engineering proceedings

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Proceeding Paper

A Holistic Approach on Smart Garment for Patients with Juvenile Idiopathic Arthritis †

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† Presented at the International Conference on Recent Advances on Science and Engineering, Dubai, United Arab Emirates, 4–5 October 2023.

Abstract: Juvenile Idiopathic Arthritis (JIA) is a widespread and chronic condition that affects children and adolescents worldwide. The person suffering from JIA is characterized by chronic joint inflammation leading to pain, swelling, stiffness, and limited body movements. Individuals suffering from JIA require ongoing treatment for their lifetime. Beyond inflammation, JIA patients have expressed concerns about various factors and the lack of responsive services addressing their challenges. The implementation of smart garments offers a promising solution to assist individuals with Juvenile Idiopathic Arthritis in performing their daily activities. These garments are designed to seamlessly integrate technology and clothing, providing not only physical support but also addressing the psychological and emotional aspects of living with a chronic condition. By incorporating sensors, these smart garments can monitor joint movement, detect inflammation, and provide real-time feedback to both patients and healthcare providers. To tackle these comprehensive challenges, the research aims to offer a solution through the design of a smart garment, created with a holistic approach. This smart garment is intended to improve the overall well-being of JIA patients by enhancing their mobility, comfort, and overall quality of life. The integration of technology into clothing can potentially revolutionize the way JIA is managed, allowing patients to better manage their condition and minimize its impact on their daily lives. The synergy between healthcare and technology holds great potential in addressing the multifaceted challenges posed by Juvenile Idiopathic Arthritis patients. Through innovation and empathy, this research aims to pave the way for a brighter future for individuals living with Juvenile Idiopathic Arthritis.

Keywords: juvenile idiopathic arthritis; patients; health care; holistic; smart garments

Citation: Safal, C.; Princy, R.; Sampath, K.J.P.; Prasad, H.C.S. A Holistic Approach on Smart Garment for Patients with Juvenile Idiopathic Arthritis. *Eng. Proc.* **2023**, *59*, 83. https://doi.org/10.3390/engproc2023059083

Academic Editors: Nithesh Naik, Rajiv Selvam, Pavan Hiremath, Suhas Kowshik CS and Ritesh Ramakrishna Bhat

Published: 20 December 2023

1. Introduction

In the medical landscape, Juvenile Idiopathic Arthritis (JIA) stands as the prevalent incurable rheumatic disease in children and a significant contributor to both short-term and long-term disability [1]. It is an incurable rheumatic disease of unknown origin, with a higher occurrence among young female patients [2]. The International League Against Rheumatism (ILAR) classifies JIA into seven separate and mutually exclusive groups, based on the observed disease characteristics during the initial 6 months of its emergence [3], the subtypes are depicted in Figure 1. JIA encompasses all forms of chronic childhood arthritis, affecting not only joints but also extra-articular structures, which can lead to disability and, in severe cases, even associated fatality [4]. As active JIA persists into adulthood, the cumulative effect leads to a higher degree of functional limitation and joint destruction. Nevertheless, some patients may encounter detrimental effects such as joint deformities,

destruction, growth abnormalities, and retardation, leading to pain, impaired psychological health, or challenges with daily activities [5].

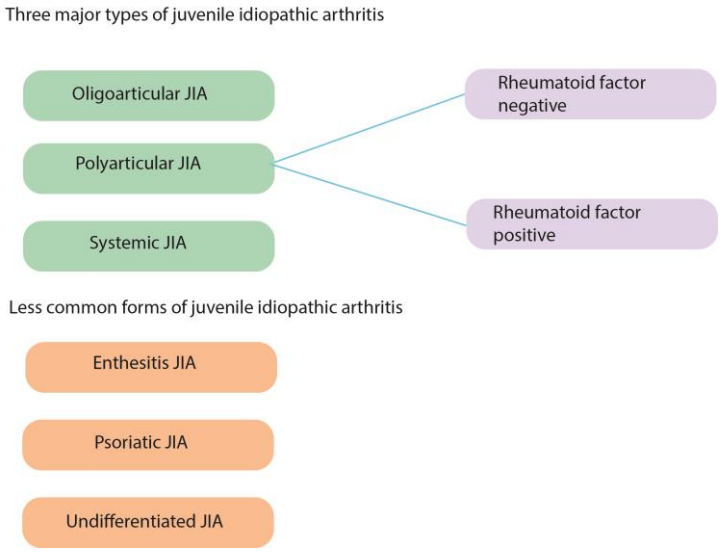

Figure 1. Types of Juvenile idiopathic arthritis.

