AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|

TYPES, FUNCTION, AND MANUFACTURING STATUS OF COMPRESSION PRODUCTS

https://doi.org/10.5281/zenodo.15522419

Yermatov R.B., Xanxadjaeva N.R.
Tashkent Institute of Textile and Light Industry Tashkent, Uzbekistan

Abstract

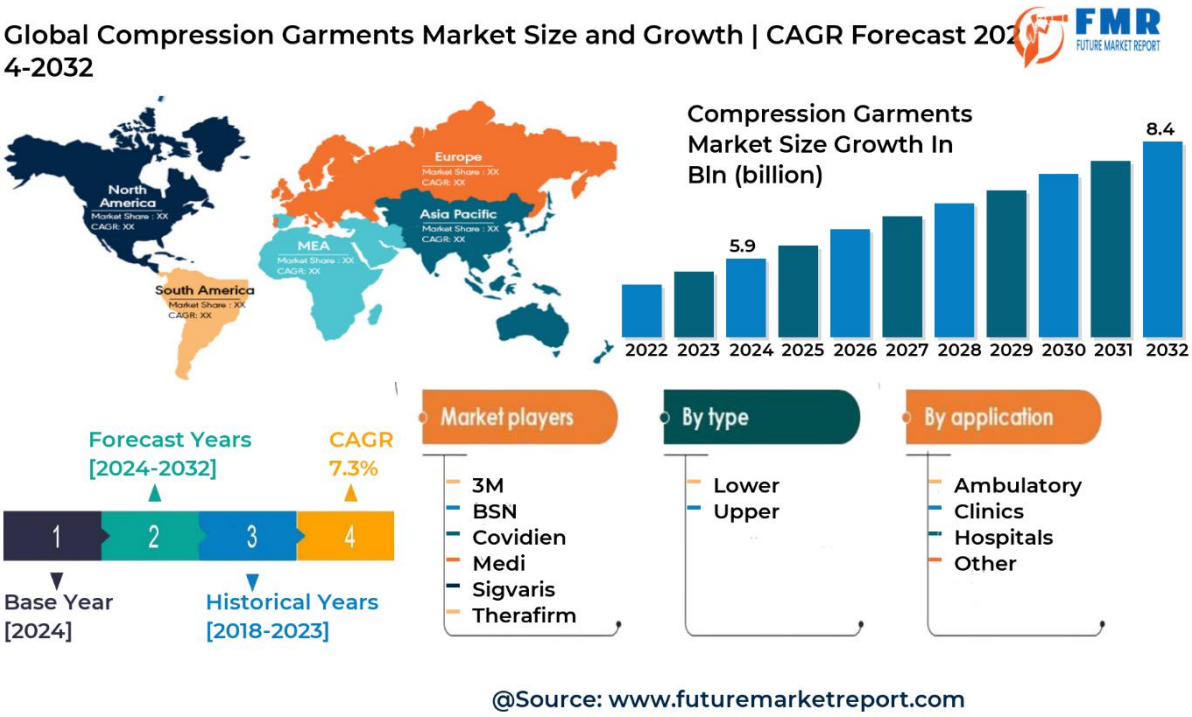
This article reviews the types of compression products, their function and manufacturing conditions, and the results of research on the production of compression stockings using natural and synthetic raw materials. The use of digital technologies and innovative fabrics in the production of compression products around the world is also affecting the development of the compression products market. In particular, research on improving the effectiveness of compression products through the use of sensor fabrics, 3D-knitting technologies, and artificial intelligence-based design methods is currently one of the most relevant areas. Such innovative approaches not only increase clinical effectiveness, but also improve the ease of production and use of products. Therefore, this research aims to improve the effectiveness of compression therapy by improving production technologies, researching new materials, and developing personalized solutions, which is not only of scientific but also practical importance.

