Plantar Static Pressure Distribution in Normal Feet Using Cotton Socks with Different Structures

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Background: The major goal of investigating plantar pressure in patients with pain or those at risk for skin injury is to reduce pressure under prominent metatarsal heads, especially the first and second metatarsals. In research, the insole is used to reduce plantar pressure by increasing the contact area in the midfoot region, which, in turn, induces an uncomfortable feeling near the arch during walking. It is deduced that sock structure can redistribute plantar pressure distribution.

Methods: Seven sock types with seven structures (plain, single cross tuck, mock rib inlay, cross miss, mock rib, double cross tuck, and double cross miss) for the sole area were produced. A plantar pressure measurement device was used to measure plantar static pressure in ten participants. The barefoot plantar pressure distribution was compared with the plantar pressure distribution with socks.

Results: In the seven sock samples, the mean plantar pressure of the cross miss and mock rib structures at high plantar pressure zones (toe and first through fourth metatarsal bone regions) were decreased, and, as a result, the pressure shifted to relatively low pressure zones (fifth metatarsal bone and midfoot regions).

Conclusions: These results indicate that wearing socks with cross miss and mock rib structures will reduce mean plantar pressure values compared with the barefoot condition in high plantar pressure zones. In general, the results suggest that mean plantar pressure is redistributed from high to low plantar pressure zones. (J Am Podiatr Med Assoc 107(1): 30-38, 2017)

Plantar pain and ulcer is a commonly encountered problem that can cause difficulty in weightbearing owing to significant discomfort over the metatarsal heads. Often different shapes of insole have been used to change plantar pressure distribution.[1-3] When wearing the optimal insole there is a significant pressure shift from the rearfoot (RF) to the midfoot (MF) region. Although a total-contact insole can reduce plantar pressure, the extra volume completely touching the MF region sometimes induces an uncomfortable feeling near the arch during walking. Another solution that has not been considered so far is to wear socks with a specific structure. Socks are an essential component of footwear for people, especially for athletes and patients with diabetes.

The concept of sport-specific socks emerged during the 1970s with the invention of roll-top socks by James Throneburg, the owner of THORLO, Inc, a sock company (Rockwell, North Carolina).[4] Early patented designs from THORLO placed extra padding in strategic locations of socks to provide protection during running, playing tennis, skiing, and cycling. During the next 30 years, numerous manufacturers emerged, offering many designs for virtually every sport in which shoes are worn. In some cases, the use of sport-specific socks is valid, and in other cases, many models and designs have questionable unique functions.[4] Considerable research has also been conducted on specialized sports hosiery to determine physiologic benefits.

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This research has suggested that athletic socks can significantly reduce plantar pressures,[5-13] impact shock,[14] incidence of friction blisters,[15,16] and symptoms of venous insufficiency.[17,18] These medical benefits, validated by scientific study, gave rise to a new category of socks—therapeutic hosiery—designed for athletes and patients with diabetes.

Soft-tissue thickness is 36% to 48% greater under the heel than under the metatarsal heads.[19] This increased soft-tissue thickness probably helps to distribute plantar pressure to increased areas and to attenuate peak pressures and pressure gradients, which affects subsurface stress distribution. Furthermore, the shape of the calcaneus tends to remain fairly intact, but the metatarsal heads often are deformed by an increased metatarsophalangeal joint angle (hammertoe deformity) and arthropathy that can contribute to high pressures and peak pressure gradients. The influences of the pressure distribution characteristics on the stress distribution at the different foot regions, especially in the forefoot (FF) region, seem to be substantial.[19] For these reasons, most researchers have focused on the FF region.[1,2,5,7,8,11,19] They have reported that ulcer risk is greater under the hallux and the first and second metatarsals. The critical loading of the hallux occurs when people are not walking straight ahead, and then the range of motion of the first metatarsophalangeal joint is important in determining pressures under the hallux.

