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Designing a Denim Shirt for Persons with Upper Limbs Locomotor Disabilities

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Abstract

Life quality improvement issue is an international interest, especially for persons with upper limbs locomotor disabilities. Functional clothing designed for people with disabilities aims to enhance health recovery, improve lifestyle, fulfill personal expectations, enable them to lead dignified and comfortable lives, and facilitate their integration into both family and society. Research methods in this field focus on document synthesis, motion limitation analysis, and design enhancement. When studying to design collar-buttoned down and long-sleeve shirts for men with limited upper extremity mobility, design solutions need to focus on improving the functionality of the garment. This ensures that people with disabilities can independently put on and take off their clothes without requiring external assistance. One solution is the use of magnetic buttons, which enable wearers to easily fasten buttons, which takes less time and does not require dexterity or the hand muscles strength. Besides, the choice of denim material would improve moisture comfort; while, the shirt was constructed with ventilation at the back yoke and armpits, as well as splits along the sleeves to enhance the movement comfort. The functional male shirt presented in this study meets the needs of people with limited upper limb disabilities by improving their quality of life and promoting health rehabilitation.

Keywords: Denim, functional design, locomotor disabilities, shirt, 3D virtual.

1. Introduction

Disability is an umbrella term encompassing activity limitations and participation restrictions, reflecting the negative aspects of an individual's interaction with external factors. People with disabilities include those with physical, mental, intellectual, or sensory impairments, as well as other barriers that hinder their full and effective participation in society on an equal basis with others [1]. According to the World Health Organization, over 1 billion individuals, representing approximately 15% of the global population live with a disability. Vietnam is among the countries with a high prevalence of people with disabilities. Various factors contribute to this situation, with major causes including diseases, the aftermath of war, and public health challenges during the country's development, such as accidents and injuries, particularly traffic accidents, as well as mental health issues [1]. Presently, Vietnam has approximately seven million people with disabilities, accounting for over 7.06% of the population aged two years and older. Statistics from the General Statistics Office and the 2016 - 2017 National Survey on People with Disabilities conducted by UNICEF indicate that the number of individuals with upper body motor disabilities, such as difficulty in lifting objects weighing 2 kg from waist to eye level or in using fingers to grasp small objects, reaches 2,158,988 people [2].

A 2019 survey conducted by the disability charity Leonard Cheshire revealed that 75% of disabled individuals felt their clothing needs were not being met, while 96% believed the fashion industry did not adequately address their specific requirements. This neglect stems from the diverse conditions associated with disability, including congenital impairments, accidents, and disease-related disabilities [3]. Significant disparities exist between individuals with physical disabilities and those without, particularly in daily life experiences. Due to these differences, people with physical disabilities often exhibit distinct psychological characteristics. To maintain a sense of normalcy and social identity, many individuals with limb disabilities rely on prosthetics and clothing that conceal these devices, enabling them to integrate more seamlessly into society. For individuals with limb disabilities, beyond functional aid to compensate for physical limitations, comfortable and aesthetically pleasing clothing plays a crucial role in fostering psychological well-being and self-confidence, ultimately facilitating social inclusion. However, the availability of specialized clothing for people with disabilities remains significantly limited in both domestic and international markets, with very few garments specifically designed for this demographic [3]. Therefore, there is an urgent need to prioritize research on clothing design tailored for individuals with limited mobility.