Key words

Compression knitwear, seamless knitwear, compression pressure, eco-friendly products

The global compression products market is estimated to be valued at 5.9 billion US dollars in 2024, with expectations to reach 8.4 billion US dollars by the end of 2032. The market's Compound Annual Growth Rate (CAGR) between 2024 and 2032 is projected at 5.3% [1]. This forecasted growth is primarily attributed to the expanding use of compression products in the medical sector (hospitals, clinics, outpatient facilities, and others). The compression products market is influenced by a combination of medical, sports, and aesthetic trends [2]. From a medical standpoint, the increase in chronic venous diseases, sedentary lifestyles, obesity, and aging-related issues is driving the demand for garments that improve blood circulation and reduce swelling. Conversely, athletes widely use compression products for injury prevention and recovery, stimulating the market's bilateral development (Figure 1).

AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|



1- Fig. Compression products market growth trend.

The incorporation of digital technologies and innovative fabrics in the global production of compression products is also contributing to the market's growth. Smart textile products are being developed that integrate sensors for health monitoring with compression pressure. Technological advancements in materials, such as seamless knitting, moisture-wicking fabrics, and odor control technologies, are enabling manufacturers to produce enhanced and more comfortable products. Innovations are also focused on improving aesthetics, attracting younger consumers by combining functionality with fashion. Furthermore, consumers are seeking high-quality, affordable, and environmentally friendly products. Manufacturers are supporting this demand by incorporating recycled fibers and employing more eco-friendly production methods [3].

Large-scale reforms are being implemented in the republic to develop the textile industry, deep processing of local raw materials, and the production of high-quality, competitive products.[4] Within the framework of the New Uzbekistan Development Strategy for 2022-2026, the goal is to double the volume of textile production [5].

With the increasing popularity of sports and an active lifestyle, the demands of professional and amateur athletes for muscle support and injury prevention are rising sharply [6]. This necessitates the widespread use of compression therapy not only in medicine but also in sports and rehabilitation fields. Compression products (therapeutic socks, bandages, sportswear) are now viewed in modern medicine not just as a symptomatic solution, but also as a preventive measure [7]. However,

existing production technologies and materials still have a number of limitations in terms of usability, effectiveness, and environmental impact. Therefore, the challenges of applying new materials, individual design methods, and smart technologies in the production of compression products are becoming increasingly important. Although research on compression therapy has so far focused mainly on its clinical effectiveness and application methods, the following aspects have not been sufficiently studied [8]:

1. **Materials science challenges:** Physiological effects and long-term stability of materials used in compression products;
2. **Manufacturing technologies:** Innovative production methods ensuring precise pressure distribution;
3. **Personalized solutions:** Methodology for designing products that conform to individual anatomical characteristics;
4. **Environmental impact:** Potential for using recyclable and biodegradable materials.

In particular, research on improving the efficiency of compression products through the use of sensor-embedded fabrics, 3D knitting technologies, and artificial intelligence-based design methods is currently one of the most relevant areas. Such innovative approaches not only increase clinical effectiveness but also improve the manufacturability and usability of products. Therefore, this study aims to enhance the effectiveness of compression therapy by improving production technologies, researching new materials, and developing personalized solutions, which is significant from both scientific and practical perspectives.

In recent years, as a result of implementing comprehensive measures to develop the textile, garment, and knitwear industry in our country and supporting the investment and export activities of enterprises in the sector, 100% of cotton fiber and 45% of yarn produced in the republic are being processed, and the industry's annual export potential has exceeded 3.2 billion dollars [9]. At the same time, intensifying competition in world markets and cost reduction by foreign manufacturers through the production of blended products necessitate additional measures for developing this industry. The Ministry of Investments, Industry and Trade [10] and the "Uztextileprom" Association have set tasks to increase the production volume of high value-added finished products and textile goods by 2.1 times and export indicators by 2.6 times over the next five years through deep processing of cotton fiber, as well as to bring textile production to a new level. These tasks include increasing the industry's export potential to 5 billion US dollars through large-scale state support for the textile, garment, and knitwear industry, raising the utilization level of garment and knitwear production capacities from 65

percent to 81 percent, and gradually bringing cotton yarn processing to 100 percent by the end of 2027 by creating infrastructure and financial conditions to increase the production volume of 35 thousand types of fabrics and knitted materials [11].

