Effect of wearing and washing temperature on the performance of compression socks

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ABSTRACT – REZUMAT

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Compression socks regulate blood flow in venous systems and are used for therapeutic purposes. The present study, it was aimed to analyse the influence of multiple levels of wearing and washing temperature on compression pressure. 9 pieces of compression socks samples with 3 different combinations (with different polyamide/ elastane body and inlaid yarn) were developed using compression socks knitting machine with a 1×1 laid in, 1×1 knit-miss structure. After the production of the samples, to simulate the "wearing and washing effect" a test protocol was designed. Compression pressure values were measured by using MST Professional II Medical Stocking Tester in different phases and results were evaluated statistically. The results show that when compression socks are worn for 15 days and washed 5 times, their compression pressure and graduation values change. After wearing compression socks on wooden leg pressure values shows a slight decrease due to a long period of stretching. In addition, after wearing and washing cycles it is seen that the pressure values increase as the washing temperature increases. 50˚C results show the highest increase at compression pressure. Statistical results show a correlation between temperature and compression pressure. Many researches were carried out on the production factors of compression socks, however, there are very few research studies on the usage performance of socks. The study contains results for both the literature and the producers/end users.

Keywords: *compression socks, washing of compression socks, pressure*

Influența timpului de purtare și a temperaturii de spălare asupra performanței șosetelor de compresie

Șosetele de compresie reglează fluxul sanguin în sistemele venoase și sunt utilizate în scop terapeutic. În studiul de față, s-a urmărit analiza influenței nivelurilor multiple ale purtării și temperaturii de spălare asupra presiunii de compresie. 9 probe de șosete de compresie cu 3 combinații diferite (conținut diferit de poliamidă/elastan) au fost dezvoltate folosind o mașină de tricotat șosete de compresie cu structură 1 × 1 laid in, 1 × 1 knit-miss. După producerea probelor, pentru a simula „efectul de purtare și spălare", a fost conceput un protocol de testare. Valorile presiunii de compresie au fost măsurate prin utilizarea dispozitivului MST Professional II Medical Stocking Tester în diferite faze, iar rezultatele au fost evaluate statistic. Rezultatele arată că atunci când șosetele de compresie sunt purtate timp de 15 zile și spălate de 5 ori, presiunea de compresie și valorile gradației acestora se modifică. După purtarea șosetelor de compresie pe piciorul din lemn, valorile presiunii arată o scădere ușoară datorită perioadei lungi de întindere. În plus, după ciclurile de purtare si spălare se observă că valorile presiunii cresc pe măsură ce temperatura de spălare crește. Rezultatele la 50˚C arată cea mai mare creștere pentru presiunea de compresie. Rezultatele statistice arată o corelație între temperatură și presiunea de compresie. Au fost efectuate multe cercetări asupra factorilor de producție ai șosetelor de compresie, cu toate acestea există foarte puține studii de cercetare privind performanța de utilizare a șosetelor. Studiul conține rezultate atât pentru literatura de specialitate, cât și pentru producătorii/utilizatori finali.

Cuvinte-cheie*: șosete de compresie, spălarea șosetelor de compresie, presiune*

INTRODUCTION

Compression socks are commonly recommended to exert maximum compression at the lower part of the leg at the ankle position to mitigate the intensity of venous-related disease efficiently [1]. The working method of this action is the exertion of compression pressure while gradually decreasing pressure, starting from the lowest girth point called ankle at position "b" to the maximum girth point called the calf "c" position (ankle to calf portion) of the leg. The compression pressure decreases from the ankle to the calf in the leg, regulating blood flow. By this way muscles will be kept in the proper alignment to reduce the risk for injury. It also provides relief to varicose patients and is used in the treatment as shown in figure 1 [2–4]. Compression pressure can be classified as moderate ranging from 20 to 30 mm Hg and firm ranging from 30 to 40 mm Hg compression. In addition to important diseases such as chronic varicose veins, these pressure ranges can also be applied to different symptoms such as fatigue, discomfort and soreness in the legs [5–8]. In theory, the pressure value seen on the leg is contingent upon the radius R of the leg and the reverse force T (N) exerted around the leg [9].

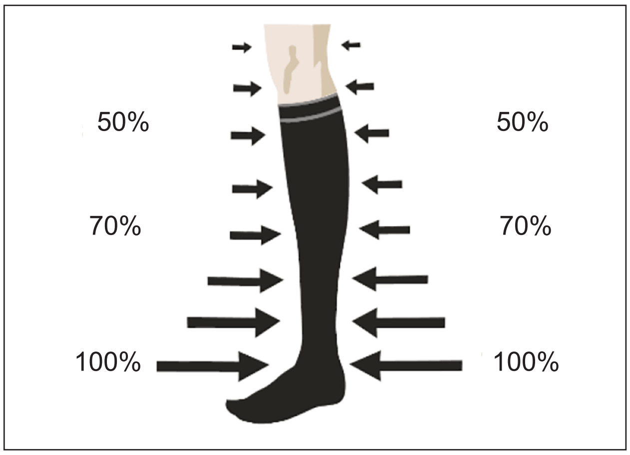

Fig. 1. Graduation of compression pressure

As described by Laplace's Law:

$$P(\mathrm{Pa}) = \frac{T(\mathrm{N})}{R(\mathrm{cm})} \quad (1)$$

$$P(\mathrm{Pa}) = \frac{T(\mathrm{N}) \times 2\pi}{C(\mathrm{cm})} \quad (2)$$

where P is pressure (Pa), T – Reverse fabric force (N), and R – radius of the leg (cm). It should be noted that graduation percentage (G%) is an important factor that helps regulate blood flow. The most famous standard method for the evaluation of compression socks is RAL GZ-387-1. According to this standard, the graduation percentage values must lie between 50–80% (Knee High). The graduation percentage (G%) in the part between the ankle and the calf is calculated with the formula shown below:

$$(G\ \%) = (P^c \div P^a) \times 100 \quad (3)$$

where P^c is the pressure at the calf portion, P^a – the pressure at the ankle portion [10].

