

THE NEEDS FOR COMPRESSION SOCKS

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ABSTRACT

Different sock shapes and compression socks are described. Compressions of classic short socks in the sock body and cuff are analysed. The measuring was done on rigid cylinders of different diameters/circumferences which corresponded to leg circumferences in particular places. Special focus was placed on preventive and medical compression socks and amounts of compression on particular parts of the sock sleeve, as determined by an international doctors' agreement. The measuring of the sock sleeve compression in long compression socks was conducted on the wooden leg model in certain sizes. Sock compression up to 13 hPa (10 mmHg) is generally considered small and is not stated on the sock manufacturing label. In the German norm, the smallest amount of compression is 24 hPa (18 mmHg) and preventive compression socks are usually made below this compression area. A larger compression classifies the sock as a medical compression sock. Compression socks help people to perform their everyday or professional activities in a simpler, less painful, faster, more precise and happier way and to lead a more joyful life. The classic construction of the medical (therapeutic) compression sock follows the principle of the highest compression in the ankle area which gradually decreases towards the crotch. Depending on the purpose, it is possible to make a compression sock with specifically determined amounts of compression in particular leg parts.

Key words: compression sock, polyamide, elastane, elongation, compression

INTRODUCTION

Socks are an important aesthetic and functional part of dressing. In developed countries, they are worn every day, both on private occasions and in different occupations. Constructional shapes and functionality of socks are adapted to their intended use. Socks can be divided into different groups and are equally worn by healthy people, men, women and kids. They can be very short (ankle socks), short, knee highs, long stockings or pantyhose. Special-purpose socks have specific constructions and properties [1].

Short classic male and female socks are basically made in three material compositions. Ground yarn used to make the entire length of the sock usually consists of natural fibres, cotton or wool. Breaking elongation of these yarns is commonly 5 to 15 % and they cannot form a good-quality classic sock on their own. In order for the sock to have an adequate elasticity, apart from the already mentioned yarns, multifilament polyamide (PA) yarns with the breaking elongation 20 to 40 % are usually knitted in. They provide the sock with elasticity, acceptable fit on the leg and wearing comfort. This multifilament yarn is simultaneously knitted in with the ground yarn along the entire length of the sock. The third yarn used in the production of classic short socks is elastane and it is significantly coarser. It is knitted into the upper, open cuff of the sock and makes it self-supported. Such classic socks are most often mass produced for an unknown buyer [2].

Special-purpose socks have specific constructions, material compositions and tensile properties. For example, there are constructional differences among the so-called sports socks for athletes, skiers, alpinists, football, basketball and handball players, etc. Many professional athletes use socks which are made according to their leg measurements and have a specific construction. They use one kind in their everyday life, other during practice and third in competitions [3].

Some hosiery is used for medical therapeutic purposes in the treatment of leg diseases. Chronic venous insufficiency (varicose veins) is often treated by compression socks which press on the tissue, and thereby also the veins, thus restoring the right blood flow through the legs. Other medical therapeutic socks are used to cover wounds wrapped in bandages. These socks do not usually exert

compression on the leg but keep the bandage in a certain position and keep the leg warm or protect it from cold [4,5].

