benefits of the participants. In this experimental analysis, it is revealed that RD 120 PU insert represents meritorious features to provide therapeutic benefits, especially on the plantar region of the feet. Hence, based on the current research findings, RD 120 insert is recommended as one of the appropriate choices of foot-comfort component for rendering therapeutic benefits to the participants.

RECOMMENDATIONS

The reflexology study reveals that foot inserts of polyurethane material of thickness 0.25 inch with density RD-120 are recommended with design innovation of protruded contours to lessen the pressures exerted over the plantar region of the feet with the increased surface area for accomplishing therapeutic advantages for the needy participants. It is found that pressure exerted with barefoot is lesser than that in cases of FD followed by RD.

DECLARATIONS

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ETHICALAPPROVAL

All necessary ethical approvals have been obtained for this research work and publication.

CONSENT TO PARTICIPATE

Consent of participation was obtained before commencement of the research.

CONSENT TO PUBLISH

Consent to publish was obtained for this research publication.

COMPETING INTERESTS

There is no competing interest in this publication. There is no financial conflict for this publication.

AUTHORS' CONTRIBUTIONS

S. Mathivanan supervised the research and has partly drafted the paper, and Rames C. Panda made the final draft of the paper, drew the graphs, and mathematical formula, while S. P. Anandaraman worked in the experimental section of this paper during his postgraduate study.

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AVAILABILITY OF DATA AND MATERIALS

Data and materials will be available on reasonable request.

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