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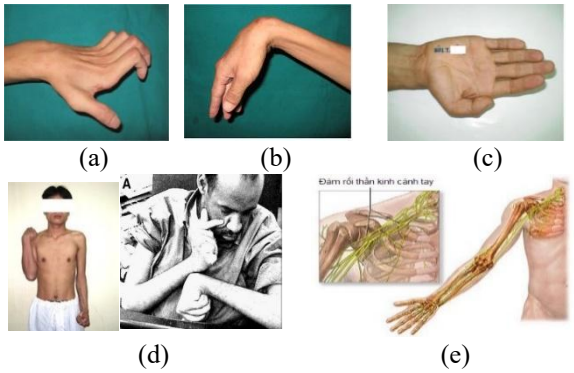


Fig. 1. Upper limb mobility restrictions with nerve damage

This study focuses on analyzing upper limb mobility impairments to develop appropriate shirt designs for men facing such challenges. Motor disabilities result from structural and functional abnormalities in the musculoskeletal, skeletal, and nervous systems, leading to movement restrictions that differ from those of the general population. These disabilities may be congenital or acquired throughout life and can exist independently or in conjunction with other forms of disability [1]. Common types of motor disabilities, including upper limb mobility impairments, are summarized and illustrated in Fig. 1 [4, 5].

When the ulnar nerve is damaged, symptoms include atrophy of the interosseous muscles of the hand and deformity of the first knuckle of the fingers, leading to a loss of finger extension and thumb closure, resulting in ulnar claw hand or monkey hand deformity (Fig. 1a). Radial nerve palsy manifests as muscle atrophy in the posterior forearm, causing wrist and finger drop, commonly known as a 'wrist drop' deformity (Fig. 1b). Median nerve damage results in the loss of thumb, index, and middle finger flexion, along with impaired thumb opposition (Fig. 1c). Muscular paralysis leads to atrophy of the anterior arm muscles, resulting in an inability to flex the elbow (Fig. 1d). Brachial plexus injury presents with a tingling or burning sensation along the arm, numbness, and muscle weakness. In severe cases, mobility in the shoulder, arm, and hand may be significantly impaired (Fig. 1e) [5].

Denim shirts and jeans have long been associated with a strong and confident male image across all age groups. Denim shirts, in particular, serve as a versatile wardrobe staple, offering ease of layering and styling [6]. In contemporary fashion, denim products play a crucial role in sustainability, as recent innovations focus on fabric recycling and repurposing old denim garments to promote environmental conservation [7]. Traditional denim shirts often feature metal buttons, which pose significant challenges for individuals with limited upper limb mobility. Therefore, this study aims to analyze upper limb mobility limitations and develop improved denim shirt designs that accommodate the needs of individuals with upper limb disabilities, enabling them to dress independently. Addressing this issue through innovative fashion design has the potential to enhance the quality of life for wearers and foster greater inclusivity in the fashion industry.

2. Research Methodology

2.1. Surveying Interests for Adaptive Apparel among Individuals with Upper-Limb Disabilities

To systematically identify user priorities in adaptive clothing design, a structured questionnaire-based survey was conducted with 23 individuals who have limited upper-limb mobility and were recruited from disability support centers in Northern Vietnam. The questionnaire comprised two parts. The first section collected demographic and physical information, including age, gender, and the degree of upper-limb mobility limitation. The second section used a five-point Likert scale (1 means not important, 5 means extremely important) to assess the perceived importance of five predefined design criteria: functionality, comfort, material quality, aesthetic appeal, and cost. Respondents also provided optional open-ended comments to elaborate on their preferences. Descriptive statistical analysis was applied to calculate frequency and percentage distributions for each criterion.

2.2. Material Selection Oriented toward Sustainability

In line with sustainable development goals, selecting appropriate materials plays a crucial role in reducing the environmental footprint of fashion production. A review of global fashion sustainability data was conducted to identify suitable textiles. The United Nations has identified the fashion industry as the second-largest global polluter, accounting for approximately 8% of total carbon emissions and 20% of wastewater production [8]. A key strategy involves repurposing waste materials as secondary raw resources to eliminate waste. One such effort has led to the mechanical extraction of recycled cotton fiber from discarded denim scraps. These fibers are then blended with virgin cotton to produce recycled cotton yarns in varying proportions [9].

