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INTEGRATED ANALYSIS OF THE EFFICACY AND FUNCTIONAL BENEFITS OF COMPRESSION-BASED TREATMENTS FOR CHRONIC VENOUS INSUFFICIENCY

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Abstract

This comprehensive thesis provides an in-depth analysis of compression therapy products used in the treatment of varicose veins and chronic venous insufficiency. The research employs a systematic literature review methodology to evaluate the multifaceted benefits of these medical textiles, focusing on their biomechanical properties, material composition, and clinical effectiveness. The study reveals that the therapeutic value of compression garments is directly determined by their engineering characteristics, including compression class specifications, elastic properties, and durability parameters. Our findings demonstrate that optimal patient outcomes are achieved through precise matching of product specifications with individual pathological requirements. The thesis also explores future directions in smart textile technology and personalized treatment approaches, offering valuable insights for clinicians, researchers, and medical textile manufacturers working in vascular health management.

Keywords: compression therapy, chronic venous insufficiency, medical textiles, vascular disorders, biomechanical engineering, material science, patient compliance, therapeutic efficacy, smart textiles.

Varicose veins and chronic venous insufficiency represent significant healthcare challenges affecting millions worldwide, with substantial impact on quality of life and healthcare economics. Compression therapy has emerged as the cornerstone of conservative management, employing mechanically engineered garments to provide graduated external pressure that counteracts venous hypertension. This thesis undertakes a comprehensive examination of compression treatment products, investigating how their design parameters and material properties translate into

clinical benefits. The research addresses critical gaps in understanding the relationship between textile engineering and therapeutic outcomes, providing evidence-based recommendations for product selection and development. By synthesizing current scientific knowledge, this work aims to establish a framework for optimizing compression therapy in clinical practice while identifying promising avenues for technological innovation [1].

This research employed a systematic multidisciplinary approach to investigate compression therapy products:

Comprehensive analysis of peer-reviewed publications, clinical guidelines, and technical standards from medical, textile engineering, and biomechanical perspectives.

Technical Evaluation Parameters:

- Compression classification systems (European and international standards)
- Material composition analysis (natural/synthetic fiber ratios, elastane content)
- Biomechanical testing data (tensile strength, elasticity metrics, recovery properties)
- Performance durability studies (wash resistance, shape retention, pressure maintenance)

Clinical Outcome Assessment:

- Efficacy evaluation through hemodynamic parameters
- Patient compliance and comfort studies
- Long-term therapeutic effectiveness data

Data Synthesis Methodology:

- Comparative analysis across product categories
- Correlation establishment between technical specifications and clinical outcomes
- Identification of optimal parameter ranges for different pathological conditions

The research yielded significant insights across multiple dimensions:

The established classification system (Classes I-IV) provides crucial guidance for therapeutic targeting. Our analysis demonstrates that each compression level serves specific clinical indications, from mild preventive care (15-21 mmHg) to severe

pathological conditions requiring >49 mmHg pressure. This stratification enables precise intervention matching, particularly important given that inappropriate compression selection can lead to either therapeutic failure or vascular compromise [2].

The investigation revealed complex relationships between material composition and functional performance:

- ❖ High-density polyamide structures provide exceptional mechanical durability and shape maintenance but require elastane integration for adequate elasticity
- ❖ Cotton content (optimally ≥50%) proves essential for moisture management and cutaneous health, significantly reducing dermatological complications
- ❖ Advanced knitting technologies, particularly seamless construction, enhance comfort while maintaining therapeutic pressure gradients

The classification of compression products by elongation properties (short: ≤70%, medium: ≤140%, long: >140%) determines their specific therapeutic mechanisms:

- ❖ Short-stretch systems excel in active therapy through high working pressure generation during muscle contraction
- ❖ Long-stretch products provide consistent compression suitable for continuous wear and patient self-management
- ❖ The stiffness index (pressure increase per unit extension) emerges as a critical parameter influencing hemodynamic efficacy

High-quality compression products maintain functional integrity through approximately 30-50 wash cycles, representing significant economic advantages through extended usability while ensuring consistent therapeutic pressure application. This durability aspect is particularly crucial for chronic conditions requiring long-term management [3-4].

Modern compression therapy incorporates ergonomic design principles that enhance:

- ❖ Wearability and comfort through anatomical shaping
- ❖ Ease of application through innovative closure systems
- ❖ Cosmetic acceptability through contemporary design approaches

These factors collectively improve treatment adherence and overall therapeutic success.

Conclusion. This thesis establishes that compression therapy products offer a sophisticated, effective, and economically viable approach to venous disorder management. Their benefits extend beyond simple mechanical compression to encompass multiple therapeutic dimensions:

Clinical Efficacy: Proven effectiveness in symptom reduction, edema management, and ulcer healing through biomechanically optimized pressure delivery.

Patient Safety: Enhanced through material biocompatibility, graduated compression physiology, and appropriate product classification systems.

Long-term Value: Durability and maintenance of therapeutic properties ensure cost-effective management of chronic conditions.

User-centered Design: Modern manufacturing approaches prioritize patient comfort and adherence without compromising therapeutic effectiveness.

Future development should focus on several promising areas:

- ❖ Integration of smart textile technologies for pressure monitoring and compliance tracking
- ❖ Development of personalized compression solutions based on individual anatomical and hemodynamic parameters
- ❖ Advancement of sustainable materials maintaining therapeutic efficacy while reducing environmental impact
- ❖ Enhanced comfort engineering for improved long-term wearability

The optimal implementation of compression therapy requires collaborative efforts between clinicians, engineers, and patients to ensure appropriate product selection and usage. This multidisciplinary approach will continue to drive innovations that improve outcomes in venous disease management while expanding treatment accessibility and effectiveness.

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