There are two knitted structures widely used in specially designed socks, namely, terry and simple jersey. Moreover, padding is placed at selected areas, such as the toes, the FF, and the heel.

The first study of pressure relief of specialized padded hosiery was conducted by Veves et al.[5] When wearing padded hosiery, which has specially designed padding particularly around the heel and FF, a significant 26% reduction of peak plantar pressure was recorded. Foot pressure measurements were made with an optical pedobarograph. The researchers concluded that specialized padded hosiery could be a useful, acceptable, and inexpensive addition to existing methods for protecting the insensitive foot from abnormal pressures and loads. In a subsequent study, Veves et al[6] compared the pressure reduction of experimental extra-padded hosiery with padded sport socks in the reduction of plantar pressures in patients with diabetic neuropathy using an optical pedobarograph. Both styles of socks reduced plantar pressures significantly, although the extra-padded socks reduced pressures by 31% compared with 17% and 10% pressure reductions by THORLO sport socks. In another study by Veves et al,[7] the use of experimental extra-padded hosiery (high- and medium-density padding) was studied in patients with rheumatoid arthritis. Foot pressures were measured using an optical pedobarograph. Significant reduction of plantar pressure (32%) was achieved when wearing the padded socks compared with barefoot walking. In addition, pain relief after wearing the padded socks for 3 months demonstrated a 51% reduction. Flot et al[8] examined the effect of padded hosiery on plantar pressures at the sock-shoe interface using the EMED system (Novel GmbH, Munich, Germany) and reported significant reductions in FF pressures at the hallux and central FF regions of the foot. Donaghue et al[9] examined the effect of using specially padded hosiery combined with specially fit footwear on providing in-shoe pressure relief. Fifty patients at risk for foot ulceration were recruited for the study. All of the patients were provided with three pairs of specially designed hosiery with extra-density padding at the heel and FF and covering the tops of the toes and with two pairs of extra-depth footwear or extra-width running shoes. Dynamic foot pressures were measured at baseline and at each subsequent visit using the F-Scan system (Tekscan, Boston, Massachusetts), with the patients wearing their regular socks alone, their regular footwear and socks, the padded socks, and the new footwear and padded socks. Their results show that the tested footwear provided initial significant pressure relief and that no changes were found after 6 months of continuous use, but foot problems were not fully avoided. Garrow et al[10] studied 19 patients with diabetes and peripheral neuropathy. In-shoe plantar pressure measurements were recorded using the F-Scan system and compared new double-layer socks with ordinary socks to determine pressure relief in various areas of the foot. A specialized double-layer hosiery product provided a significant 9% reduction of in-shoe total foot pressure compared with ordinary supermarket socks. In addition, a 14% reduction of peak FF pressure and 8% increased surface area contact were achieved when wearing specialized socks compared with ordinary socks.

The construction of athletic socks can vary substantially among manufacturers. Depending on the type of knitting machine, socks can have very dense terry loop pads or a flat knit design. The gauge of the knitting needle will determine the density of the fabric in the socks. In general, more expensive socks use more fabric and tightly woven knit patterns in their construction to provide maximum protection for the foot by constructing

different parts with different materials, tensions, and stitching.[4]

Theoretical Considerations

The investigation of reduction stresses in soft tissues over the high-contact pressure zones during standing, especially under the first metatarsal heads, is a fundamental step toward dynamic stress analyses of the diabetic and athletic foot.

Wearing socks seems to increase the contact area between the feet and the socks, thus decreasing the average plantar pressure. Also, socks with denser construction reduce the free space between the foot and the ground and, hence, increase the plantar area, thus decreasing the average plantar pressure. Sanders et al[20] proposed an explanation for differences between thick and thin sock responses (Fig. 1). When composed under in-plane biaxial strain, thin socks are stretched, which increases distances between adjacent fibers and allows greater fiber deformation during compression loading. For thick socks, fibers are butted against each other and, thus, do not deform. As a result, thin socks are compressed more than thick socks when in-plane biaxial strain is present. Thus, with increased density, contact area and compressive stiffness are increased.

