DESIGN INNOVATIONS ON FOOTWEAR FOR OVERWEIGHT/OBESE PEOPLE

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The overweight/obese population is aggressively growing worldwide due to laxity on physical fitness, sedentary lifestyle and eating habits. The obese individuals, in general, experience instability during locomotion and they are towards the direction of rapid development of musculoskeletal disorders, pain symptoms on the regions like heel, ankle and plantar surface of the foot. The main objective of Design innovation concept is to evolve varied angles particularly on the heel region of footwear to relieve pain and stress posed by obese people. The comfort solution has been attempted pragmatically through adaptation of innovative research in this paper. In the developmental process, the design modifications externally on the heel regions with the varied angles 20 degree, 30 degree and 40 degree have been designed. The slip resistance tester is employed for the estimation of Coefficient of friction between the sole surface and floor surface. The results revealed that the externally designed shoes represented with improved values of Coefficient of friction while compared with standard shoe. The design innovation concepts have resulted in higher coefficient of friction values on the externally modified footwear and the newly designed footwear is referred as an ideal remedy to acquire therapeutic advantages and benefits for overweight/obese individuals.

Keywords: obesity, friction, design innovation

INTRODUCTION

The foot is a structural marvel consisting of 26 bones laced together with many layers of ligaments, tendons and muscles. The foot is built to absorb shock like a suspension bridge and is subjected to pressure at all time of life of human. An average person strides predominantly 5000 to 10000 steps a day and the impact of each step exerts a force about 50% greater than the body weight. In an average day of walking, a force equal to hundreds of tons is placed on the feet .Due to these factors, the occurrence of foot related problems have become frequent and common phenomenon especially to heavier categories.

The overweight/obese population is aggressively growing worldwide due to laxity on physical fitness, sedentary lifestyle and eating habits. The obese people possess wider foot dimensions and lower foot arch index while comparing with normal foot people. The body weight of obese people itself is a major disadvantageous factor which tends to develop all the foot related consequences as well as ill-healthy foot. Hence, the design and development of footwear necessitates the higher BMI individuals to feel comfort as well as foot health friendly.

Those footwear that are in existence for overweight/obese individuals are predominantly possessed with wider fit and dimensional characters. The Sports footwear is suitably meeting these characteristics especially for overweight/obese individuals. This necessitates the footwear specifically to address the foot related problems and evolve external design modifications and innovations in order to gain therapeutic benefits for overweight/obese individuals.

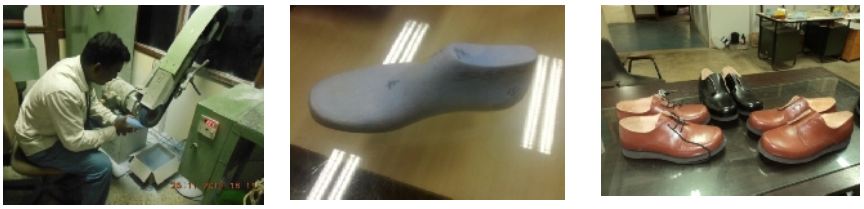
This paper mainly deals on the design concepts of external modifications particularly on the heel regions of footwear thereby rendering comfort for the targeted people. The main objective of this paper is to design varied angles/curvature on the heel

profile of footwear to relieve pain and stress experienced by the overweight/obese individuals. The advantages of externally modified profiles on the heel region of footwear would influence weight diffusion/dispersion between the foot and floor surface. The specific research is aimed at in this paper to render comfort solution pragmatically for the goodwill of the overweight/obese individuals.

MATERIALS AND METHODS

The foot anthropometric parameters of overweight/obese individuals were primarily studied in this paper. There were more than 100 individuals covered under the anthropometric measurement analysis and the varied parameters were collected and presented for modelling suitable shoe lasts exclusively meeting the requirements of overweight/obese individuals.

The Shoe lasts ranging between size 6 and 10 were designed and developed by M/S Shangavi Shoe Accessories P (Ltd) at Chennai, India. The design and development of footwear for overweight/obese individuals were prototyped.



a *b* *c*

Figure 1. Last Making (a and b) and Full shoes (c)

The shoes were constructed over the lasts to meet the targeted beneficiaries. The uppers were designed with Derby model on varied size ranges and subsequently were converted into three dimensional shaped lasted upper in the manufacturing process of footwear. The leather from cowhides was chosen as upper portion as it possesses improved degree of physical strength characteristics and elongation behaviours when subjected to application of force. The bottom material Micro Cellular Rubber (MCR) was chosen and fabricated as a rubber unit sole for bottom application. The shoes developed were provided with wider inside room for the accommodation of broad fit characteristics of foot of overweight/obese individuals. The shoes were reinforced with counter and toe stiffener to maintain its shape and dimension for the users to feel comfort and satisfaction.

In the specialisation of footwear, the external design modifications play a pivotal role in achieving improved comfort features for the beneficiaries. The design modifications externally on the heel regions of footwear with the varied angles 20 degree, 30 degree and 40 degree – figure 2 – were designed and configured on footwear ranging between 7 and 8. The control shoes on these sizes were developed during initial phase of developmental process.