This section of the dissertation analyzes sources on medical compression knitwear products.

The analysis of sources primarily examined journals, monographs, educational literature, theses, dissertation abstracts, and patent and invention documents related to medical knitted products (compression socks).

Applications in the field of sports (1970-2000) Research in the field of sports during the 1970s demonstrated that applying a certain degree of compression to muscles helps increase strength and reduce fatigue. Consequently, athletes began using compression socks. In the 1980s, major sports brands such as Nike and Adidas started producing compression socks for professional athletes for the first time [12]. In the 1990s, Under Armour introduced "body-hugging" compression t-shirts designed to provide warmth for athletes and facilitate movement. In 1998, the Australian brand SKINS emerged and introduced dynamic compression technology. These garments provided additional supportive pressure to the muscles during movement. Modern Innovations (from the 2000s to the present) In the 21st century, compression knitwear products have become widespread not only in medicine and sports but also in everyday fashion.

Smart compression fabrics - brands like CW-X and 2XU have developed "zonal compression" technology that aligns with the anatomical structure of muscles. Biofeedback-based clothing - some compression products are equipped with sensors that monitor the user's muscle activity and heart rate. Compression socks and t-shirts - today many people wear compression garments during fitness activities or even on a workday. 3D knitting technology [13] enables the production of special compression socks precisely tailored to the shape of a patient's legs or arms. The history of compression knitwear products has expanded from medical needs to sports and fashion. Today, they are used not only for health care but also for improving athletic performance and even for everyday comfort. With technological advancements, this field continues to offer increasingly innovative solutions.

While compression knitwear may initially seem to be intended only for medical purposes, there are actually many reasons for its use in everyday life [14]. Today, people in the following conditions are increasingly finding a need for it:

- Sedentary lifestyle
- Overweight
- Professions requiring prolonged
- Athletes
- People with disabilities
- Pre-operative and post-

AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|

standing (teacher, hairdresser)

- Pregnancy
- People predisposed to vascular diseases

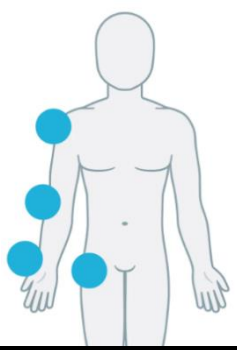
operative recovery

Compression knitwear products can be defined as compression items used for medical, sports, or body-shaping purposes. While the main focus is on the compressive properties of these products, aesthetic qualities, comfort, and end-use characteristics are of great importance to consumers. Compression products intended for medical purposes can be classified according to the condition of the human body.

If the pressure level at the ankle area of the foot is equal to 30 mm of mercury column, the pressure distribution will be approximately as follows:

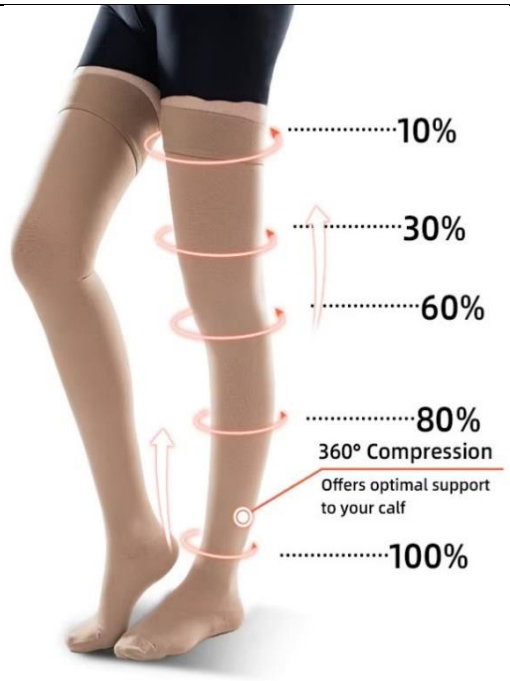
This principle helps improve blood flow in blood vessels and prevents blood accumulation in the extremities as pressure decreases upward. In everyday life, compression hosiery can be used by both men and women, and the notion that socks or stockings are exclusively for women is incorrect. The main difference between men's and women's compression hosiery is manifested in their anatomical features. Women's compression hosiery takes into account the shape of the female body, especially curves in the thigh and waist area. Women's compression stockings have an expanded upper part for better fit and comfort. Compression hosiery for men has less pronounced curvatures in the thigh and waist area, which makes it comfortable for men.[15] The types of compression hosiery depend on the location of the problem and the level of activity. Considering this, currently, a wide range of compression hosiery products is used in the fields of medicine, sports, and fashion. There are many types of these products, and information about their popular product types is provided below [16] (Table 1).

Table 1. Classification of compression garments based on the condition of the human body

Body parts		Location
Arm part	Forearm Elbow Shoulder	
Leg part	Ankle	

AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|

	Knee
	Thigh
Other part	Abdomen (for pregnant women)
	Lower back/spine



3-Fig. Distribution of pressure levels in compression socks

Pressure level distribution for compression socks

In compression stockings and socks, the pressure on the foot surface is not distributed evenly: the strongest pressure occurs in the ankle area. Then, as it progresses along the leg towards the thighs, it gradually decreases (Fig.3).

Position	Pressure %		

AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|

Ankle	100%		
Calf	70–80%	Calf:	~21–24 mmHg
Knee	50–60%	Knee:	~15–18 mmHg
Thigh	20–30%	Thigh:	~6–9 mmHg

Compression hosiery is recommended for patients with venous diseases (varicose veins), thrombosis of the leg veins, or impaired lymph flow of any origin [17]. The product should be selected according to its purpose. There are several types of such hosiery, each of which performs a specific function:

1. Prophylactic stockings - help prevent the development of venous diseases. Recommended for people who sit or stand for long periods, as well as pregnant women.

2. Therapeutic stockings - used for the treatment of specific pathologies.

3. Anti-thrombosis stockings - worn to prevent thrombosis during childbirth or surgery.

4. Anti-ulcer stockings - used in the treatment of purulent wounds.

Compression levels: In medicine, there are several compression classes of knitted stockings with different compression forces [18]. The degree of compression determines the pressure applied to the ankle, which is measured in millimeters of mercury (mmHg) and is divided into 4 levels of compression: (Table 2).

1. First degree - used in the initial stage of varicose veins, with slight venous dilation and early signs of venous insufficiency. This can be identified by pain, weakness, periodic numbness and swelling, and the appearance of capillary vessels. Such products can be used for preventive purposes.

2. Second degree - used to narrow and strengthen dilated veins, preventing fluid accumulation in muscles. It can only be used with a doctor's prescription.

3. Third degree - such product has a strong effect on blood vessels. Used for chronic severe venous insufficiency, persistent edema, and before and after vascular surgery.

4. Fourth degree - used for the treatment of elephantiasis, deep vein thrombosis, and lymphatic flow disorders. Can only be recommended by a doctor [19].

(2-table)

COMPRESSION DEGREES

AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|

Compression class refers to the level of pressure in the ankle area of the leg; as the class increases, the pressure also increases.		
0 class (Preventative)	**I class**	**II class**
18 mmHg scarce	**18 - 21 mmHg**	**23 - 32 mmHg**
When heaviness and fatigue occur in the legs, accompanied by slight swelling. This is suitable for people prone to venous diseases, those who sit or stand for long periods at work, have excess weight, or experience a feeling of heaviness in their legs.	*During the early signs of varicose veins, when there is a tendency for leg contraction and swelling, and during pregnancy;*	*For varicose veins, in complex post-operative therapy, and for the prevention of thrombosis.*
III class	**IV class**	Reanimatory
34 - 46 mmHg	**49 < mmHg**	**18, 23 va 35 mmHg**
In cases of varicose veins with trophic disorders and lymphatic swelling, blood vessel thrombosis, and following vein surgeries.	*It is prepared on order and recommended for congenital diseases, severe and complex venous diseases, and lymphedema.*	*For the prevention of thrombosis during pregnancy and childbirth, as well as before, during, and after surgical procedures.*