Utilizing Laplace formula, applied pressure should be highest at the narrowest radius of leg and gradually decreasing towards the areas with the maximum radius. Also, the circumference of the leg requires optimal pressure on the skin layers according to Laplace's Law, equation 2 [11].

In recent years, many studies have been conducted on compression stockings and are mostly related to the effects of raw material characteristics, fabric constructions and machine settings on compression pressure. Based on scientific literature review, it is observed that a few studies exist in which the performance of compression socks had been analysed after multiple wearing, machines washing and their influence on compression pressure.

More than 200 brands exist around the globe developing and selling their products ultimately recommending handing the socks samples at 40°C rather than washing on washing machines and drying them by placing them between two layers of towels avoiding any external force deteriorating compression socks. A few brand manuals are mentioned here for reference purposes [12–17].

In addition, Siddique et al. investigated the performance of compression stockings. After washing the same sock sample at 30°C first, he washed the same sock at 50°C and finally at 75°C. In this study, the products were washed without being worn between washes. He concluded that there is a significant increase in compression pressure as the wash temperature level increases [18].

RAL-GZ 387/1 standard quality evaluation protocol of compression socks recommends that before testing, compression socks should be washed once according to DIN EN 26 330/6 A. The test samples should be dried for two minutes and dried flat as specified in DIN EN 26 330, Method C. after washing, conditions the socks samples by spreading out after drying for a minimum of 12 hours in a standard atmosphere according to DIN EN 20139 [10].

According to guidelines for the use and prescribing of compression hosiery recommended by NHS subjected to care of compression socks. The guide recommends that compression stockings be hand washed at 40°C. It is also stated that some products can be machine washed with a mild detergent on a gentle setting.

According to the guide, it is recommended that compression stockings should not be wrung, twisted, dried without a tumble dryer and not ironed. [19].

Liu et al. developed heterogeneous hybrid knitted structures to enhance the stability of knitted panels. In this structure, thermoplastic yarns were plated with a ground thread heated at a certain temperature and reset when cooled. They recommended that compression stockings be washed regularly to restore and balance their mechanical performance. The authors also stated that heterogeneous fabrics developed in this way could be washed as many as 50 times with low tension losses and generally exhibited balanced elasticity and shape retention under high tensile strain cycles [20].

Maleki et al. investigated the pressure change effect due to repeated washing of different knitted fabrics. The study results show that repeated washing and repeated usage have a significant effect on the interfacial pressure reduction of the fabrics [21].

Harpa et al. attempted to develop an approach to evaluate the compression properties of compression stockings after repeated wearing and repeated washing cycles. For his research, 2 pairs of sock samples were used for their evaluation for 15 and 30 days. All the socks' samples were tested before washing, after 15 and 30 wearing and washing. It was concluded that after repeated washing there is a decrease in compression pressure due to different levels of wearing and washing [2].

Based on the above scientific literature review, it is observed that there are few studies in which compression socks are purely analysed for their performance characterization based on wearing and different washing levels. This research aims to analyse the performance behaviour of compression socks after wearing and washing at different temperatures.

MATERIALS AND METHODS

Materials

In this research work, nine pieces of compression socks samples with three different combinations were developed using the MERZ compression socks knitting machine. Machine properties are type (SC or DC) and model/year (CC4 II, 2015), cylinder diameter of 4.75-inches, machine gauge of E28, four systems and 420 needles. These socks samples were comprised of body yarn (BY) and inlaid yarn (IL). Both body and inlaid yarns are double covered except for varying twist per meter (TPM) range.

Body yarn (BY) was purchased that contains an elastane (EA) core of linear density (50 dtex) sheathed with polyamide (PA) multifilament yarn exhibiting the linear density (44 dtex).

Three different types of inlaid yarns (IY1, IY2 and IY3) were purchased comprised of elastane (EA) as core material and polyamide (PA) materials as sheathed material simultaneously. Here; IY1 contains elastane (EA) core of linear density (285 dtex) sheathed polyamide (PA) yarn of linear density (33 dtex), IY2 contains elastane (EA) core of linear density (475 dtex) sheathed polyamide (PA) yarn of linear density (33 dtex), IY3 contains elastane (EA) core of linear density (570 dtex) sheathed polyamide (PA) yarn of linear density (78 dtex). The microscopic internal view and technical specifications of inlaid double-covered yarns are given below in figure 2 and table 1.

The structure [1×1 Laid in, 1×1 knit-miss structure] and machine settings of all the three socks' samples are fixed and produced three pieces from each sample code for a different level of washing temperature. Moreover, the microscopic structures of the developed compression socks are shown below in figure 3. Table 2 represents the technical and physical properties of the compression socks samples.