As mentioned earlier herein, many researchers use padded socks to reduce plantar pressure. However, these socks are thick and, as a result, a person has to wear larger shoes that are usually not desirable.

On the other hand, the research by Bakhtiari et al[21] showed that structures of knitted fabric are effective on single jersey weft-knitted fabric compression behavior. In addition, structures of knitted fabric are changing fabric thickness, contact points, and contact areas between the socks and the ground and also the socks and the foot. It may be deduced that with restructuring of the weft-knitted fabric with tuck and miss stitches, the plantar pressure distribution can change. In general, the tuck loops reduce fabric length and lengthwise elasticity and increase course density because the higher yarn tension on the tuck and the held loops causes them to rob yarn from adjacent knitted loops, making them smaller and providing greater stability and shape retention.[22] As the loops come closer to each other due to increased course density, overlapping of loops takes place, which enhances the higher fabric thickness.[22] Hence, the number of fabric stitches that are in contact with the foot and ground (contact points) increases, which leads to a greater contact area. Knit-miss

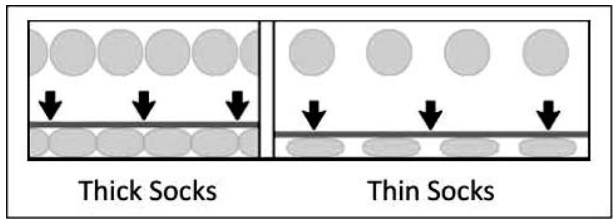


Figure 1. Differences between thick and thin socks under in-plane biaxial strain.[20]

structures incorporating float stitches tend to exhibit fain horizontal lines. A float stitch or welt stitch is composed of a held loop, one or more float loops, and knitted loops. It is produced when a needle holding its old loop fails to receive the new yarn that passes, as a float loop, to the back of the needle and to the reverse side of the resultant stitch, joining together the two nearest needle loops knitted from it. The float stitch shows the missed yarn floating freely on the reverse side of the held loop[22] and makes contact with the foot. In general, the float stitches create a surface similar to terry fabric structure. The terry loops increased contact elements between the plantar foot and the socks.

There is little work available on the plantar pressure distribution of socks with different structures and materials. Blackwell et al,[11] Dai et al,[12] and Blackmore et al[13] indicated that wearing socks composed of different materials has not been effective at reducing plantar pressure compared with not wearing socks. This study aims to examine the effect of sock structure on changes of plantar pressure distribution compared with barefoot plantar pressure distribution.

Materials and Methods

Fabric Processing

In this study, seven sock types corresponding to the seven knitted structures (plain, single cross tuck, mock rib inlay, cross miss [CM], mock rib (MR), double cross tuck (DCT), and double CM [DCM]) were produced in two shoe sizes (42 and 39 for men and women, respectively). Socks are composed of different parts: toe, sole, heel, foot, and leg (Fig. 2). The structure of the toe, heel, foot, and leg in all of the socks was plain knitted fabric. Accordingly, to produce several different socks with seven structures for the sole area, a single jersey flat knitting machine (Matec Silver model with 156 needles and a 3.75-inch diameter) was used. The same cotton yarn (N_e 20/1) and Lycra yarn (N_m 50) were knitted for all

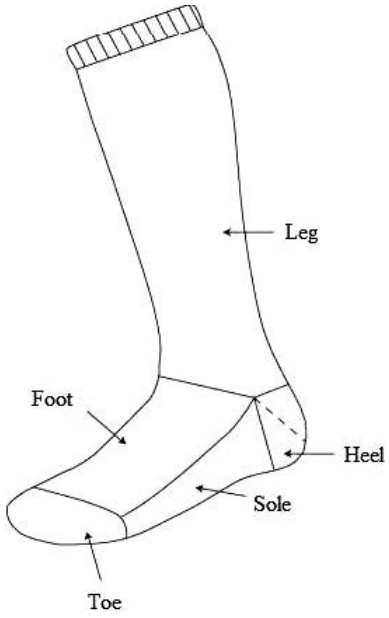


Figure 2. Different parts of socks.