Table 1. Fabric specifications

Fabric name	CAPE E
Components	95% Cotton, 5% Recyled Cotton
Weaving type	3×1 twill
Fabric Weight before washing	8.75 oz
Fabric Weight after washing	9.5 oz
Fabric Width	58 inch
Dyes	Indigo dye
Color	Icon blue
Shrinkage after washing	Warp Yarn: 9.3% Weft Yarn: 15.2%

Based on this review and alignment with current trends forecasted by the World's Global Style Network (WGSN) for 2025 [10], denim containing recycled cotton fibers was selected. For this study, CAPE E denim fabric, composed of 95% cotton and 5% recycled cotton, was chosen. The fabric offers durability, moisture absorption, and comfort while contributing to sustainable production. Its specifications, including weaving type, weight, width, shrinkage after washing, and color properties, are presented in Table 1.

2.3. Movement Restriction Analysis and Design Solutions Mapping for Upper-Limb Adaptive Shirts

An ergonomic analysis was conducted to map upper-limb mobility limitations to dressing difficulties and corresponding garment design needs. This included a literature review on musculoskeletal limitations [4, 5] and integration of user-reported dressing challenges from the survey. Each type of joint limitation (shoulder rotation deficit, elbow contracture, wrist flexion, clenched fist, thumb-in-palm deformity, and muscle atrophy) was examined in relation to ease of dressing, comfort, hygiene, and independence. Observational data and ergonomic guidelines were used to define functional garment features.

3. Results and Discussion

3.1. User Priorities in Adaptive Clothing Design

The proportional distribution of responses is presented in Fig. 2. Results indicated that functionality received the highest priority, encompassing ease of dressing, fastening, and unrestricted movement. Comfort ranked second, emphasizing proper fit, flexibility, and ventilation. Material quality followed, focusing on breathability, durability, and ease of care. Aesthetic appeal, reflecting preferences for fashionable and stylish garments, was next, and cost was identified as an important factor influencing purchasing decisions.

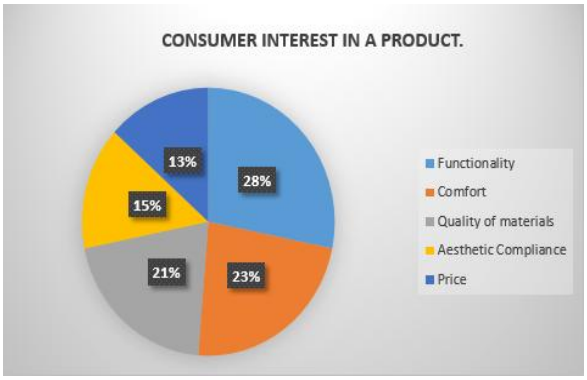


Fig. 2. Consumer interest in product design

The findings of this survey align closely with previously reported principles for designing clothing for people with disabilities. Earlier studies have emphasized that garments for individuals with physical limitations should integrate practicality and aesthetic appeal with comfort, ease of wearing and maintenance, durability, washability, and affordability [8]. These design priorities correspond well with the present survey, in which functionality and comfort emerged as the two most important criteria. The participants in this study consistently valued ease of dressing, fastening, and movement, confirming that practical usability remains fundamental. Comfort, including proper fit, flexibility, and ventilation, was also strongly emphasized, echoing earlier recommendations to consider the wearer's body shape, size, and degree of mobility limitation when designing adaptive apparel.

Overall, the results support the importance of integrating ergonomics, anthropometry, and garment technology into the design process, as suggested in the literature [8], while also revealing the specific weight that end users assign to each factor within their local and social context.

3.2. Design Solutions for Upper-Limb Adaptive Shirts

Designing adaptive apparel for individuals with upper-limb disabilities requires a systematic analysis of movement restrictions in order to translate functional limitations into clear design criteria. Understanding how joint deformities and reduced mobility affect daily dressing activities enables the development of garments that improve independence, safety, and comfort while maintaining aesthetic appeal. This section presents an analytical approach combining ergonomic evaluation, user-centered input, and material selection to establish comprehensive recommendations for adaptive shirt design.