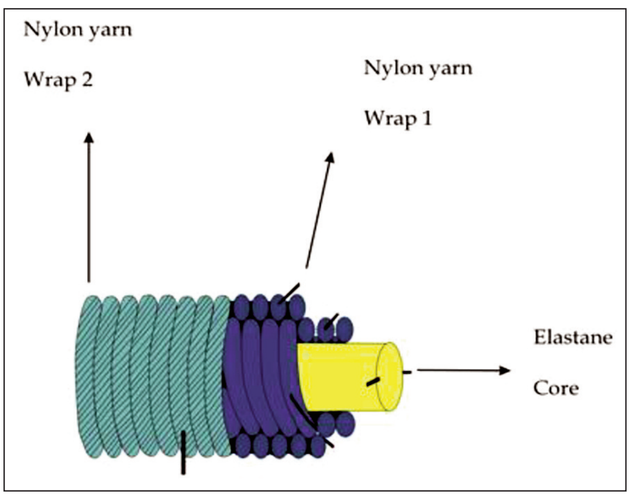

Fig. 2. Double covered Nylon filament yarn [11, 22]

Methods

Nine pieces of compression socks samples were tested at different washing temperatures. The aim was to simulate 'wear' and 'washing' of compression socks during the usage. The test protocol consists of 6 steps listed below and shown in figure 4:

1. Production of sock samples. Nine samples were pro-duced with a different combination.
2. Pressure measurement before wearing.
3. In vitro-wearing simulation. In each case to simulate the "wearing effect" all socks were put on the wood-en leg for 2 days (48 h).
4. Pressure measurement after wearing.
5. Washing the samples at three different levels of tem-peratures as seen in table 3.
6. Pressure measurement after washing.

This cycle is repeated five times for analysing and simulating the daily usage (wearing and washing) of people. It took fifteen days to compare the compres-sion pressure results measured at 1st washing and then 5th washing cycle.

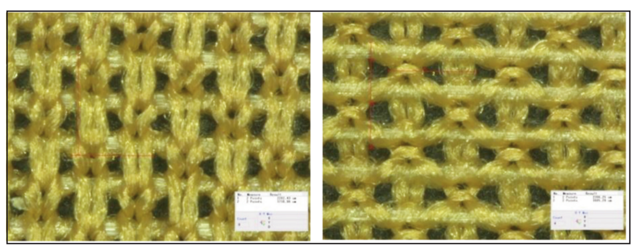

Fig. 3. Microscopic views of compression socks structure

Table 1

SPECIFICATIONS OF INLAID YARNS (IY)							
Sample codes	Yarn codes	Yarn type	Fibre type	Linear density	Resultant count (dtex)	Fibre composition (%)	Draft
S1	IY1	Core	EA	285 dtex	275/48f/1 dtex	Polyamide: Elastane 80:20	4
		Sheath	PA 6.6	33 dtex (24 f)			
S2	IY2	Core	EA	475 dtex	450/48f/1 dtex	Polyamide: Elastane 70:30	2.9
		Sheath	PA 6.6	33 dtex (24 f)			
S3	IY3	Core	EA	570 dtex	550/48/1dtex	Polyamide: Elastane 60:40	1.95
		Sheath	PA 6.6	78 dtex (24 f)			

Table 2

TECHNICAL SPECIFICATIONS OF COMPRESSION SOCKS									
Sample code	**S1**			**S2**			**S3**		
	S1-30	**S1-40**	**S1-50**	**S2-30**	**S2-40**	**S2-50**	**S3-30**	**S3-40**	**S3-50**
Measurement points and parameters	50-285 (dtex) DCV			50-475 (dtex) DCV			50-570 (dtex) DCV		
B-Ankle Wales density (stitches/cm)	28			26			26		
B-Ankle Courses density (stitches/cm)	12			11			11		
B-Ankle Stitches density (stitches/cm^2)	336			286			284		
C-Calf Wales density (stitches/cm)	22			21			20		
C-Calf Courses density (stitches/cm)	12			11			11		
C-Calf Stitches density (stitches/cm^2)	264			231			220		
Thickness (mm)	0.54			0.63			0.87		
Fabric mass per unit area (g/m^2)	270			305			360		
Fiber analysis (%) [Elastane: Polyamide]	20:80			25:75			30:70		
Ankle Width – b (cm)	8.5			8.5			9.2		
Calf width – c (cm)	12.5			13			14		
Calf width – c (cm)	12.5			13			14		