of the socks. The stitch density was kept constant. The sock soles were produced with the seven different structures. These seven fabric structures are shown in Figure 3. The plain structure is a basic structure of single jersey fabric produced by the knitting needles as a single set, drawing the loops away from the technical back and toward the technical face side of the fabric (Fig. 3A).[22] In a single cross tuck structure, a tuck stitch is composed of a held loop, one or more tuck loops, and knitted loops (Fig. 3 B, C, F).[22] In a single CM structure, the float or welt stitch is the missed yarn floating freely on the reverse side of the held loop, which is the technical back of single jersey structures (Fig. 3 D, E, G).[22] A summary of the fabric construction parameters for seven sock types at the underfoot region in sizes for men and women is presented in Table 1. For each sample sock, three specimens were produced. All of the sample socks were maintained in their packages and were not put under mechanical stress until the start of the test.

Participants

Ten healthy, asymptomatic individuals participated in the study. Age, height, weight, and body mass index were determined for each participant at baseline (Table 2).

All of the participants had normal feet: absence of any apparent disturbance in the observed walking pattern; absence of significant structural abnormalities in the feet or legs; absence of corns, excessive callus formation, and other lesions of the feet or legs; and freedom from discomfort, disability, and excessive fatigue during prolonged standing.

Measurement Device

Time-integral mean plantar pressures were measured during barefoot standing using the Gaitview

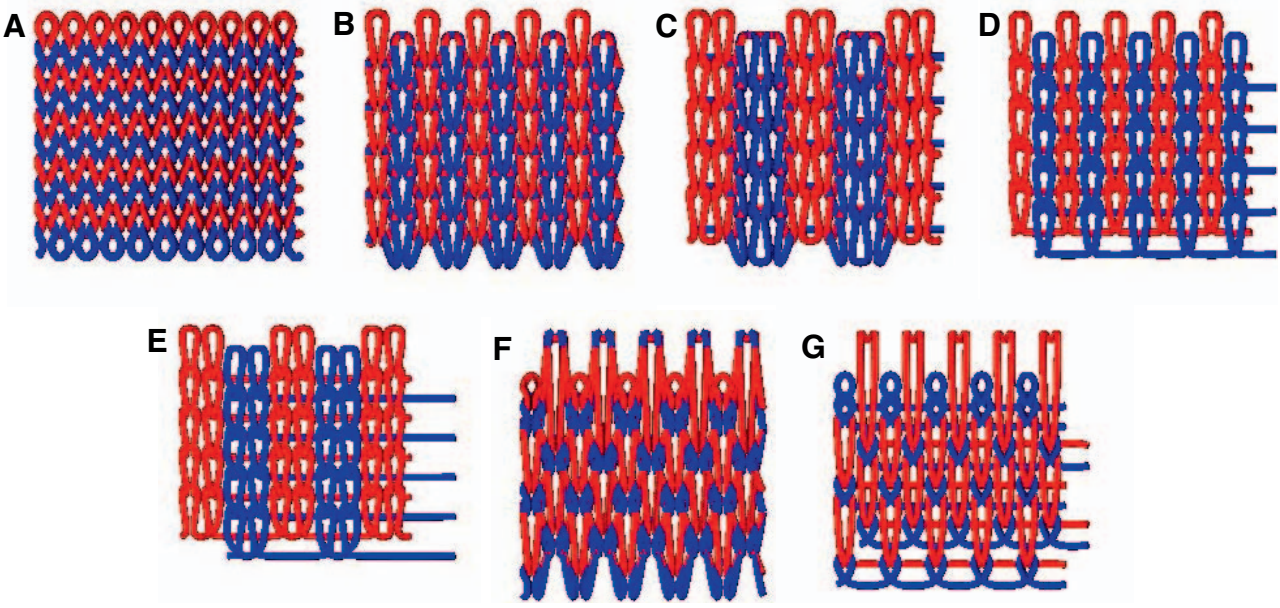


Figure 3. The structures of socks in the sole region: plain (A), cross tuck (B), mock rib inlay (C), cross miss (D), mock rib (E), double cross tuck (F), and double cross miss (G).