3.2.1. Movement restriction analysis and product design recommendations

The mobility limitations of the upper limb are analyzed to establish specific design requirements as following:

- Shoulder rotation deficit: Shoulder rotation limitations result in the arm being fixed against the chest wall. The elbows are typically bent, and the shoulders rotate inward, with the hands and forearms resting on the chest. This condition leads to shoulder stiffness and restricted movement [4]. Limited shoulder mobility causes the armpit to remain closed, potentially leading to skin darkening, peeling, and unpleasant odors. Additionally, lifting and lowering the arm becomes difficult, making hygiene and dressing challenging. Consequently, garments should incorporate ventilated openings in the back, shoulders, and armpit areas. Moreover, antibacterial and deodorizing fabric treatments are ideal.

- Elbow Curvature: Individuals with persistently bent elbows experience painful muscle contractions and stiffness [4]. This condition can lead to deformities, contractures, and skin folds in the elbows and neck. Difficulty in extending the elbow makes wearing long-sleeved garments challenging. Therefore,

long-sleeved shirts should be designed with improved sleeve openings to allow easy dressing without requiring the wearer to pass their hands through the sleeves.

- Wrist Flexion: Wrist flexion results in a bent, often inwardly or outwardly deviated wrist. It is frequently associated with clenched hand deformity. While most wrist deformities involve flexion, excessive extensor deformities can worsen grip difficulties due to finger flexor tendon involvement [4]. A bent wrist position complicates dressing, particularly fastening buttons. Thus, shirt designs should emphasize ease of opening and closure without reliance on finger dexterity.

- Clenched Fist: This condition involves fingers curling into the palm or thumb deformity within the palm, reducing grip efficiency [4]. The ability to grasp, manipulate, and release objects depends on finger and thumb control.

- Palm-Fitting Thumb: This condition occurs when the thumb is pulled into the palm and cannot extend during grasping movements, limiting its ability to support other fingers [4]. Grip function is impaired due to thumb extension restrictions and gaps forming before grasping objects.

- Muscle Atrophy: Muscle atrophy leads to reduced muscle mass and strength, resulting in hand weakness, tremors, and prolonged immobility, making it difficult to hold objects [4, 5].

Conditions such as clenched hands, thumb articulation into the palm, and muscle atrophy severely limit grip function. Therefore, shirts should be designed with accessible openings and fastenings that do not require fine motor skills.

3.2.2. Discussion and proposed design criteria

When designing shirts for individuals with limited upper limb mobility, it is essential to prioritize ease of opening and closing. These users often rely on residual arm movements rather than fine motor skills. For example, magnetic buttons are preferable to traditional buttons and fasteners, as they enable automatic closure without requiring finger dexterity. By utilizing magnetic buttons, wearers can fasten their shirts using only forearm movement, rather than engaging the upper arm, thus enhancing their independence in dressing. Therefore, integrating magnetic buttons into the shirt design is a key criterion for improving usability and convenience for individuals with upper limb mobility impairments.

For individuals with elbow contractures, shirts with short-sleeved may offer greater convenience; however, long-sleeved shirts remain an essential component of men's wardrobes. When designing long-sleeved shirts for individuals with limited upper limb mobility, incorporating an extended slit along the sleeves is crucial. This design allows for easier dressing while also improving ventilation around the elbows and armpits. Additionally, incorporating openings in the back of the shirt can further enhance airflow and help mitigate odor-related concerns.

Material selection is vital to support mobility and comfort for individuals with upper-limb disabilities. Durable, elastic fabrics facilitate joint movement and adapt to the wearer's needs. To enhance functionality, materials should offer antibacterial properties, moisture control, warmth retention, and long-term durability. Because specialized functional textiles are often more expensive than conventional fabrics, affordability must also be considered to ensure accessibility of adaptive clothing.