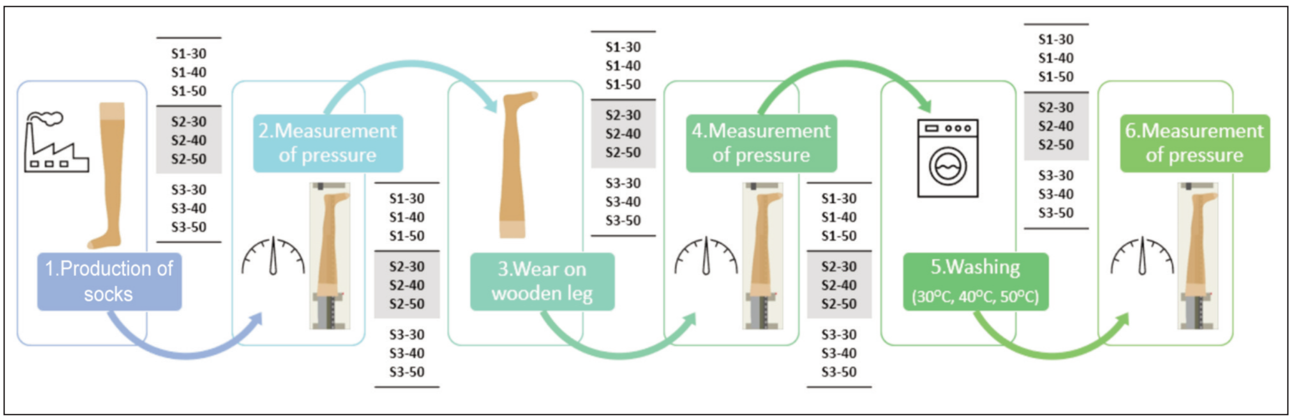

Fig. 4. Wearing & washing steps and measurement of compression pressures of socks

Table 3

PARAMETERS OF WASHING TYPES			
Washing type parameters	**Time (minutes)**	**Temperature (°C)**	**Machine type**
1st Washing Type	30	30 °C	Front Loading Washing Machine
2nd Washing Type	30	40 °C	
3rd Washing Type	30	50 °C	

Measurement of compression pressure

There are basically two methods that can be used to measure compression performance. These methods are; direct in vivo and indirect in vitro methods. In this study, the compression pressure of socks was measured in vitro using the MST Professional II Medical Stocking Tester, known as indirect method (Salzmann AG, St Gallen, Switzerland). It consists of a thin plastic sleeve. Sensors are located on the medial side of a linearly moveable attachment at a constant rate. The placement of sensors between the to and from the movement of the back side of the leg simulates the muscle's stretch and relaxation as shown in figure 5. The mechanical movement of the leg part possessing 10 sensors (depending on the length and longitudinal stretch of socks) from the ankle to calf portion measures the average exertion of compression pressure at the ankle and calf along with graduation percentage values as shown in figure 5. The envelopes are inflated with an air pump until the contacts in the device open. After that, the transducers read the pressure value at the defined points and display it on the digital display with a resolution of 1 mmHg.

These tests were carried out under the standard test method RAL-GZ 387/1. Test samples were tested under the standard laboratory conditions according to CEN 15831 (RH, 65±5%, temperature, 20±2°C). Tests were repeated five times for each sample.

Fig. 5. MST Professional II medical stocking tester

RESULTS AND DISCUSSION

Effect of wearing and washing on compression pressure

In this part of the study, we can see the compression pressure measurement results of the samples. Table 4 shows the compression pressure values of socks at the ankle before wearing, after wearing for two days and washing and after fifteen days of wearing and washing.

1st cycle of measurement of compression pressures at ankle and calf

Figure 6 and table 4 portray that samples 1 (S1-30, S1-40 and S1-50) after knitting (before wearing) pertain to equal compression pressure values of 23.7 mmHg at the ankle and 14.35 mmHg at the calf.
While samples S1-30, S1-40 and S1-50 after two days of wearing on wooden leg portray a different trend of exertion of compression pressure. S1-30 sample 23.43 mmHg in the ankle and 14.2 mmHg in the calf area, S1-40 sample 23.40 mmHg in the ankle and 14.20 mmHg in the calf area, S1-50 sample in the foot applies 23.45 mmHg pressure on the wrist and 14 mmHg in the calf area.
The sample socks (S1-30, S1-40 and S1-50) were also evaluated for the intensity of compression pressure after two days of relaxation and were again washed at three levels of temperatures (30˚C, 40˚C and 50˚C). Figure 7 and table 4 show that at 30˚C, 40˚C and 50˚C washing found a slight increase in compression pressure to 25 mmHg (S1-30), 25.3 mmHg (S1-40) and 25.5 mmHg (S1-50) at the ankle and 15.1 mmHg (S1-30), 15.2 mmHg (S1-40) and 15.23 mmHg (S1-50) at calf respectively. The reason for this slight increase in compression pressure after relaxation of two days of wearing on the wooden leg was due to a long time stretching and then quick contraction after washing at various levels of washing. It was also observed that their circumference increased when the socks were taken off from the wooden leg.
For S2-30, S2-40 and S2-50, the results of compression pressure after knitting (before wearing) were almost similar (figure 6 and table 4). After the socks were worn on wooden legs for two days, pressure values were measured as follows, respectively; 32.10 mmHg in the ankle and 18.7 mmHg in the calf in sample S2-30, 32.3 mmHg in the ankle and 18.3 mmHg