Table 1. Fabric Construction Parameters for the Sock Soles Tested

Fabric ID	Courses per Centimeter	Wales per Centimeter	Stitch Density (Stitches/cm^{-2})	Thickness (mm)	Weave
Men's sizes					
P_M	7.46	9.18	68.48	1.16	Plain
SCT_M	12.12	9.75	118.17	1.70	Single cross tuck
MRI_M	11.14	10.83	120.65	1.98	Mock rib inlay
CM_M	8.58	10.68	91.63	1.79	Single cross miss
MR_M	8.44	11.14	94.02	2.13	Mock rib
DCT_M	11.83	8.67	102.57	1.77	Double cross tuck
DCM_M	8.08	10.54	85.16	1.56	Double cross miss
Women's sizes					
P_W	7.73	9.75	75.37	1.10	Plain
SCT_W	13.08	10.00	130.80	1.62	Single cross tuck
MRI_W	12.14	10.83	131.48	2.08	Mock rib inlay
CM_W	9.44	10.83	102.24	1.58	Single cross miss
MR_W	8.76	12.00	105.12	2.00	Mock rib
DCT_W	12.50	8.96	112.00	1.66	Double cross tuck
DCM_W	8.95	10.68	95.59	1.52	Double cross miss

AFA-50 system (alFOOTs Co, Seoul, Republic of Korea) (Fig. 4), with dimensions of 410 × 410 × 3 mm, an active area consisting of a 45-mm-thick floor mat (700 × 500 mm) comprising 2,304 (48 × 48) force-sensitive resistor sensors, and sampling data at 17 Hz. The reliability of this system was investigated by Kim and Lee.[23]

Protocols

The participants were instructed to stand on the platform such that their hands were positioned at the sides of their legs and were directed to look ahead at a fixed position away from the platform and not to look down at the platform. The system measures plantar static pressures for 12 sec and then calculates the average value for each data set at each zone. Each participant was asked to randomly wear a specimen of each sock structure.

Table 2. Characteristics of the Ten Study Participants

Characteristic	Men (n = 5)	Women (n = 5)
Age (years)	23.25 ± 2.5	32.2 ± 1.3
Height (cm)	176 ± 2.7	164.2 ± 5.8
Weight (cm)	72.8 ± 4.9	65 ± 8.7
Body mass index[a]	23.5 ± 1.9	23.9 ± 4

Note: Data are given as mean ± SD.

[a]Calculated as weight in kilograms divided by height in meters squared.

In each session test, three consecutive trials were recorded by one examiner.

Statistical Analysis

To analyze the plantar pressure data precisely, the foot was divided into eight anatomical areas (Fig. 5). After data collection, GaitView Pro software version 1.0 was used to determine the time-integral mean pressure, expressed in kilopascals (1 kPa = 1.98 kg/cm^2), under the following eight regions of the foot: first toe (T1), second through fifth toes (T2–T5), first metatarsal (M1), second through fourth metatarsals (M2–M4), fifth metatarsal (M5), MF, medial heel (MH), and lateral heel (LH). The FF (the total of T1, T2–T5, M1, M2–M4, and M5), the RF (the total of MH and LH), and the contact area were also assessed. These regions are identified automat-



Figure 4. The Gaitview AFA-50 system.