Dressing difficulties arising from upper limb impairments extend beyond functionality; clothing design should also contribute to body enhancement and confidence-building. While adaptive clothing must address functional challenges, it should seamlessly blend into mainstream fashion rather than visibly stand out as a specialized design. An effective design should discreetly integrate functional features while maintaining aesthetic appeal.

Based on these discussions, the following design criteria are proposed.

Functional Design Criteria

Ease of Opening and Closing Fastenings: To improve shirt usability for individuals with limited upper-limb mobility, traditional buttons should be replaced with magnetic fasteners to simplify opening and closing and support those with restricted wrist and elbow movement. Magnetic fasteners on sleeve openings also benefit users with thumb deformities, wrist contractures, or tremors. In addition, extended sleeve openings with velcro closures help individuals with weak hands and limited shoulder mobility insert their arms more easily, promoting greater independence in dressing.

Long-Sleeve Comfort and Flexibility: Individuals with elbow contractures often struggle to put on sleeves because of restricted mobility. As shoulder joints also have limited rotation when lifting and lowering the arms, shirts should be designed with flat sleeve structures and fitted with magnetic fasteners to make dressing easier and more comfortable.

Deodorizing and Antibacterial Properties: Shoulder stiffness can increase the risk of skin problems such as bruising, peeling, and unpleasant odors in the armpit area; therefore, fabrics with deodorizing properties should be used, and ventilation features should be incorporated into the armpit design, with options like laser-cut perforations or structured openings with adjustable closures to further improve breathability.

Enhanced Elbow Mobility: Elbow contractures cause skin folds and tightness, so sleeves should include openings up to the elbow with detachable joints secured

by velcro tape or magnetic buttons to improve flexibility and comfort.

Material Selection Criteria

Materials should provide breathability and moisture absorption, with ventilation features at the armpit, elbow, and back to improve comfort and hygiene. They must be durable to resist tension and movement, and include elastic components to enhance flexibility. Wrinkle-resistant fabrics, such as denim with inherent crease recovery, help maintain garment appearance. Sustainability should also be addressed by using eco-friendly options like cotton blends with recycled fibers to support sustainable fashion goals.

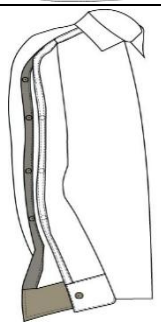
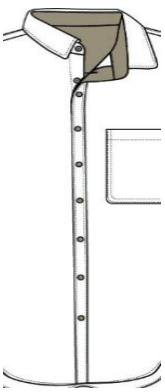
Aesthetic Criteria

Adaptive shirts should maintain the traditional aesthetics of standard denim shirts, ensuring they blend seamlessly into mainstream fashion. This includes retaining classic denim color tones and wash finishes. Additionally, finishing techniques such as garment washing and softening treatments should be applied to enhance comfort and preserve the stylish appearance of denim shirts.

3.2.3. The outline of design solutions

Following an in-depth analysis of upper limb mobility restrictions, product requirements, and proposed design criteria, this study developed a series of design solutions for each functional component of the garment. These solutions are summarized in Table 2 below.

Table 2. Design solution sketches

Identified Mobility Challenges	***Proposed Design Features***	***Proposed Design Features and Functional Benefits***
1. Increase ventilation needs due to shoulder joint restrictions and muscle atrophy 2. Increase ventilation at the back yoke close to armhole area		- Leave the back yoke partially open while adding facing for aesthetic appeal - Enhance airflow, reduce heat buildup, and improve overall comfort.
3. Difficulty inserting or removing hands due to restricted elbow and wrist mobility. 4. Limited ability to lift and lower the shoulder and arm joints 5. Limit finger and wrist movement when opening and closing sleeves		- Add a slit from the shoulder tip extending 6 cm along the arm. - Use magnetic buttons instead of traditional sleeve fastenings. - Lengthen and widen sleeves to ease elbow movement. - Simplify sleeve closures for reduced hand dexterity.
6. Reduced finger and wrist mobility, making front fastenings dificult to manage		- Integrate magnetic buttons along the front torso placket - Allows for effortless opening and closing, reducing reliance on fine motor skills

3.3. Final Design and Fabrication of the Adaptive Shirt for Individuals with Upper-Limb Disabilities

3.3.1. Product description and measurements

After analyzing the product requirements and developing proposed design solutions, the authors completed the design of an adaptive shirt tailored for an adult male with limited upper-limb mobility. Its product description and measurements are presented in Fig. 3 and Table 3.