Table 4

COMPRESSION PRESSURE RESULTS OF ANKLE (B) AND CALF (C) AFTER WEARING AND WASHING					
Samples	**Measurement position**	**Before wearing (mmHg)**	**After 2 days of wearing (mmHg)**	**After 2 days wearing & washing (mmHg)**	**After 15 days wearing & washing (mmHg)**
S1-30	ankle (b)	23.7	23.43	25	23.7
	calf (c)	14.35	14.2	15.1	14.1
S1-40	ankle (b)	23.7	23.4	25.3	23.9
	calf (c)	14.35	14.2	15.2	14.4
S1-50	ankle (b)	23.7	23.45	25.5	25.5
	calf (c)	14.35	14	15.23	15.2
S2-30	ankle (b)	32.4	32.10	34.4	33.2
	calf (c)	19.1	18.7	19.8	19.4
S2-40	ankle (b)	32.4	32.3	34.5	33.6
	calf (c)	19.2	18.3	19.9	19.5
S2-50	ankle (b)	32.4	32	35.1	35.2
	calf (c)	19.2	17.8	20.4	20.3
S3-30	ankle (b)	33.8	33.36	37.2	35.4
	calf (c)	20.3	20.5	21.7	21.5
S3-40	ankle (b)	33.8	33.7	37.3	37.5
	calf (c)	20.2	20.06	22	22.4
S3-50	ankle (b)	33.8	33.45	38.3	38
	calf (c)	20.3	20.5	22.1	23.2

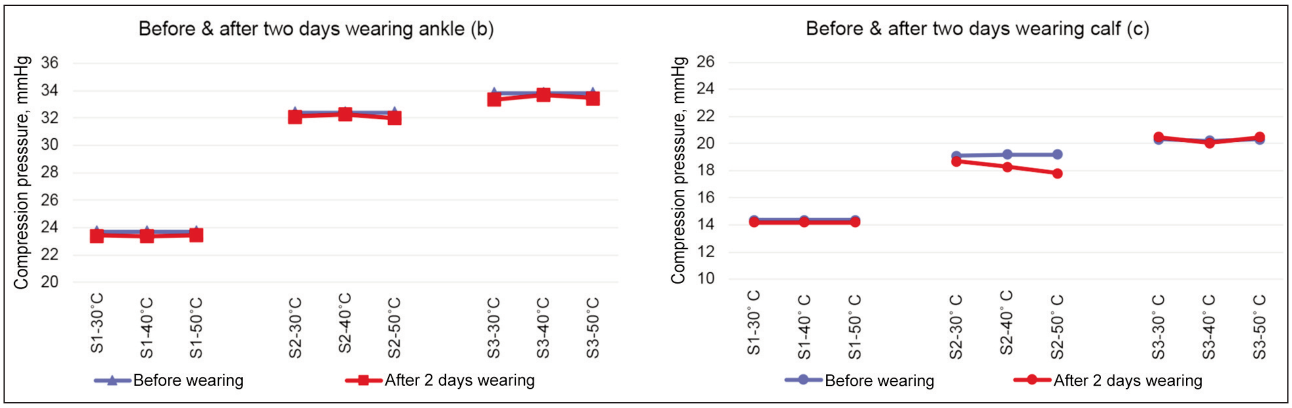

Fig. 6. Pressure comparison of the ankle (b) and calf (c) before and after two days of wearing

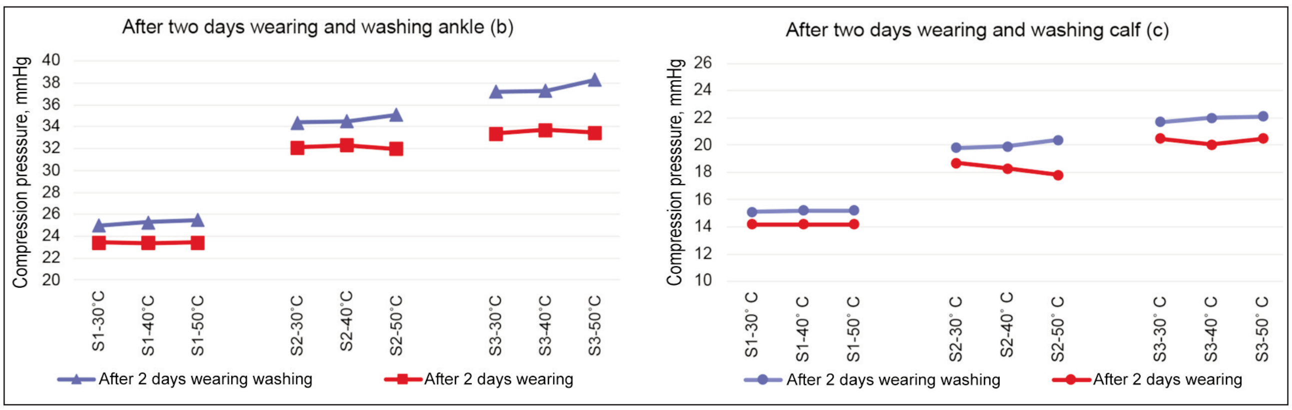

Fig. 7. Compression pressure change of ankle (b) and calf (c) after two days of wearing and washing

in the calf in the sample S2-40, 32 mmHg in the ankle and 17.8 mmHg in the calf in the sample S2-50. These worn sock samples were taken off from the wooden leg and again relaxed. It was then washed simultaneously at three different levels of temperatures 30˚C, 40˚C and 50˚C. When the pressure values in the ankle were examined after washing at different temperatures, an increase was observed at the ankle and calf. These values were measured at the ankle as respectively, from 32.10 mmHg to 34.4 mmHg after 30°C washing, from 32.30 mmHg to 34.5 mmHg after 40°C washing, from 32 mmHg to 35.1 mmHg after 50°C washing. At calf, portions were measured as 19.8 mmHg in the sample S2-30, 19.9 mmHg in the sample S2-40 and 20.4 mmHg in the sample S2-50.