Figure 5. Eight-zone distribution: first toe (T1), second through fifth toes (T2–T5), first metatarsal (M1), second through fourth metatarsals (M2–M4), fifth metatarsal (M5), midfoot (MF), medial heel (MH), and lateral heel (LH).

ically by the software. The results for the left and right feet corresponding to the same participant for a specific sex (male or female) were summed, and the mean value was calculated to obtain the overall performance of the structure of socks.

The effect of the structure of socks on plantar pressure redistribution was evaluated by one-way analysis of variance testing on various zones of the foot and in different sexes using a statistical software program (IBM SPSS Statistics for Windows, Version 21.0; IBM Corp, Armonk, New York). Tukey post hoc tests were used to determine specific significant differences between mean plantar pressure values of different socks and the barefoot condition. Significance was set a priori at $\alpha = .05$.

Results and Discussion

Tables 3 and 4 show the mean plantar pressure values of different socks compared with the

Table 3. Effects of Sock Structure on Plantar Pressure Values of Standing Posture for Men

	Pressure Zones								
Sock Structure	T1 (kPa)	T2-T5 (kPa)	M1 (kPa)	M2-M4 (kPa)	M5 (kPa)	MF (kPa)	MH (kPa)	LH (kPa)	CA (cm^2)
Mean pressure (% change)									
BF	29.45	8.78	56.36	83.29	29.87	11.06	123.13	120.15	93.43
P	21.17 (–28.08)	7.88 (–10.25)	52.72 (–6.46)	80.00 (–3.95)	38.52 (28.96)	14.22 (28.57)	118.34 (–3.90)	115.24 (–4.08)	97.73 (4.60)
SCT	18.42 (–37.42)	7.76 (–11.57)	48.13 (–14.73)	77.02 (–7.53)	46.67 (56.24)	13.92 (25.77)	113.11 (–8.14)	108.12 (–10.00)	99.07 (6.02)
MRI	23.04 (–21.77)	6.69 (–23.75)	49.67 (–11.87)	77.62 (–6.73)	43.73 (46.40)	14.92 (34.81)	113.23 (–8.05)	110.93 (–7.67)	99.66 (6.67)
CM	18.91 (–35.79)	5.85 (–33.31)	45.48 (–19.30)	74.91 (–10.06)	49.64 (66.19)	15.47 (39.78)	107.02 (–13.08)	98.62 (–17.91)	99.59 (6.59)
MR	22.35 (–24.09)	6.04 (–31.09)	44.12 (–21.74)	77.02 (–7.53)	50.95 (70.59)	16.45 (48.72)	96.09 (–21.96)	92.26 (–23.21)	100.41 (7.46)
DCT	20.97 (–28.79)	7.67 (–12.60)	45.90 (–18.56)	76.54 (–8.10)	41.29 (38.23)	14.33 (29.48)	117.58 (–4.51)	111.20 (–7.45)	99.39 (6.38)
DCM	19.08 (–35.19)	7.40 (–15.72)	46.00 (–18.38)	78.40 (–5.86)	47.51 (59.06)	16.74 (51.27)	112.67 (–8.50)	111.55 (–7.16)	99.75 (6.76)
P value									
P	.862	.993	>.99	>.99	.821	.786	>.99	>.99	.978
SCT	.588	.987	.969	.990	.102	.847	.982	.956	.909
MRI	.956	.549	.991	.994	.268	.541	.981	.989	.840
CM	.643	.158	.884	.947	.026[a]	.392	.805	.508	.862
MR	.950	.229	.808	.993	.024[a]	.209	.254	.242	.767
DCT	.846	.975	.903	.984	.551	.756	>.99	.992	.908
DCM	.636	.921	.908	.997	.071	.112	.974	.993	.829

Abbreviations: BF, barefoot; CA, contact area; CM, cross miss; DCM, double cross miss; DCT, double cross tuck; LH, lateral heel; M1, first metatarsal; M2-M4, second through fourth metatarsals; M5, fifth metatarsal; MF, midfoot; MH, medial heel; MR, mock rib; MRI, mock rib inlay; P, plain; SCT, single cross tuck; T1, first toe; T2-T5, second through fifth toes.