Table 3. Sample specification sheet

Position of Measurement Description	***POM ID***	***Measurement (cm)***
Placket width	A	3
Placket length	B	63.11
Chest pocket opening	C	12
Chest pocket length	D	16
Chest width	E	58.76
Collar stand width	F	3.3
Sleeve overlap width	G	3
Sleeve cuff	H	6
Sleeve opening width	I	12
Back yoke length	J	11
Back shoulder width	K	51.06
Shoulder length	L	17.5
Back body length	M	82
Sleeve length	N	62

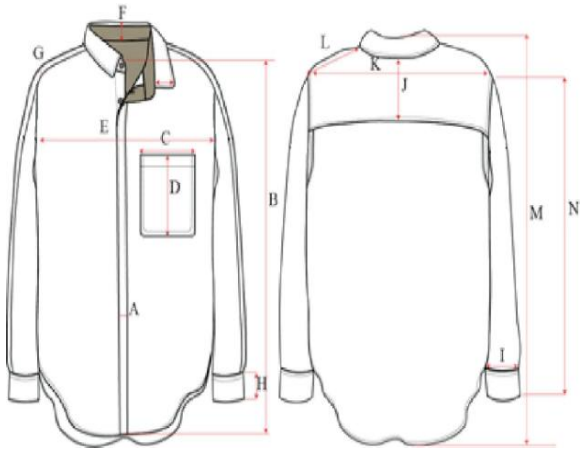


Fig. 3. Product flat Sketch

The shirt features a front with two symmetrical panels; the plackets contain concealed magnetic buttons within the tabs and decorative metal buttons on the right side. A single patch breast pocket is placed on the left front panel, finished with two lines of topstitching and reinforced with bar tacks at both sides of the pocket opening for security and decoration. The back includes a lower back panel and a back yoke, with the lower panel reshaped to integrate two ventilated openings near the armpits and just below the yoke. The collar follows a standard shirt construction with a collar stand and main collar. The sleeves consist of front and back sections with an extended tab along their length, designed to cover hidden magnetic buttons and enhance ease of use.

3.3.2. Designed patterns, 3D simulated try-on 3D, and actual product

After analyzing the characteristics of adaptive clothing, reviewing recommendations, and proposing design solutions for denim shirts suitable for individuals with limited upper limb mobility, the author utilized Optitex software and Winnie Aldrich's pattern drafting method to develop the product model, as illustrated in Fig. 4. The number of pattern components is detailed in Table 4. The shirt features a total of 17 magnetic buttons, including 9 for the front placket and collar stand and 4 for each sleeve. Additionally, since denim shirts are traditionally characterized by metal buttons, the research team incorporated 10 decorative shank buttons on the outer layer to create the appearance of a traditional metal button placket and sleeve cuffs.