As far as the S3-30, S3-40 and S3-50 are concerned, the compression pressure exerted by the S3 sample at the ankle was 37.2 mmHg after 30℃ washing (S3-30), 37.3 mmHg after 40℃ washing (S3-40) and 38.3 mmHg after 50℃ washing (S3-50) as shown in table 4. At calf, portions were measured as 21.7 mmHg in sample S3-30, 22 mmHg in sample S3-40 and 22.1 mmHg in sample S3-50.

The reason for the successive increase in compression pressure by increasing temperature is when the socks samples are worn to fixed-sized wooden legs they are stretched and when they are taken off their circumference increases. Again, when it was washed at different levels of temperature (30˚C, 40˚C and 50˚C) it shrinks more due to generated voids in the knitted structure of socks and higher regain the value of nylon material. The same trend and reason were for all of these socks' samples at successive temperatures.

Statistical analysis of all three socks' samples at three different levels of washing temperature was made using simple linear regression analysis as given in figure 8. The statistical significance of effect of different levels of temperature was fixed on the basis of coefficient of determination values (R-square) ((S1-30, S1-40, S1-50) = 0.98, (S2-30, S2-40, S2-50) = 0.85 and (S3-30, S3-40, S3-50) = 0.82). The statistical portrays that the influence of three different levels of temperatures exists but is not symmetric or consistent around the simple regression line. At calf portion coefficient of determination values (R-square) ((S1-30, S1-40, S1-50) =0.91, (S2-30, S2-40, S2-50) =0.87 and (S3-30, S3-40, S3-50) = 0.98) as shown in figure 8. Correlation values in both the ankle (0.9, 0.92 and 0.99) and calf (0.95, 0.93 and 0.99) portion explain the increase in pressure values as the temperature increases.

5th cycle of measurement of compression pressures at ankle and calf

Figure 9 shows the effect of five times wearing and washing on compression pressure at the ankle and calf portion of compression socks. As seen in figure 9,

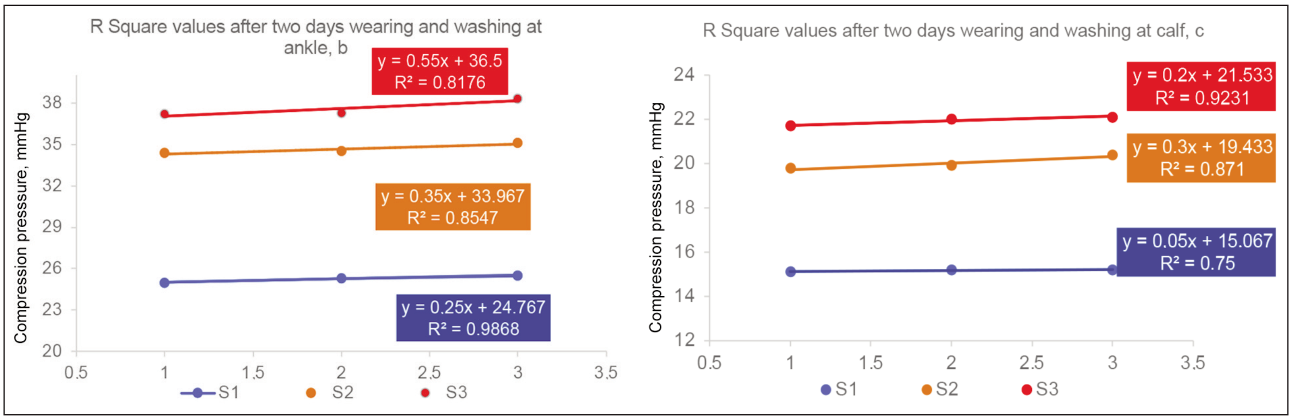

Fig. 8. R Square values of tests after two days of wearing and washing at the ankle (b) and calf (c)

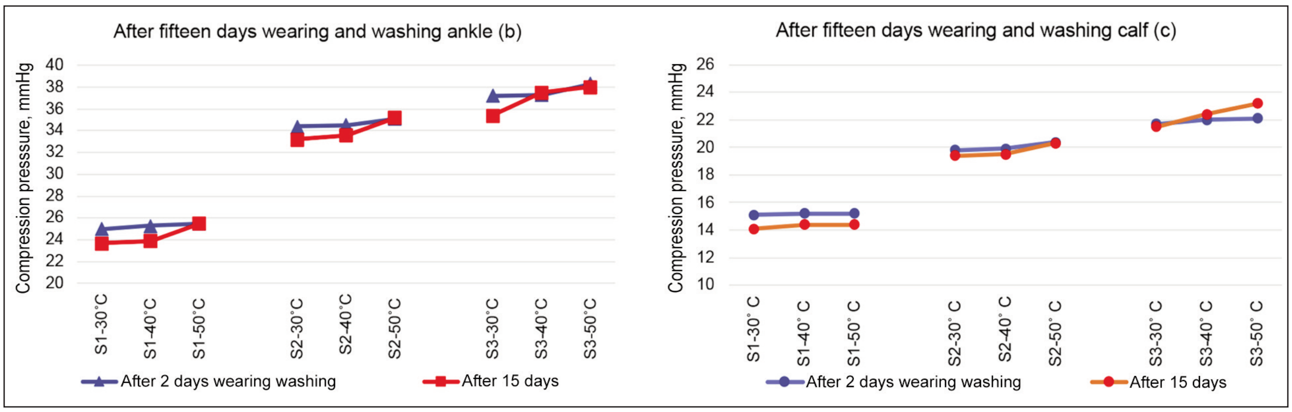

Fig. 9. Pressure comparison of the ankle (a) and calf (b) after fifteen days of wearing and washing

after five washing cycles, it is seen that the pressure values increase as the temperature increases. When the results after the 5th wearing and washing in the calf portion are examined, 14.1 mmHg in the S1-30 sample, 14.4 mmHg in the S2-30 sample, and 15.2 mmHg in the S1-50 sample were measured.