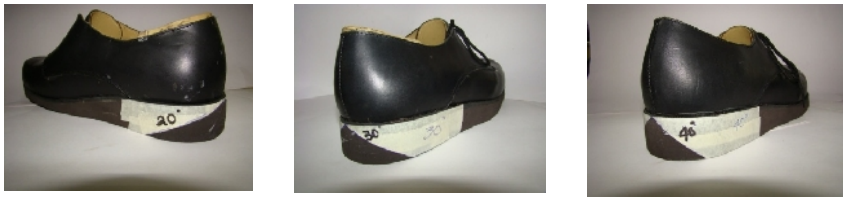


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Figure 2. External design modifications on shoes for obese

The SATRA slip resistance tester (STM 603) was employed for experimentation of shoes exclusively designed and developed for overweight/obese individuals. This tester is an indicator of conditions encountered during walking when slip is most likely to occur. This device measures the slip resistance between the sole of the shoe and the floor.

Figure 3. Slip resistance tester

The machine – figure 3 – is equipped with a specially-designed control and data acquisition system which provides the coefficient of friction values on each test sample tested. This tester is finally illustrated with a multiple graph showing varied components produced after the test performed. There are four lines displayed on the graph representing vertical load, speed of table movement, horizontal load and coefficient of friction.

RESULTS

The shoes (Size 8) on standard and externally designed categories were subjected for experimentation analysis. These shoes were scientifically assessed for determining Coefficient of Friction (COF) between the bottom surface of footwear and the surface of flooring. The floor Quarry tiles was specified under SATRA TM144 test method and employed for analysis using the shoes. Initially, the standard shoe of size 8 was subjected for evaluation of COF and subsequently, the shoes configured with varied angles such as 20 degree, 30 degree and 40 degree were experimented on two parameters namely forward foot slip and forward heel slip respectively. In the method of evaluation, a vertical load of 500 Newton was subjected for analysis on shoes and each shoe was assessed for minimal five times and the mean value of COF was calculated accordingly.

Table 1. COF of Standard Shoe

Material		Mean ± S.D.
Forward Foot Slip	Left Shoe (COF)	0.552 ± 0.0130
Condition	Right Shoe (COF)	0.514 ± 0.0089
Forward Heel Slip	Left Shoe (COF)	0.532 ± 0.0228
Condition	Right Shoe (COF)	0.526 ± 0.0270

The Table 1 illustrates the mean COF values of left and right shoe of standard design on two parameters namely forward foot slip and forward heel slip condition. The mean values of COF for left and right shoe in respect of forward foot slip are 0.552 and 0.514 and the mean values in respect of forward heel slip condition are 0.532 and 0.526 respectively.

Table 2. COF of 20 Degree heel Modified Shoe

Description		Mean ± S.D.
Forward Foot Slip	Left Shoe (COF)	0.694 ± 0.0195
Condition	Right Shoe (COF)	0.644 ± 0.0152
Forward Heel Slip	Left Shoe (COF)	0.782 ± 0.0444
Condition	Right Shoe (COF)	0.828 ± 0.0630

With regard to Table2, the mean values of COF for left and right shoe of 20 degree modified design in case of forward foot slip condition are 0.694 and 0.644 and the mean COF values in respect of forward heel slip condition are 0.782 and 0.828 respectively.

Table 3. COF of 30 Degree heel Modified Shoe

Description		Mean ± S.D.
Forward Foot Slip	Left Shoe (COF)	0.674 ± 0.0207
Condition	Right Shoe (COF)	0.638 ± 0.0164
Forward Heel Slip	Left Shoe (COF)	0.760 ± 0.0292
Condition	Right Shoe (COF)	0.866 ± 0.0329

The Table 3 refers 30 degree heel modified shoe with their mean values of Coefficient of friction. The values of mean COF for left and right shoe are 0.674 and 0.638 in respect of forward foot slip condition and the values of COF for left and right shoe of forward heel slip condition are 0.760 and 0.866 respectively.

Table 4. COF of 40 Degree heel Modified Shoe

Description		Mean ± S.D.
Forward Foot Slip	Left Shoe (COF)	0.628 ± 0.0228
Condition	Right Shoe (COF)	0.606 ± 0.0195
Forward Heel Slip	Left Shoe (COF)	0.598 ± 0.0363
Condition	Right Shoe (COF)	0.658 ± 0.0383

In respect of Table 4, the mean COF values for left and right shoe of forward foot slip condition are 0.628 and 0.606 and the mean values of COF for left and right shoe for forward heel slip condition are 0.598 and 0.658 respectively.