[a]Statistically significant.

Table 4. Effects of Sock Structure on Plantar Pressure Values of Standing Posture for Women

	Pressure Zones								
Sock Structure	T1 (kPa)	T2-T5 (kPa)	M1 (kPa)	M2-M4 (kPa)	M5 (kPa)	MF (kPa)	MH (kPa)	LH (kPa)	CA (cm^2)
Mean pressure (% change)									
BF	35.52	13.44	67.04	84.08	26.81	12.4	131.89	123.67	83.59
P	25.22 (–29.00)	9.77 (–27.32)	55.61 (–17.05)	77.72 (–7.56)	37.48 (39.8)	18.58 (49.84)	128.49 (–2.58)	119.06 (–5.43)	87.6 (4.8)
SCT	26.42 (–25.62)	10.04 (–25.33)	56.53 (–15.66)	79.27 (–5.72)	41.61 (55.23)	17.61 (42.02)	126.78 (–3.88)	116.34 (–8.62)	88.32 (5.66)
MRI	24.85 (–30.06)	10.94 (–18.62)	52.41 (–21.82)	77.35 (–8.00)	42.05 (56.84)	18.3 (47.58)	129.30 (–1.96)	119.09 (–5.4)	87.43 (4.60)
CM	22.41 (–36.91)	8.58 (–36.17)	46.17 (–31.11)	73.89 (–12.12)	38.98 (45.39)	18.68 (50.64)	125.85 (–4.58)	121.65 (–2.38)	89.18 (6.69)
MR	25.04 (–29.51)	9.44 (–29.76)	52.88 (–21.11)	78.21 (–6.98)	42.67 (59.16)	18.81 (51.69)	129.43 (–1.86)	117.71 (–7.02)	88.99 (6.46)
DCT	28.24 (–20.51)	11 (–18.15)	57.51 (–14.21)	81.05 (–3.60)	40.96 (52.78)	17.5 (41.13)	129.17 (–2.06)	114.56 (–10.72)	87.10 (4.20)
DCM	29.16 (–17.90)	9.72 (–27.73)	63.01 (–6.01)	85.48 (1.70)	38.41 (43.27)	18.22 (46.94)	125.25 (–5.03)	116.44 (–8.52)	87.96 (5.23)
P value									
P	.290	.169	.672	.992	.423	.185	.997	.992	.959
SCT	.454	.251	.759	.999	.076	.394	.967	.900	.905
MRI	.247	.649	.351	.989	.061	.236	>.99	.992	.968
CM	.068	.017[a]	.039[a]	.893	.252	.170	.921	>.99	.799
MR	.269	.097	.395	.995	.043[a]	.150	>.99	.965	.826
DCT	.728	.678	.839	>.99	.106	.422	.999	.743	.980
DCM	.843	.155	.999	>.99	.312	.252	.876	.906	.936

Abbreviations: BF, barefoot; CA, contact area; CM, cross miss; DCM, double cross miss; DCT, double cross tuck; LH, lateral heel; M1, first metatarsal; M2-M4, second through fourth metatarsals; M5, fifth metatarsal; MF, midfoot; MH, medial heel; MR, mock rib; MRI, mock rib inlay; P, plain; SCT, single cross tuck; T1, first toe; T2-T5, second through fifth toes.

[a]Statistically significant.

barefoot condition together with their *P* values for men and women, respectively. Mean barefoot pressures in the T1 zone for women (35.52 kPa) were usually greater than those for men (29.45 kPa). However, the mean barefoot weights of men (72.8 kg) were greater than those of women (65.0 kg), but the mean underfoot contact areas of women (83.59 cm^2) were smaller than those of men (93.43 cm^2), which indicates that contact areas show critical roll in pressure.