It was measured that the S1-30 sample applied 23.7 mmHg after 30°C washing, the S1-40 sample 23.9 mmHg after 40°C washing, and the S1-50 sample applied 25.5 mmHg after 50°C washing. In the S2-30 sample in the calf area 19.4 mmHg, 19.5 mmHg in the S2-40 sample, and 20.3 mmHg in the S2-50 sample were measured.

In addition, 33.20 mmHg in the S2-30 sample after 30°C washing, 33.60 mmHg after 40°C washing in the S2-40 sample and 35.2mmHg after 50°C washing in sample S2-50 were measured. Finally, when the pressure values of S3 samples in the ankle area were measured, respectively, the pressure results were obtained as follows: S3-30 35.40 mmHg after washing at 30°C, S3-40 after washing at 40°C 37.50 mm Hg and 50°C after washing S3-50 38 mm Hg. If we compared the results of sample S3-50 between 1st (33.8 mmHg) and 5th (38 mm Hg) wearing washing, there is a significant increase in compression pressure after multiple wearing and machine washing that is maximum for the sample S3-50 washed at 50°C.

The statistical significance of effect of different levels of temperature was analysed on the basis of coefficient of determination values (R-square) ((S1-30, S1-40, S1-50) = 0.83, (S2-30, S2-40, S2-50) = 0.88 and (S3-30, S3-40, S3-50) = 0.89) as shown in figure 10 at ankle portion. At calf portion coefficient of determination values (R-square) ((S1-30, S1-40, S1-50) = 0.93, (S2-30, S2-40, S2-50) = 0.84 and (S3-30, S3-40, S3-50) =0.98). The value of the coefficient of determination values of the socks sample (S3-30, S3-40, S3-50) is 89% which portray that the independent variable (x) which is different levels of temperatures is more significantly influencing the intensity of compression pressure. The reason behind this sort of trend is due to the heavier linear density of inlaid yarns used in samples (S3-30, S3-40, S3-50), heavier linear density of inlaid yarn used, and more draft required that permits the socks to shrink more. If the shrinkage increases, more reversal pressure on the surface wooden human leg is exerted. The significance of the input variables can also be judged on the basis slope value equation of the regression line. The slope value is the ratio of the rise (y-axis) to run (x-axis) and in the equation of the regression line, it is found as the coefficient of independent variable value (x) that the different levels of temperatures (30°C, 40°C and 50°C). Here the slope value of (S3-30, S3-40, S3-50) is (b=0.89) which is toward 1 that represents the steepness in the regression line. The

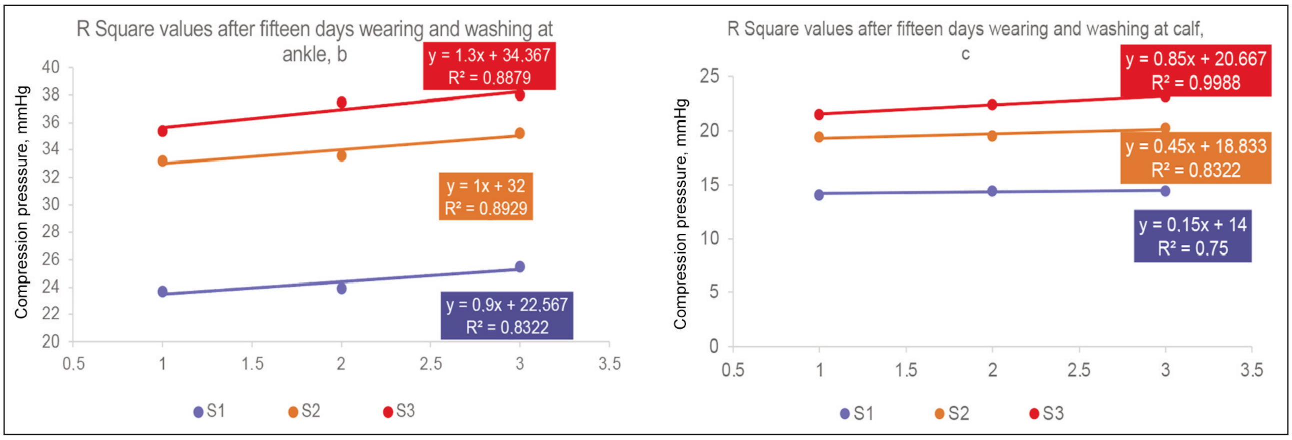

Fig. 10. R Square values of tests after fifteen days of wearing and washing at the ankle (b) and calf (c)