HOSIERY COMPRESSION

In order to adequately fit on the leg, the sock presses the leg with a certain force, i.e., the moderately longitudinally elongated body of the sock comfortably fits on the leg, which is how the sock becomes self-supported. In classic socks, sock compression on the leg is not that significant and is not stated on the manufacturing label. The amount of hosiery compression is relevant in medical compression (therapeutic) stockings. The pressure that blood exerts on the artery wall is called blood pressure. With each heartbeat, the blood is introduced into the arterial system under pressure. At that moment, the blood pressure is the highest and is called systolic. In the period between two heartbeats, the blood pressure is lower and is called diastolic. The value of blood pressure is therefore expressed by two numerical values. The first value is always higher and represents systolic pressure, while the second is lower and represents diastolic pressure. In healthy people, the optimal value of blood pressure should be below 120/80 mmHg. The blood pressure above 140/90 mmHg is considered high blood pressure or hypertension. In people suffering from diabetes, kidney or heart disease and those who have had a stroke, the target blood pressure is below 130/80 mmHg [6]. Based on blood pressure measurements, doctors have accepted mmHg as a unit of measurement for the compression of compression hosiery on the leg. Some European countries made standards for measuring the compression of hosiery on the leg, and the compression is expressed in mmHg. [7-9]. In mechanics, especially fluid mechanics, pressure is measured in the pascals (Pa), which is a relation between force in newtons (N) and surface on which the force acts expressed in square metres (m²), (Pa = N/m²). Since the pascal is a small unit, we use kPa and hPa, (1 mmHg = 1.33 hPa; 1 hPa = 1 g/cm²; 67 hPa = 50 mmHg). Depending on the intended purpose of the stocking, its compression is usually measured on the leg from the ankle to crotch. Doctors defined certain places (points) in which compression is measured [4,5]. Apart from compression stockings or leg sleeves, there are compression arm sleeves which are put on the arms, Fig. 1. They are used by professional athletes, typically basketball and handball players, but also volleyball players and skiers. The function of a compression leg or arm sleeve differs between sick and healthy people, i.e., athletes.



Figure 1: Different types of compression hosiery: a) knee-high stockings, b) women's preventive pantyhose, c) preventive maternity pantyhose, d) sports short compression socks, e) compression leg sleeves, f) compression arm sleeves

COMPRESSIONS OF SHORT SOCKS

There are different constructional shapes of short socks. In the classic construction of short summer or winter socks, compression is irrelevant and is therefore not stated on the manufacturing label.

However, a coarser elastane yarn is incorporated into the upper sock part or the open cuff, and sometimes presses the leg more strongly and leaves a deformation on the leg. Since such sock is uncomfortable for everyday wear, its use is avoided. There are two reasons why the cuff pressure on the leg is too large. The first reason is to be found in the relation of the sock construction and the leg. The sock was probably made for the classic leg shape, while the leg on which the cuff lies has larger dimensions. The second reason is that the sock was really made with a smaller share of elastic elongation in the cuff area. In such socks, the compression of the sock body on the leg is 4 to 10 hPa (3 to 7 mmHg). A comfortable cuff compression on the leg is often twice as large as the compression of the sock body on the leg and ranges between 8 and 20 hPa, Fig. 2. Short classic socks are made for an unknown buyer and usually unknown market. Therefore, this sock group involves various compressions of the sock body and cuff on the leg. For this reason, the measuring of the short sock body and cuff compressions on the leg is simply and cheaply done on cylinders with the human leg diameter, e.g., 80 to 130 mm with the 10 mm spacing. By mounting the sock on the cylinder of a larger diameter/circumference, the elongation increases, and thereby the mounting force and finally the amount of the measured compression, Fig 2b.