DISCUSSION

In general, the COF value higher than 0.50 is considered to be good and comfort for the end-users benefits. The coefficient of friction is a prime factor mainly determines the overall stability of footwear over the flooring surfaces during the locomotion phases. The standard shoe represented COF value greater than the prescribed value of 0.50. The externally modified shoes designed with 20 degree, 30 degree and 40 degree represented with higher values of 0.50 for forward foot slip and forward heel slip condition than the standard shoe and it was clearly understood that the externally designed shoes are advantageous on stability and comfort parameter of the targeted beneficiaries due to its highest COF values.

Statistical Analysis test was carried out to ascertain whether there was any significant difference on COF values between Standard shoes and externally designed heel modified shoes of 20 degree, 30 degree and 40 degree. From (ANOVA) Variance test conducted, it was observed that there existed significant differences amongst all categories of shoes as p value is less than 0.05.Also, it was revealed that the left and right shoe of forward foot slip and forward heel slip condition existed with similar pattern of significance. The Bonferroni multiple comparison test was carried out to investigate what the significant differing groups are? It was clearly understood that the COF for standard shoe was significantly different from the externally modified shoes of 20 degree, 30 degree and 40 degree irrespective of left or right shoe of either forward foot slip or forward heel slip condition. It was critically observed that the COF values of modified 20 degree and 30 degree resulted with no statistical significance and difference as the p value is greater than 0.05 and in all other cases (forward foot slip for left and right shoe, forward heel slip for left and right shoe) resulted with significant differences.

The medical professionals recommend externally modified Shoes for overweight and obese individuals so that their expenditure of oxygen would be higher than the general shoes. The shoes designed and presented in this paper are unstable in nature and aid gear-up the pace of walking and subject to expend additional energy thereby achieving waist and weight loss gradually. The bevelled angles developed in shoes render added advantage of stability for the beneficiaries while landing of foot at heel strike point on the ground surface. Hence, the externally modified shoes influence better stability on the ground and also these shoes possessing higher COF values particularly on forward heel slip conditions. These characters minimise the possible occurrence of slip and maximise the stability on the phases of locomotion with comfort and satisfaction for the beneficiaries.

The externally designed shoes of varied angles influence higher COF values than the standard shoe and the interlocking of surface profile of footwear and floor surface was established mainly due to the resultant of higher COF values. The total area of surface beneath the footwear revealed that the standard shoe possesses greater surface profile than other externally modified shoes. The 20 degree modified shoe possessed lesser area of surface than other two externally modified shoes and standard shoe. It was observed that 20 degree modified shoe represented higher COF values on forward foot slip and forward heel slip as well due to its significant design feature and also rendered added advantage of lesser area of surface profile especially on the bottom of footwear. The higher COF values with lesser surface profile are meritorious for rendering therapeutic benefits for the targeted overweight/obese individuals.

CONCLUSION

In this paper, the standard shoe and externally modified shoes with varied angles was experimented using SATRA Slip resistance tester and subsequently, the Coefficient of Friction values were estimated. It was revealed that the externally designed shoes possess higher COF values than the standard shoe. Amongst the shoes experimented, 20 degree externally modified shoe possessed superior Coefficient of friction value than others and its lesser area of surface profile rendered improved landing at heel strike phase of walking. The higher the value of the coefficient of friction, the less is the possibility of slipping: the smaller the value, the greater the danger. It is finally concluded that the 20 degree externally modified shoe deserves meritorious characteristics to provide therapeutic advantages for overweight/obese individuals.

REFERENCES

Cham, R. and Redfern, M.S. (2001), "Effect of flooring on standing comfort and fatigue, *Journal Human factors*, 43(3), 1439-1445.

James, D.L. *et al.* (1983), "Rubbers and Plastics in shoes and flooring: The importance of kinetic friction", *Ergonomics*, 26, 73-82.

Maffiuletti, N.A. *et al.* (2012), "Unstable Shoes increase energy expenditure of Obese Patients", *Am J Med*, 125(5), 513-6.

Pater, R. (1985), "How to reduce falling injuries", *National Safety and Health news*, 132, 87-91.

Perkins, P.J. and Wilson, M.P. (1983), "Slip resistance testing of shoes", *Ergonomics*, 26(1), 73-82.

Petcu, D., Berijan, G. (2013), "General considerations on computer assisted design of lasts for therapeutic footwear", *Revista de Pielarie Incaltaminte* (*Leather and Footwear Journal*), 13(4), 283-294.

Redfern, M.S. and Bloswick, D. (1987), "Controlling slips and falls in industry", *Occupational Health and Safety Magazine*, 56(3), 34-43.

Redfern, M.S. *et al.* (1990), "A dynamic Coefficient of friction measurement device for shoe/floor interface testing", *Journal of Safety Research*, 21(2), 61-65.

Sarghie, B., Costea, M., Mihai, A. (2013), "3D Modelling of shoe lasts using templates based on anthropometrical mesurments of the foot - case study", *Revista de Pielarie Incaltaminte* (*Leather and Footwear Journal*), 13(3), 221-234.

Strandberg, L. and Lanshammar, H. (1981), "The dynamics of slipping accidents", *Journal. occup. Accidents*, 3, 153-162.