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SEVERAL TYPES OF SOFTWARE AND HARDWARE SYSTEMS THAT SUPPORT AND ASSIST BODY MOVEMENT IN THE TEXTILE INDUSTRY

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Abstract: *The textile industry involves repetitive tasks, prolonged standing, and heavy lifting, leading to fatigue and muscle strain. Modern technologies now use integrated software and hardware systems to support body movement and reduce physical workload. This study analyzes several assist systems-such as passive, powered, chairless, upper-limb, and back-support systems-for textile manufacturing. Results show that passive and chairless systems are best for prolonged standing, while powered and back-support systems reduce strain during lifting. These findings help select appropriate solutions to improve safety and efficiency in textile production.*

Annotatsiya: *To‘qimachilik sanoatida takrorlanuvchi harakatlar, uzoq vaqt tik turish va og‘ir yuk ko‘tarish charchoq va mushak-skelet tizimining zo‘riqishiga olib keladi. Zamonaviy texnologiyalar tana harakatini qo‘llab-quvvatlovchi dasturiy va apparat tizimlarini joriy qilmoqda. Ushbu tadqiqot passiv, motorli, stulsiz, yuqori oyoq va belni qo‘llab-quvvatlovchi tizimlarni tahlil qiladi. Natijalar shuni ko‘rsatadiki, passiv va stulsiz tizimlar uzoq vaqt tik turishda, motorli va belni qo‘llab-quvvatlovchi tizimlar esa yuk ko‘tarishda samarali. Ushbu xulosalar to‘qimachilik ishlab chiqarishida xavfsizlik va samaradorlikni oshirish uchun mos yechimlarni tanlashga yordam beradi.*

Аннотация: *Текстильная промышленность связана с повторяющимися операциями, длительным стоянием и подъёмом тяжестей, что приводит к усталости и нагрузке на опорно-двигательный аппарат. Современные технологии внедряют программно-аппаратные системы для поддержки движений тела и снижения физической нагрузки. В данном исследовании анализируются пассивные, моторизированные, безстульевые системы, а также системы поддержки верхних конечностей и спины. Результаты показывают, что пассивные и безстульевые системы наиболее эффективны при длительном стоянии, а моторизированные и системы поддержки спины снижают нагрузку при подъёме тяжестей. Эти выводы помогают выбрать подходящие решения для повышения безопасности и эффективности текстильного производства.*

Keywords: *wearable support system, human movement assistance, textile industry, industrial automation, worker safety, software and hardware integration.*

Tayanch so‘zlar: *taqiladigan qo‘llab-quvvatlash tizimi, inson harakatiga yordam berish, to‘qimachilik sanoati, sanoatni avtomatlashtirish, ishchi xavfsizligi, dastur va apparat integratsiyasi.*

Ключевые слова: *носимая система поддержки, поддержка движений человека, текстильная промышленность, промышленная автоматизация, безопасность работника, программно-аппаратная интеграция.*

Introduction. The textile industry remains one of the most labor-intensive manufacturing sectors, requiring workers to perform repetitive movements, maintain static postures, and handle materials for extended periods [1-4]. These working conditions often lead to fatigue, reduced productivity, and an increased risk of work-related musculoskeletal disorders. In many textile factories, employees spend long hours standing at sewing machines, cutting tables, sorting stations, and packaging lines, which places continuous stress on the human body.

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Recent advances in industrial engineering and wearable technology have introduced new categories of systems designed to support and assist human body movement [1-4]. These solutions consist of integrated software and hardware components that enhance physical performance, stabilize posture, and reduce biomechanical load during manual work. Such systems typically include mechanical support frames, sensors, control units, and ergonomic design features that interact with human motion [5].

The objective of this study is to identify and analyze several types of software and hardware systems that support and assist body movement in textile industry operations. The research focuses on evaluating their structural characteristics, operational functions, ergonomic benefits, and application suitability for different textile production processes.

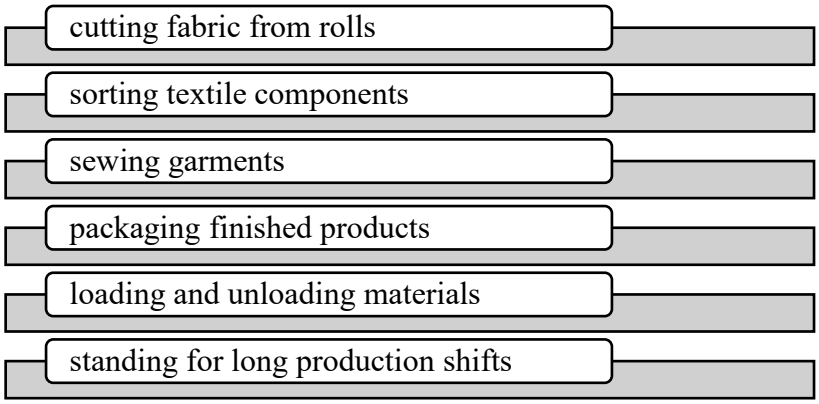


Figure 1. Main operations in a textile industry

Methods. This research employed a qualitative engineering analysis and system classification approach to evaluate movement-support technologies for textile industry applications [5].