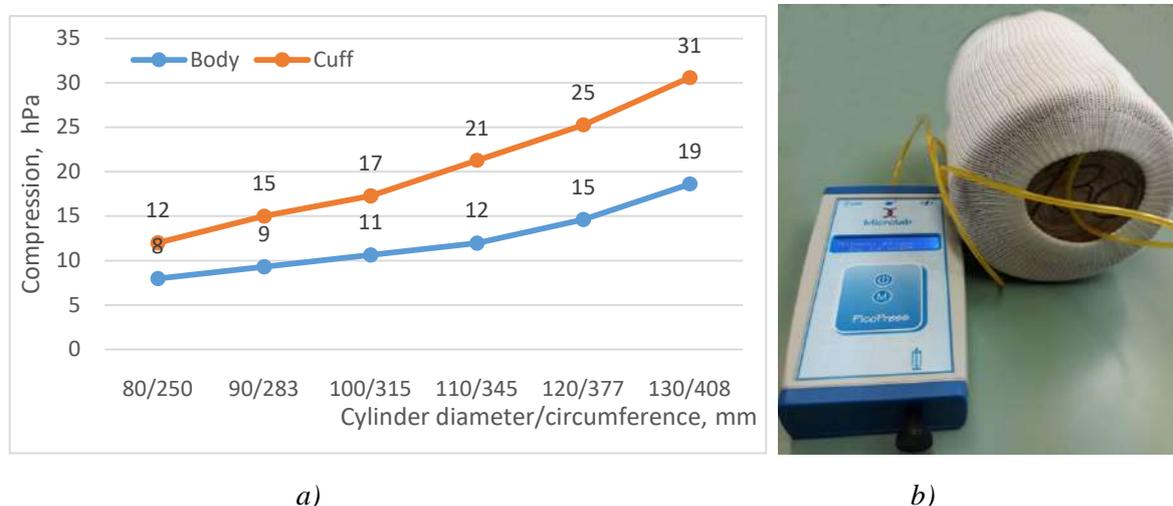


Figure 2: Compression of the body and cuff of the short classic sock: a) amounts of compression at a certain elongation, b) measuring compression on a stiff cylinder of a certain diameter [10]

Compressions of the body of short socks with various structures and purposes were measured. A representative sample of a light spring/summer short sock, with the mass of 15 g, made with a ground cotton yarn in the count 20 tex and PA multifilament yarn in the count 156 dtex, exerts the compression on a stiff cylinder from 4 to 13 hPa, Fig. 3, curve A, [10]. If the sock body is mounted on a leg circumference from 250 to 300 mm, the compression is the smallest and amounts 4 to 5 hPa. In the leg circumference from 300 to 360 mm, the sock body exerts the compression from 6 to 10 hPa, and in the largest circumference of 400 mm, the achieved compression is around 13 hPa. These socks are appropriate for the use in leg circumferences from 250 to 330 mm, where an acceptable wearing comfort is achieved. Objectively speaking, this sock is not comfortable to use if it exerts a compression larger than 10 hPa.

The second sock from this group selected for compression measurement has similar constructional properties. It is intended for winter use. It was made from a ground cotton yarn in the count 50 tex and PA multifilament yarn in the count 220 dtex, and had the mass 20 g. By mounting the body of this sock on cylinders with diameters/circumferences from 80/250 to 130/408 mm, the measured compression was from 6 to 20 hPa – curve B. In such socks, increased compression leads to greater comfort during use. As in the first sock, the compression linearly increases with respect to the increase in cylinder circumference on which the sock is mounted. The third sock is made from similar

yarns as the second, except that it is made in the plush weave, and is featured on the market as a thermal sock. The sock is significantly more massive than the winter sock and has the mass of 26 g. It is also intended for use during winter. In winter, it is often worn by the young, but the old as well, during walks or in the house/apartment. The compression of this sock is similar to the compression of the winter sock. It tends to be more acceptable to wear with a smaller compression. The fourth in this group is the so-called sports sock. Unlike the previous ones, this sock is made from the ground cotton yarn in the count 34 tex and the elastane yarn 54 tex. The elastane yarn is knitted into each course together with the ground yarn. As a result, it significantly shrinks the tubular shape of the sock upon removal from the machine. Therefore, this sock elastically stretches during application and presses the leg more firmly. In some sock constructions, the body and foot are entirely made with the ground and elastane yarn, while in other constructions only partially. This sock in this sock group exerts the largest compression on the leg in the amount 8 to 35 hPa. Many users, especially amateur or recreational athletes, consider the compression 12 to 25 hPa as the most suitable for themselves. Recreational athletes who use such socks with an increased compression, i.e., 20 to 25 hPa, remove them from their legs after a practice or game because large compression causes discomfort in the resting position. During use and after a dozen washes, the compression in these socks slowly decreases, often up to 30 %, [3].