Typically, compression knitted products (such as elastic bandages, stockings, arm sleeves, and others) are manufactured worldwide, including in Asian countries, in accordance with medical standards. However, each region adheres to its own specific regulations and rules [20].

(3-table)

NATIONAL STANDARDS					
STANDARDS	0 class mmHg	1 class mmHg	2 class mmHg	3 class mmHg	4 class mmHg
Russia ГОСТ Р 58236-2020	Dan kichik<18	18-21	22-32	33-46	47< greater than
Britain	-	14-17	18-24	25-35	-
Germany (Ral Gz 387)	-	18-21	23-32	34-46	49< greater than
France	-	10-15	15-20	20-36	36< greater than

Europe	-	15-21	23-32	34-46	49< greater than
America	-	15-20	20-30	30-40	-

For compression knitwear to perform its function and provide assistance, it must fit the leg and body measurements properly. To use compression knitted socks or knee-high stockings, it is necessary to take accurate foot measurements. This helps ensure comfortable wear and maximum effectiveness of the garment. The measurements can be taken as follows: (Table 4)

• The circumference at the narrowest point of the calf: measured above the ankle. (B)

• The circumference at the widest point of the calf: usually the middle of the calf. (C)

• Knee circumference: measured just below the knee. (D)

• Thigh circumference: measured 10 cm above the kneecap. (F)

• Length for knee-high stockings: from heel to knee. (AD)

• For stockings and pantyhose: from heel to waist (AG) (AH)

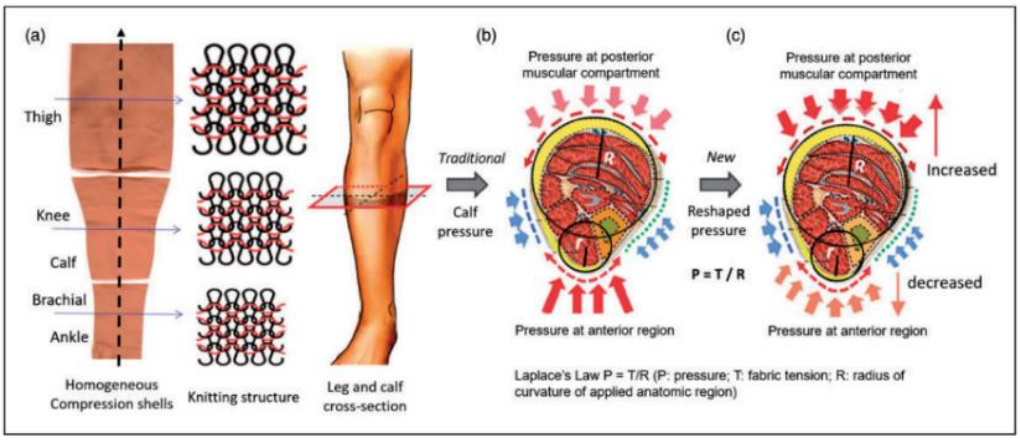
It is advisable to take measurements in the morning when the feet are not yet swollen, as during the day, especially after standing or sitting for long periods, the feet may swell, leading to inaccurate measurements. Swelling is minimal in the morning after sleep, allowing for the most precise measurements.