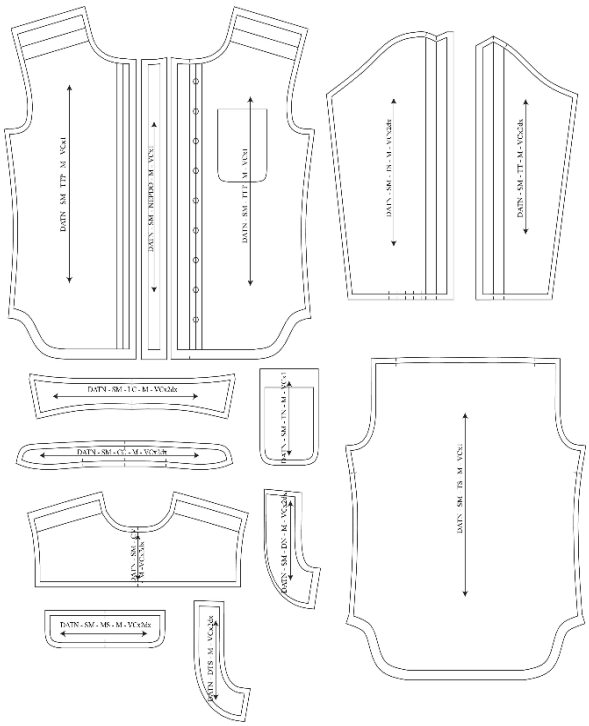


Fig. 4. Pattern pieces of the denim shirt

Table 4. List of pattern pieces quantity and material for the sample product

Position	*No.*	*Part name*	*Material*	*Quantity*
Collar	1	Collar	Main Fabric	2
	2	Collar stand	Main Fabric	2
	3	Collar interlining	Mex, nonwoven	1
	4	Collar stand interlining	Mex, nonwoven	1
Sleeve	5	Back sleeve	Main Fabric	2
	6	Front sleeve	Main Fabric	2
	7	Sleeve cuffs	Main Fabric	4
	8	Sleeve cuffs interlining	Mex, nonwoven	2
Back body	9	Back yoke	Main Fabric	2
	10	Back panel	Main Fabric	1
	11	Armhole facing	Main Fabric	2
	12	Back facing	Main Fabric	2
Front body	13	Chest pocket	Main Fabric	1
	14	Left front panel	Main Fabric	1
	15	Right front panel	Main Fabric	1
	16	Placket	Main Fabric	1
Button	17	Decorative shank buttons (r=10mm)	Metal, bronze color	10
	18	Magnetic buttons (r=10mm)	Metal, bronze color	17
Thread	19	TEX80	Orange, 43328	
	20	TEX60	Orange, 32001	

Subsequently, the virtual assembly of the product was performed using CLO3D, as shown in Fig. 5. A virtual fitting simulation was conducted, followed by the construction of the actual garment using denim fabric, as depicted in Fig. 6.

Fig. 5. Virtual product in Clo3D software

Fig. 6. Actual product is made by denim fabric before washing

3.4. Product Washing Treatment and Recipes

To enhance both the aesthetic and tactile properties of denim garments while aligning with sustainable production practices, specific washing treatments and standardized recipes are employed. These methods aim to achieve desired color effects, surface texture, and fabric softness through controlled wet-processing techniques that minimize environmental impact. Among various approaches, enzyme washing has emerged as a preferred alternative due to its eco-friendly nature, reduced chemical usage, and lower risk of fabric degradation compared to traditional methods. The following sections detail the enzymatic washing method, its procedural steps, and the applied treatment recipe for the product under investigation.

3.4.1. Enzyme washing method

For darker shades, the enzyme washing method is preferred, as it is one of the most environmentally friendly and safe wet-processing techniques. Additionally, to uphold sustainability objectives, only enzyme washing is applied to achieve the desired color effect without the use of bleaching agents. Excessive chemical detergent washes can destabilize the surface structure of denim fabric, reducing its durability.

Enzyme washing is an eco-friendly textile treatment method. Enzymes act as biological catalysts that accelerate biochemical reactions, breaking down cellulose in cotton, also referred to as "bio-stoning". This

method was first introduced in Europe in 1989. Enzymatic washing facilitates the controlled degradation of cellulose in cotton fibers, increasing fabric abrasion during processing. It is most effective at a pH level of 6 - 7 and a temperature range of 50 °C - 60 °C. The key effects of enzyme washing include enhancing fabric softness, fading the original fabric color, and removing surface fibers, thereby improving texture and appearance [11].