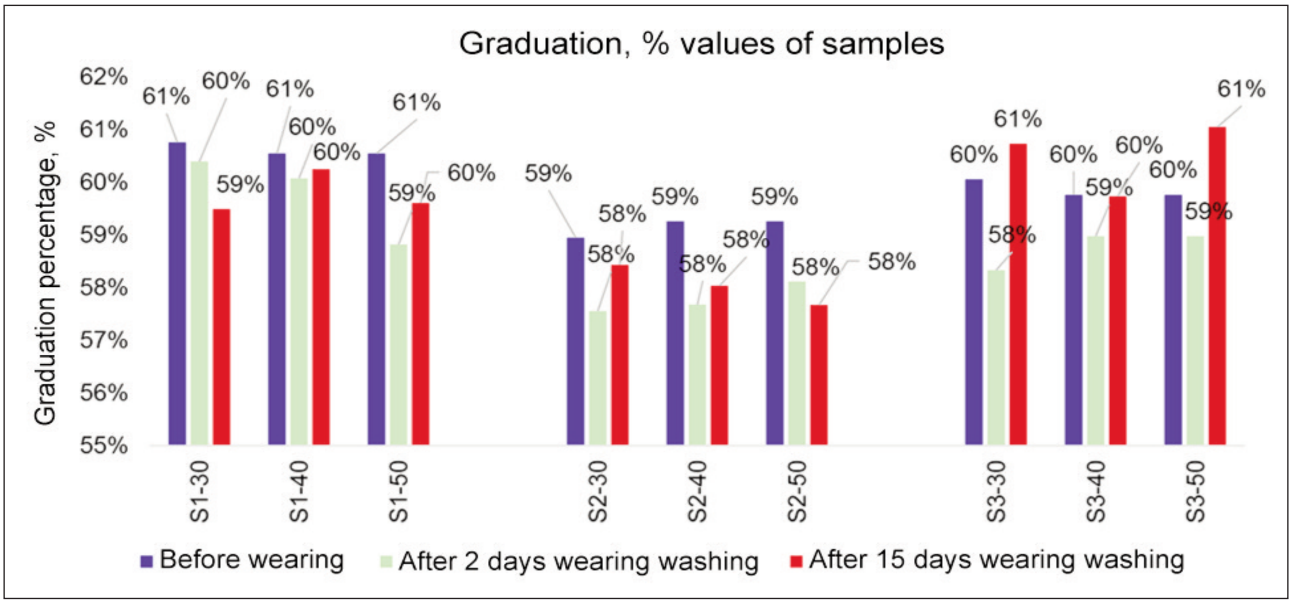

Fig. 11. Graduation values of compression socks

more steep the value, the higher the slope. The higher the slope, the more significant of the independent variable (x) influences the dependent variable (y).

Graduation values of compression socks at calf

Figure 11 shows the graduation percentages (G%) of the c point before, after two days and fifteen days of wearing and washing. The gradation values of our all samples before wearing and after fifteen days exhibit the values within the standard values as mentioned above.

In figure 11, we see that the graduation values of each sample that the graduation percentage (G %) (after two days) are slightly decreasing. As for S1-30, S1-40 and S1-50 are concerned that the graduation percentage (G %) after 30°C, 40°C and 50°C washing slightly decreases to 60%, 60% and 59%. For samples (S2-30, S2-40, S2-50) the G % values after 30°C, 40°C and 50°C washing are slightly decreased to 58%. For sample 3 (S3-30, S3-40, S3-50), the G % values after 30°C, 40°C and 50°C washing are slightly decreased to 58%, 59% and 59% respectively.

In figure 11, we see that the graduation values (G %) of each sample S1, S2 and S3 that the graduation percentage (G %) (after fifteen days of wearing and washing) is slightly increasing as the temperature increases. As for S1 (S1-30, S1-40, S1-50) is concerned that the G% (after fifteen days) after at 40°C and 50˚C washing slightly increases to 60%. As for (S2-30, S2-40, S2-50) is concerned that the G% (after fifteen days) after 30°C, 40°C and 50°C washing remains the same, 58%. Because the material has no capacity for shrinkage due to its compact structure [1×1 Laid in, 1×1 knit-miss structure]. As for S3 is concerned that the G% (after fifteen days) after 30°C, 40°C and 50°C washing is slightly increasing to 61%, 60% and 61% respectively.

CONCLUSIONS

This study aims to analyse the influence of wearing and washing cycles on the compression pressure of the socks. According to the results, it was observed that the washing temperature has a significant influence on the compression pressure for all samples.

It is concluded that the effect of temperature on the pressure of all the socks samples is different.

The socks sample S3-30, S3-40, and S3-50 exhibit the highest compression pressure as compared to S1 and S2 at the ankle and calf portion after wearing and washing. In addition, it can be said that the increase of linear density of inlaid yarns is more effective in pressure increase with the effect of temperature. The effect of temperature on the intensity of compression pressure for all three samples has a negligible increase/decrease in compression pressure.

As for graduation results G% it can be concluded that the effect of temperature (30°C, 40°C and 50°C) and wearing and washing cycles (after two and fifteen days) the graduation percentage (G%) values lie within the standardized values (50% – 80%).

Secondly, there is observed a slight increase/decrease in graduation percentage (G%) measured between two and after fifteen days at the ankle and calf portion.

As a general result of the study, wearing/washing test results for the use simulation show us that there is a decrease in the pressure values as a result of wearing, but that the pressure values can be maintained by providing recovery after washing. In addition, it was understood that the washing temperature values are effective on the pressure values.

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