When textile production activities were analyzed to determine physical workload and ergonomic risk factors, fabric cutting, sewing and assembly, material storing, manual lifting and transportation as well as prolonged standing work have become as six main types which are evaluated based on some obvious factors such as body posture, repetition frequency, load magnitude, working duration, physical fatigue risk. The analysis provided a foundation for identifying appropriate support technologies for each operation.

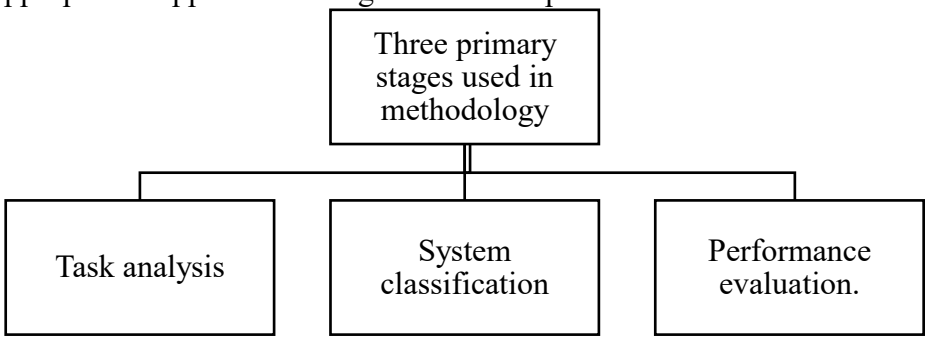


Figure 2. Three main stages used in the methodology

If we take energy source, structural complexity, level of physical assistance as well as mobility characteristics and industrial compatibility as the main classification criteria, following software and hardware systems that assist body movement are categorized into five main types according to mechanical design and functional capability.

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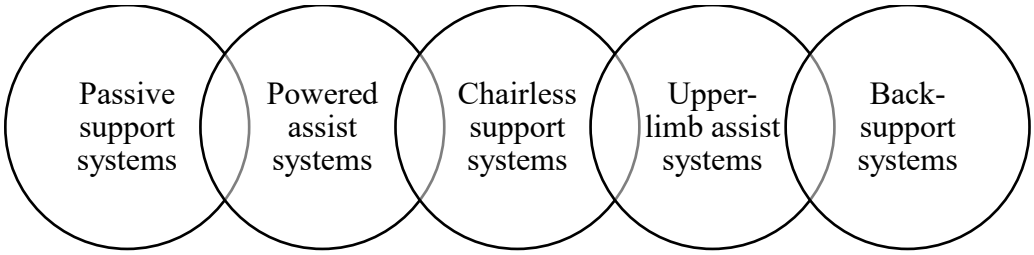


Figure 3. Five main classifications of movement-support systems

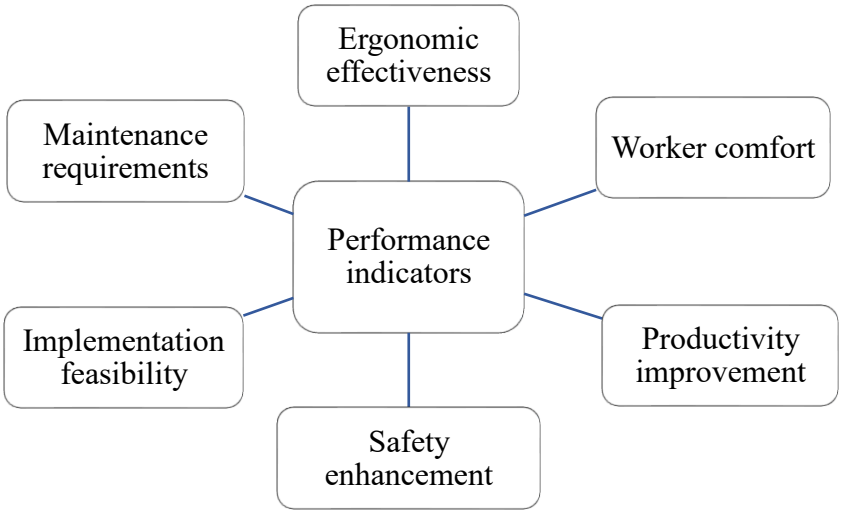


Figure 4. Performance indicators used in evaluation

The evaluation was based on engineering functionality and documented industrial usage patterns. To evaluate the effectiveness of software and hardware systems that support and assist body movement, biomechanical load reduction was estimated using standard mechanical and ergonomic relationships. These models quantify the physical forces acting on workers during textile production tasks.