3.4.2. Enzyme washing process

The washing sequence includes pool agitation, enzyme wash, rinsing, softening, spinning, and drying. Enzymatic washing offers a sustainable alternative to traditional stone washing by reducing cellulose damage, water use, processing time, waste generation, and machinery wear [11]. To create a natural distressed look, body grinding is combined with targeted potassium permanganate (PP) sprays on areas prone to wear, including the breast pocket to waist zone, front and back shoulder bridges, rear back yoke, and elbows. This approach enhances the authentic aged denim effect while supporting an environmentally friendly finishing process.

3.4.3. Washing recipe for the product

To optimize fabric performance while minimizing environmental impact, the washing procedure was carefully designed to preserve the structural integrity, softness, and durability of the adaptive shirt. The detailed recipe is as follows:

Step 1: Shake the pool: Water temperature: 50 °C,
Time: 10 minutes

Step 2: Enzymatic washing: Water temperature: 50 °C, Time: 30 minutes

Step 3: Rinse: Room temperature, 3 minutes

Step 4: Soften and Citric acid treatment with room temperature, 10 minutes

Step 5: Spin drying: 8 minutes

Step 6: Final drying: Temperature: 70 °C,
Time: 30 minutes

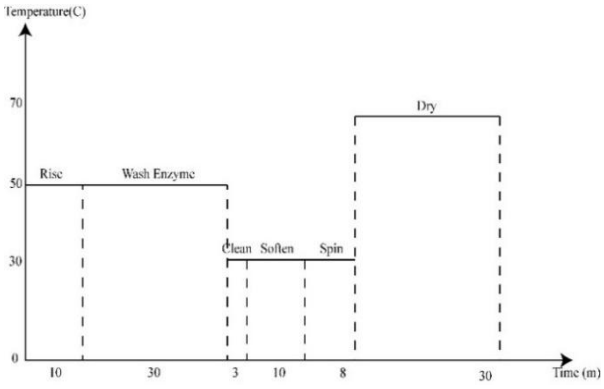


Fig. 7. Washing recipe for shirts

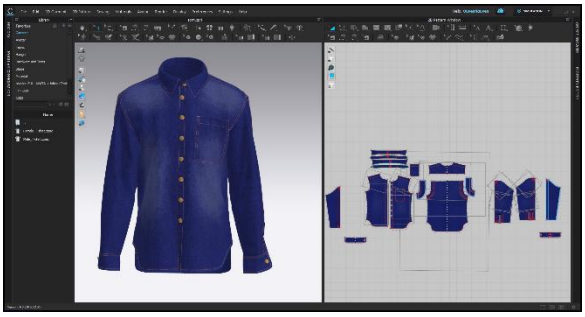


Fig. 8. Sketch Washing Goals on Clo3D

Fig. 9. Finished product after washing

Before proceeding with the actual sample washing, the washing effects were digitally simulated using Clo3D software, as shown in Fig. 8. The final prototype after washing treatment is presented in Fig. 9.

4. Conclusions

Developing adaptive clothing for men with upper-limb restrictions remains a critical challenge that requires more extensive and systematic scientific research. This study contributes to addressing this need by providing several key findings. First, it establishes the priority order of design criteria for adaptive shirts: comfort, body fit, material selection, aesthetics, and product cost. Second, it confirms that denim fabric, with its durability, substantial thickness, and high moisture

absorption, is well suited for adaptive clothing applications. Third, it emphasizes the importance of fastening mechanisms, as users with limited upper-limb mobility often depend on residual arm movements; this factor was carefully considered and integrated into the proposed shirt design.

A limitation of the research is the absence of physical wear testing with individuals who have upper-limb disabilities, which should be addressed in future studies to validate and refine the proposed solutions. Nevertheless, the application of digital design tools such as Clo3D and Adobe Illustrator enhanced the efficiency and cost-effectiveness of the development process. The functional shirt design presented in this work responds to the specific needs of men with upper-limb mobility restrictions, offering practical solutions that may improve independence, comfort, and overall quality of life while supporting rehabilitation efforts.

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