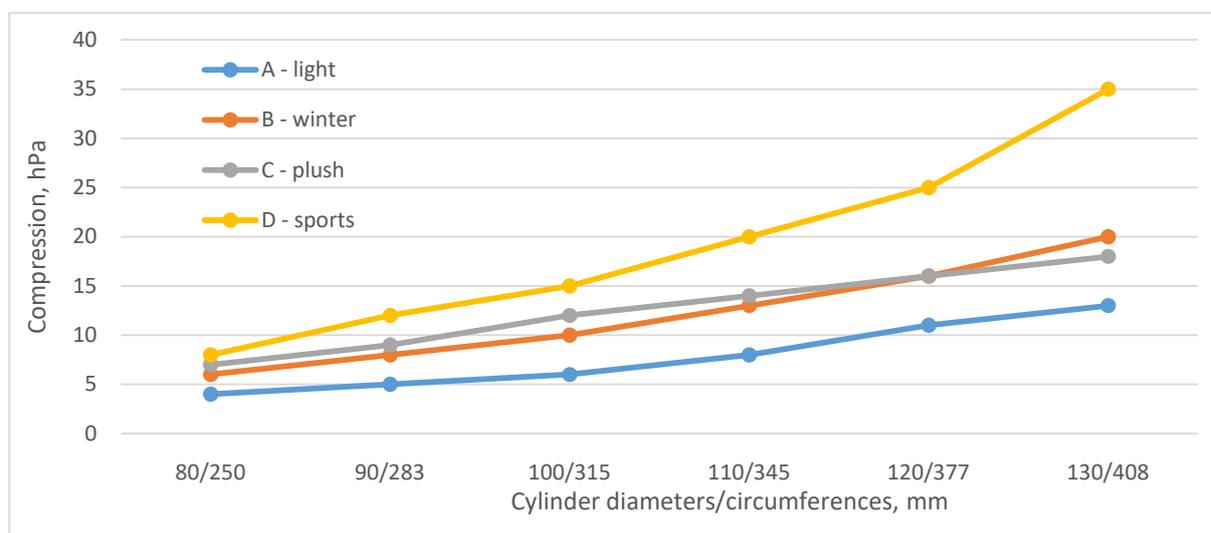


Figure 3: Compressions of the body of different short socks

There are various reasons why short socks with an increased compression are in high demand. They are happily worn by the elderly and sick as well as athletes and kids. In most cases, these socks do not cause health disorders during use. Special-purpose short or knee-high socks are custom made and exert the required compressions on certain parts of the lower leg.

MEDICAL COMPRESSION SOCKS

Classic fine women's pantyhose is made according to the principle where the sock sleeve is made from yarn in a single count with different sinking depths. The yarns used in the production of these socks are typically PA multifilament yarns in the counts 17, 22, 33, 40 or 60 dtex. The smallest sinking depth is applied in the sock part lying above the ankle (Fig. 4 – position b) and the width of tubular knitwear in this area is usually 80 to 90 mm. The leg circumference in this area is from 180 to 220 mm. When the sock is put on the leg, it elongates 30 to 50 % and exerts the compression from 5 to 8 hPa (4 to 6 mmHg). Leg circumference increases from the ankle towards the knee and with it also the width of tubular knitwear in the sock sleeve. The increased width of tubular knitwear is achieved

by the increased sinking depth. In numerous fine women's socks such as these, the compression on the lower leg (position c – diagram FINA) is around 20 % larger than the compression above the ankle. In the upper leg area, leg circumference is even larger, which means greater width of the knitwear. When the sock is put on this leg part, the compression decreases and is often around 2 hPa in the area below the crotch (position g). These are small amounts of compression which can be differently distributed along the sock sleeve and are therefore not stated on the manufacturing label. Girls or women who play sports often prefer to use socks which have the largest compression on the calf and around the knee. [11].