Weight force acting on the human body

$$F = mg$$

where: F - weight force acting on the body (N) ; m - mass of the worker or load (kg); g - gravitational acceleration (9.81 m/s²)

This equation is used to determine the total load acting on the worker during standing or lifting operations in textile production environments.

Mechanical assistance force provided by the support system

$$F_{assist} = kx$$

where F_{assist} – support force generated by the system; k – stiffness coefficient of the mechanical component; x – displacement of the support element

This model represents the behavior of springs or elastic components commonly used in passive support systems [2-4].

Reduction in Muscular load

$$R = \frac{F_{load} - F_{assist}}{F_{load}} \times 100\%$$

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where: R - percentage reduction in muscular load; F_{load} - original physical load; F_{assist} - support force provided

This equation quantifies ergonomic improvement achieved by the system.

Results. The analysis identified five major categories of software and hardware systems that effectively support and assist body movement in textile manufacturing environments.

Table 1

Major categories of software and hardware systems in textile manufacturing environments

Type	Definition and suitable environments	Applications in Textile Industry	Key Benefits
Passive Support Systems	Operate without external power sources and rely on mechanical components such as springs, dampers, or elastic structures to assist human motion [2-4]. These systems provide continuous physical support while maintaining simplicity and reliability.	- Fabric cutting stations - Sewing operations - Sorting and inspection tasks - Repetitive manual workstations	- Lightweight construction - Low maintenance requirements - Reduced muscle fatigue - Cost-effective implementation
Powered Assist Systems	Use electric motors, sensors, and control algorithms to enhance human strength and reduce physical effort during demanding tasks [3]. These systems actively respond to user movement and provide additional mechanical force when required. These systems are most effective in environments involving frequent lifting and material transport.	- Warehouse operations - Heavy material handling - Fabric roll transportation - Loading and unloading processes	- Increased lifting capability - Reduced physical strain - Improved operational efficiency - Enhanced workplace safety
Chairless Support Systems	Allow workers to maintain a seated posture without using a traditional chair. These systems support body weight while enabling mobility and stability during prolonged standing tasks [1]. Chairless support systems are particularly valuable in production lines where workers remain in fixed positions for extended periods.	- Sewing machine operations - Assembly line production - Fabric inspection stations - Quality control processes	- Reduced leg fatigue - Improved posture stability - Increased worker comfort - Enhanced productivity
Upper-Limb Assist Systems	Designed to support the arms and shoulders during repetitive or elevated work [6]. These systems reduce muscle strain and improve endurance [6,7] in tasks requiring continuous arm movement.	- Hanging garments - Sorting textile components - Repetitive arm movements - Packaging operations	- Reduced shoulder fatigue - Improved task precision - Increased working endurance

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			- Lower risk of repetitive strain injuries
Back-Support Systems	Back-support systems provide structural assistance to the lower spine and torso during lifting and bending activities. These systems help maintain proper posture and reduce mechanical stress on the back muscles [4].	- Lifting textile bundles - Transporting storage containers - Manual material handling - Warehouse operations	- Reduced lower back strain - Improved lifting posture - Enhanced worker safety - Decreased risk of injury

Discussion. The findings indicate that software and hardware systems designed to support and assist body movement provide significant ergonomic and operational advantages [1-5] in textile manufacturing environments. Each system category offers specific functional benefits depending on the physical demands of the task.

Passive and chairless support systems demonstrate strong potential for improving comfort and reducing fatigue in stationary work environments such as sewing and inspection stations. Their mechanical simplicity and low cost make them suitable for widespread adoption in textile factories.

Powered assist and back-support systems play a critical role in reducing physical stress during heavy lifting and material handling operations. These systems contribute to improved worker safety and reduced injury risk in logistics and warehouse environments.

Upper-limb assist systems are particularly effective in tasks involving repetitive arm movement, such as sorting and packaging operations. By reducing muscular load, these systems improve productivity and reduce long-term health risks.

The integration of such systems represents an important step toward modernizing textile manufacturing and improving occupational [5].

Conclusion. This study identified and analyzed several types of software and hardware systems that support and assist body movement in textile industry operations. The results demonstrate that passive, powered, chairless, upper-limb, and back-support systems provide measurable ergonomic and productivity benefits across different stages of textile manufacturing.

Passive and chairless support systems are most suitable for prolonged standing and repetitive work, while powered assist and back-support systems are better suited for heavy material handling tasks. The implementation of these technologies can significantly reduce worker fatigue, improve safety, and enhance overall production efficiency.

Future research should focus on:

- Experimental validation in textile production environments
- Development of lightweight system designs
- Integration with automated manufacturing systems
- Cost-effectiveness analysis for industrial deployment

The adoption of advanced software and hardware systems that support human body movement represents a critical advancement in sustainable and efficient textile manufacturing.

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