As seen in Tables 3 and 4, all of the socks were able to reduce mean plantar pressure in the T1, T2–T5, M1, M2–M4, MH, and LH zones and to increase it in the M5 and MF zones. However, all of the socks were able to partially increase the underfoot contact area.

In the case of plantar pressure testing for male participants (Table 3), the CM and MR structures showed significant differences in increasing plantar pressure in the M5 zone compared with the barefoot condition ($P = .026$ and .024, respectively). Compared with the barefoot condition, mean reductions in plantar pressure of 21.77% ($P = .956$) for the mock rib inlay structure to 35.79% ($P = .643$) for the CM structure were found over T1. Mean plantar pressure also decreased over T2–T5, and the maximum change was 33.31% ($P = .158$) in the CM structure. The M1 mean pressure was decreased by 6.46% ($P > .99$) in the plain structure and by 21.74% ($P = .808$) in the MR structure compared with the barefoot condition. However, these reductions were not statistically significant.

In the case of plantar pressure testing for the women (Table 4), compared with the barefoot condition, mean reductions in pressure of 17.9% ($P = .843$) for the DCM structure of fabric to 36.91% ($P = .068$) for the CM structure were found over T1. Mean plantar pressure also decreased over T2–T5: 18.15% ($P = .678$) and 36.17% ($P = .017$) in the DCT

and CM structures, respectively. The M1 mean pressure was decreased by 6.01% ($P = .999$) in the DCM structure and by 31.11% ($P = .039$) in the CM structure compared with the barefoot condition. A significant difference was demonstrated over M5 between the barefoot condition and the foot with socks in the MR structure ($P = .043$).

These results could be related to the sock material structures for the CM and MR types.

It seems likely that the miss loops make the CM and MR structures into mock terry loops. Thus, the density of loops in this particular structure for the CM type (Fig. 3D) is more than that for the MR structure (Fig. 3E). On the other hand, the stitch length of mock terry loop in the MR structure is more than that in the CM structure. These two properties (density of MR and long terry loop) affected the contact area.

By considering the mean plantar pressure, the main trend of plantar pressure redistribution was the reduction of the plantar pressure of the FF except for M5 and shifting the pressure to the M5 and MF regions. The results of this research showed that in the FF region, the lowest and highest pressure values are obtained in the M1 and M5 heads, respectively ($P < .05$).

The data explored in this study depend on the precision of the instrument used to measure mean plantar pressure. It is suggested that other instrument methods be used to precisely measure mean plantar pressure in different zones. Also note that mean plantar pressure may be affected by shear forces during dynamic activities such as walking and running, and this point will be followed in a future research study.

Conclusions

This study aimed to evaluate the effects of sock structure on plantar pressure changes. The barefoot plantar pressure distribution was compared with the plantar pressure distribution with socks.

The obtained result showed that all of the sock structures evenly redistributed plantar pressure compared with barefoot plantar pressure distribution. As a result, all of the socks in this study can redistribute plantar pressure from higher plantar pressure zones (ie, T1, T2–T5, and M1) to relatively lower pressure zones (ie, M5 and MF). This result suggests that the chances of corn and callus formation and ulcer development in diabetic and athletic persons are greatly reduced.

Comparing the mean plantar pressures of the seven sock samples with the barefoot condition, the performance of the CM and MR structures in plantar pressure percentage reduction was the best, and plantar pressure was redistributed evenly in high pressure zones in all of the other sock structures. These results seemed to be related to their special fabrication with knit-miss structures that make mock terry structure, which could greatly increase the capability of the shock-absorbing function of the sock system. The reduction of stresses in soft tissues over the high-contact pressure zones, especially under the M1 heads, where injury is common, is clinically important in the diabetic and athletic foot.

Future research is needed to measure mean plantar pressure in different zones using a more precise insole technique. In addition, mean plantar pressure may be affected by shear forces during dynamic activities such as walking and running, and this point will be followed in a future research study.

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