The correct size of compression garments is not just about comfort, but a guarantee of effective treatment and prevention of venous diseases. Excessively tight clothing can lead to circulatory disorders, while overly loose clothing fails to provide the necessary therapeutic effect. Compression garments should be comfortable to wear. A correctly chosen size reduces the risk of skin redness, discomfort, and other unpleasant sensations. Size charts provided by compression garment manufacturers serve as a unique "passport" for each product. They indicate the exact measurements necessary for selecting the optimal size.

Traditional compression stockings have a uniform fabric structure, which leads to uneven pressure distribution during use due to the geometric shape of the leg, causing side effects and discomfort. Compression socks have been knitted for specific areas of the leg using hybrid fabrics with special compositions as additional material (Fig. 4). The results were evaluated using in vivo and in vitro indicators. The experiment showed that pressure distribution in the in vivo indicators was uniform and achieved the desired result, while in the in vitro indicator, i.e., on the wooden model, these indicators had an adverse effect. Taking this into account, new heterogeneous compression socks with hybrid elastic properties, using

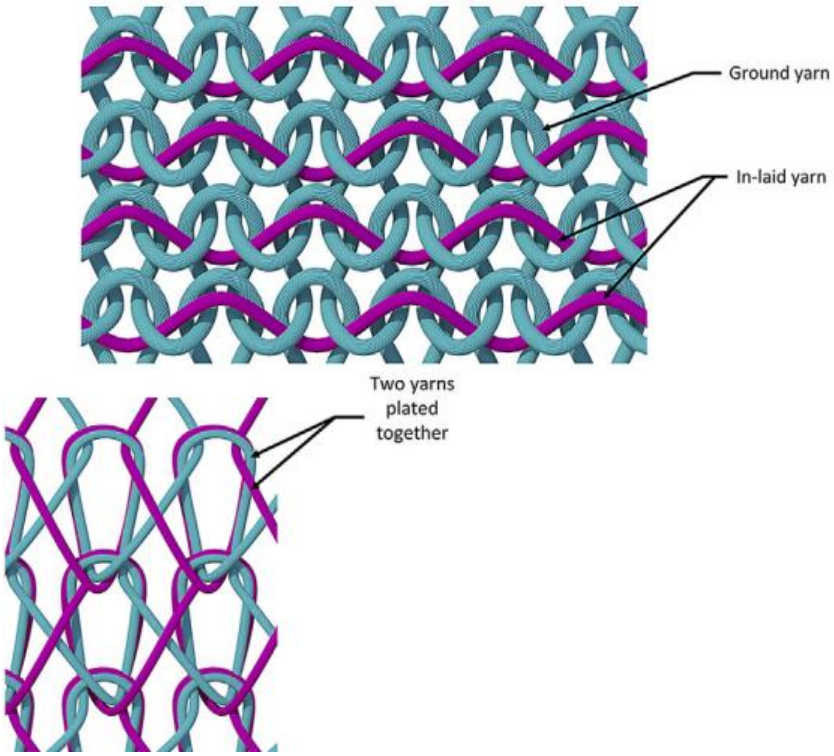
AMERICAN JOURNAL OF EDUCATION AND LEARNING
ISSN: 2996-5128 (online) | ResearchBib (IF) = 9.918 IMPACT FACTOR
Volume-3| Issue-5| 2025 Published: |30-05-2025|

advanced three-dimensional seamless knitting technology and a unique structural design, increase their effectiveness compared to conventional compression socks when used.



4-fig. Hybrid knitted fabrics.

If we introduce a new type of knitted fabric composed of a combination of woven and knitted structures into the composition of compression stockings, it will allow for better pressure control in compression hosiery (Fig. 5).



5-fig: Specially formulated hybrid fabrics.

To achieve this, we can employ a method of integrating additional filling threads into the structure of knitted fabrics, which will improve the functional properties of mixed-structure fabrics. The main component is made from a nylon-spandex blend. The following basic knitted structures were examined: single jersey,

single pique, 1 × 1 mock rib, and 2 × 2 mock rib, both with and without additional filling threads. Analysis revealed that compression stockings composed of single jersey, single pique, 1 × 1 mock rib, and 2 × 2 mock rib structures yielded the highest positive results.