Preventive compression socks (Fig. 4. - curve PREV) are often worn by people who spend a long time in the standing position or on the go: stomatologists, nurses, postmen, recreational mountaineers, shop assistants and others. They are certainly more frequently used by women and without doctor consultation. These socks have a larger compression, especially above the ankle. The compression is often 14 to 18 hPa (10 to 14 mmHg) and gradually decreases towards the crotch, where it is around 4 hPa (3 mmHg). The socks are made in plated weave with two yarns being knitted into a single course: the ground is polyamide multifilament, e.g., in the count 33, 44 or 60 dtex, and the plated is single or double covered elastane in the count of, for example, 44 dtex. According to the German standard [7] the smallest compression of a compression sock is 24 hPa (18 mmHg). Therefore, preventive compression socks are often made below the given amount of compression and in principle, they can be used without doctor consultation. However, pregnant women who have given birth more than twice are happy to consult a doctor. During pregnancy, doctors recommend using preventive compression pantyhose with compression above the ankle of up to 24 hPa. In principle, the compression in these socks decreases 60 to 80 % towards the crotch, where it is only 6 hPa. These socks also come in different constructional forms and compressions. The demand for these socks on the European market has been increasing lately. In certain areas, these socks are supplanting classic socks, e.g., among mountaineers, firefighters, police officers, truck drivers, foresters, and others.

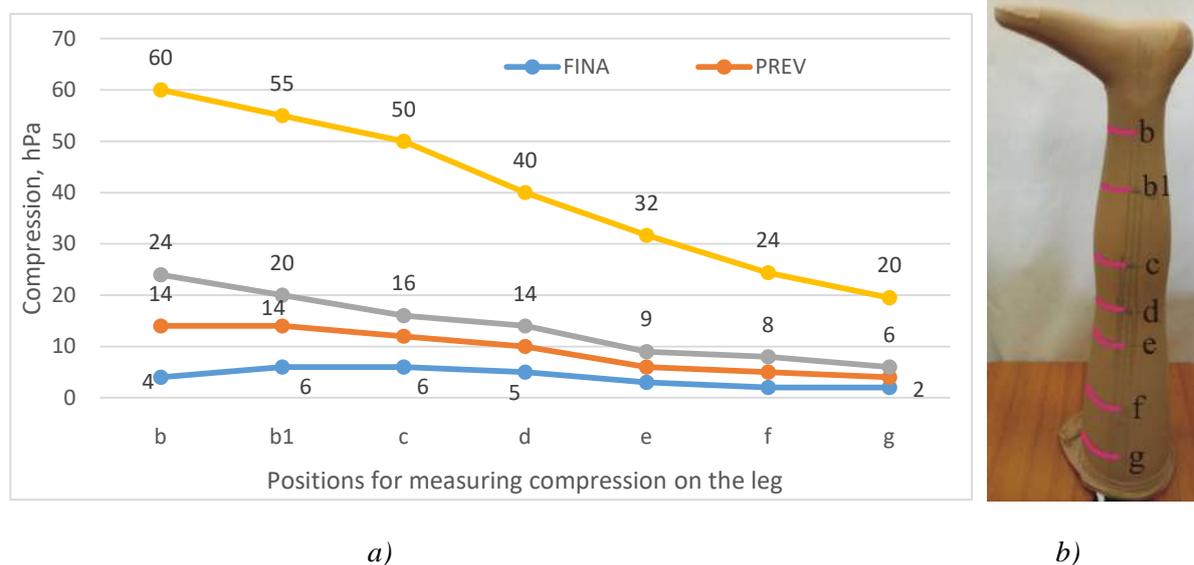


Figure 4: Compression of sock sleeves of preventive and compression medical socks; a) measured compressions of certain socks in measuring areas, b) specified areas for measuring compression on the wooden leg model