1. https://www.databridgemarketresearch.com/reports/global-compression-garments-stockings-market?srsltid=AfmBOorAdYvFn3f2gXJOvht5GnLOTwm5xXkg33PBKjdCDaREVqhji_zA
2. https://www.cognitivemarketresearch.com/medical-compression-garments-market-report?srsltid=AfmBOooqQ4OY0B13_D1TnSaOSE4T1MtpjxiCNB2EH-uBDRxpPC6Kdsa-
3. https://www.futuremarketreport.com/ru/industry-report/compression-garments-market
4. https://textileexpo.uz/uz/yangiliklar/toqimachilik-sanoatini-rivojlantirish-boyicha-chora-tadbirlar-muhokama-qilindi
5. https://president.uz/oz/pages/view/strategy?menu_id=144
6. Perrey, S. Compression Garments: Evidence for their Physiological Effect. Eng. Sports 2008, 2, 319–328.
7. Czajka, R. Development of Medical Textile Market. Fibres Text. East. Eur. 2005, 13, 13–15
8. Daniel Rabe, Hugo Partsch, Gerhard Heidl, Mirko Hirschl, Michael K undi, Eberhard RabeFelizitas Pannier, Compression treatment in acute symptomatic proximal deep venous thrombosis – Results of a worldwide survey https://doi.org/10.1177/02683555211003
9. O‘zbekiston Respublikasi Prezidentining 2023-yil 10-yanvardagi PF-2-sonli Farmoni — “Paxta-to‘qimachilik klasterlari faoliyatini qo‘llab-quvvatlash, to‘qimachilik va tikuv-trikotaj sanoatini tubdan isloh qilish hamda sohaning eksport salohiyatini yanada oshirish chora-tadbirlari to‘g‘risida”.
10. Tikuv-trikotaj sanoatini rivojlantirishga oid maqsadli dasturlar 2023-yil, UZA. https://uza.uz/uz/
11. Paxtachilik va to‘qimachilik rivoji uchun yangi imkoniyatlar belgilandi 28.06.2022 president.uz
12. Sau-Fun, N.; Chi-Leung, H.; Lai-Fan,W. Development of medical garments and apparel for the elderly and the disabled. Text. Prog. 2011, 43, 247–252. [CrossRef]

13. Troynikov, O.; Ashayeri, E. 3D body scanning method for close-fitting garments in sport and medical applications. In HFESA 47th Annual Conference; Ergonomics Australia—Special Edition; Crows: Crows Nest, Australia, 2011; pp. 1–6.

14. Saggers, M. Inflatable Garment for Intermittent Compression Therapy. U.S. Patent No. US4722332A, 2 February 2021.

15. Duffield, R.; Portus, M. Comparison of Three Types of Full-body Compression Garments on Throwing and Repeat-sprint Performance in Cricket Players. Br. J. Sports Med. 2007, 41, 409–414. [CrossRef] [PubMed]

16. Gupta, D. Functional clothing–definition and classification. Indian J. Fiber Text. Res. 2011, 36, 321–326.

17. Kowalski, K.; Mielicka, E.; Kowalski, T.M. Modelling and Designing Compression Garments with Unit Pressure Assumed for Body Circumferences of a Variable Curvature Radius. Fibres Text. East. Eur. 2012, 20, 98–102.

18. Morrison, T. American Classification of Compression Stockings. Available online: https://www.tagungsmanagement.org/icc/images/stories/PDF/morrison_american_classification.pdf (accessed on 22 May 2024).

19. https://baldinelli.ua/ua/articles/kompresijnyj-trykotazh-koryst-vydy-jak-vybraty

20. Clark, M.; Krimmel, G. Lymphoedema and the construction and classification of compression. In Lymphoedema Framework. Template for Practice: Compression Hosiery in Lymphoedema; MEP Ltd.: London, UK, 2006; pp. 2–4.