Socks which exert a compression larger than 24hPa (18 mmHg) in the German standard are used as medical compression socks or medical therapeutic socks. Generally, they are recommended by doctors to treat certain diseases (varicose veins, oedema, ankle swelling, lipodermatosclerosis, ulcerations in the healed venous stasis, active venous ulceration, venous insufficiency, chronic venous insufficiency, etc.). Standards by certain countries usually include four grades or degrees of

compression which are mutually different. In the German standard, the first class encompasses mild compression from 24 to 28 hPa (18 to 21 mmHg), the second class involves moderate compression from 30 to 43 hPa (23 to 32 mmHg), the third class includes strong compression in the amount from 45 to 61 hPa (34 to 46 mmHg) and the fourth class very strong compression which is larger than 65 hPa (49 mmHg). Depending on the disease type and stage, doctors recommend socks with a certain compression. In Fig. 4. – the curve OM-MA shows the amounts of compression in a medical compression sock with mild compression and the curve KOM-VE shows large amounts of compression in a medical compression sock belonging to strong compression, while the compression decreases from 60 hPa (position b) to 20 hPa (position g). Measuring of the sock sleeve compression is usually simultaneously performed in the seven given areas on the wooden leg model. Medical compression or therapeutic socks are worn for longer time periods under medical supervision.

As can be observed, in numerous compression medical socks, compression continuously decreases from the ankle (position b) towards the crotch (position g). Many professional athletes use compression socks which have customized and comfortable amounts of compression. Some basketball players have the largest amounts of compression in the lower leg and upper leg muscle because of mass amortisation during high jump and fall. Some handball players use compression socks with the largest compression around the knee, which suffers the biggest pressure. Such socks are custom made according to the measurements of a specific leg. Compression socks which exert a compression larger than 24 hPa are very often used by ex professional athletes who become recreational athletes. After active sports playing, their muscles lose flexibility and elasticity so compression socks strengthen their muscle tissue. They use such mild compression socks every day, and during practice or recreational matches, they use socks with a larger compression. They choose socks with a certain compression on their own, without doctor consultation.

CONCLUSIONS

In modern society, compression socks increase the joy of living by making it easier for people to perform their daily activities. In everyday life, compression socks are used by people of all ages. Some follow doctor recommendations while others use them on their own based on wearing comfort. In the world it is a generally accepted view that the socks which exert compression up to 13 hPa (10 mmHg) are not considered compression products. These socks are usually the kind that healthy people wear every day. People who do their activities in the standing position use preventive compression socks which exert the compression on the leg 13 to 24 hPa (10 to 18 mmHg). Medical compression socks exert the compression on the leg larger than 24 hPa (18 mmHg) and should be used based on doctor recommendation and control. Many compression socks are made on specially constructed hosiery automats and are made from PA multifilament and elastane yarns.

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REFERENCES

- [1] Modig N. (1988). *Hosiery Machines*, Meisenbach, Bamberg
- [2] Vrljićak Z., Kovač A. (2011). Projektiranje i izrada kratkih čarapa, *Tekstil*, 60(4), 149-159
- [3] Sperlich B. et al., (2011). Zum Einsatz von Kompressionstextilien zur Leistungssteigerung und Regenerationsförderung im Leistungssport, *Sportverl Sportschad*, 25(4), 227-234
- [4] Cavezzi A., Michelini S. (1998). *Phlebolympoedema, From diagnosis to therapy*, P.R. Communicastions, Bologna
- [5] Ramelet A.A. et al., (2008). *Phlebology*, Elsevier Masson SAS, Issy-les-Moulineaux Cedex
- [6] Balažin Vučetić A.(2007). [Accessed 12.XI. 2021] *Krvni tlak*; <https://www.plivazdravlje.hr/aktualno/clanak/16063/Krvni-tlak.html#21346>
- [7] RAL-GZ 387/1. (2008). *Medizinische Kompressionsstrümpfe – Gütesicherung*, Dueren

- [8] BS 6612. (1985). *Graduated compression hosiery*
- [9] ASQAL. (2008). *Certificat de qualite produits; Referentiel technique prescrit pur les chaussettes, bas, collants et manchous de contention/compression des membres*, Paris
- [10] <http://www.microlabitalia.it/case-history.php?azione=show&url=pico-press>. [Accessed 24.VI. 2020].
- [11] Lozo M., Vrljićak Z. (2016) Structure and Elongation of fine Ladies' Hosiery, 48. *Congress of the IFKT*, Moechengladbach.