The diagnosis is challenging as there are no specific tests to definitively confirm the condition [6]. Around 5% of children with JIA exhibit rheumatoid factor (RF)–positive arthritis, which closely resembles adult rheumatoid arthritis (RA) in its phenotype. Notably, the presence of rheumatoid factor persists throughout the patient's lifetime [7]. For patients who travel and live away from home for educational or work purposes, it can be particularly challenging. Activities that impact arthritic patients include running, cycling, dancing, traveling, climbing, dressing, skipping, engaging in physical games, lifting bags, writing, typing, opening jars and door knobs, as well as chopping food. Additionally, Arthritis sufferers may experience a detrimental effect on their sleep quality, and it is equally important to acknowledge that inadequate sleep can worsen pain levels and heighten stress levels [8]. The impact extends beyond inflammation, disrupting their daily routines and requiring more responsive services [9]. In light of this, the importance of smart garments to their needs cannot be overstated. A smart garment can be described as an intelligent system with the capability to sense and interact with the wearer's surroundings, conditions, and stimuli [10,11]. Smart garments possess the ability to remotely predict, prevent, and monitor chronic illnesses, thereby decreasing the necessity for hospital stays and empowering patients to maintain their independence [12]. Smart garments are specifically crafted to cater to health and containing various garments such as T-shirts [13–15], Bras [16–20], Sleeves [21–23], Jackets [24–26], Leggings [27–29], and more [30] with a focus on healthcare applications. Considering this, the importance of smart garments for JIA patient's needs cannot be emphasized enough. These essential resources play a crucial role in empowering patients with JIA to navigate their condition more effectively and maintain their independence, ensuring a better quality of life. This paper focuses on exploring the requirements of patients having JIA, especially within the framework of designing smart garments.

2. Objective

The main focus of this study is to elucidate the underlying complications of JIA and illustrate a smart garment for the upper bodice, with a primary goal of enhancing joint functionality for JIA patients through a holistic approach. Additionally, Research aims to raise awareness and promote further research and development in this crucial area of care, to ensure that patients with JIA have access to the resources they need to lead fulfilling lives.

3. Literature Review

Conducting research to establish design criteria for practical sports bras catering to young women affected by juvenile idiopathic arthritis, to help retailers and academia better understand their needs [31]. Adaptive clothing empowers women with rheumatoid arthritis, they can dress up independently and comfortably and still feel good about themselves, which increases self-confidence. In this study, the researcher devised the patterns of kurtas using pattern-making techniques [32]. The restricted joint functions of rheumatoid arthritis (RA) patients pose challenges in dressing, particularly with certain garments like sarees. In this study, alternative options are proposed for easier-to-drape sarees tailored to arthritis patients' needs [33]. Adaptive clothing research found special features to be highly practical, three sets of adaptive garments were designed for females with rheumatoid impairments, independence and self-confidence were assessed by wear trail test [34]. The study's main goal is to empower elderly long-term care patients with dressing independence by devising alternative fastener options for dresses [35]. This research addresses Rheumatoid arthritis, the proposed workflow concentrates on design requirements such as breathability, support in affected areas, lightweight design, and customization to alleviate individual pain points through a wearable glove solution [36]. A review assessed therapy gloves' effectiveness in hand function for RA patients, in this review grip strength, pinch strength, ROM and dexterity were selected as the outcome measures to check the effectiveness of therapy gloves [37]. The study introduces a Bluetooth-enabled glove that quantitatively assesses hand performance for rheumatoid arthritis patients, providing an alternative to subjective descriptions. Additionally, the glove is designed with rubber adjustable rings for a comfortable fit [38]. The study explores wrist orthotics typically crafted from Neoprene material, known for its resistance to abrasion, waterproof properties, and stretchability (see Table 1). These orthotics include five separate hook and close straps for secure fastening and a palmar side pocket to hold a metal bar, providing crucial wrist support [39].

Table 1. Studies related to arthritis garments and accessories.

Authors	Garment Type	Nature of Work	Type of Patient	Limitations
Mccoy (2021) [31].	Sports Bra	Developing sports bras for young arthritic women: Required features and functions. Easy joint movement (Adaptive garment).	Young adolescent girls, Juvenile Idiopathic arthritis.	The study does not incorporate smart technology to assist women in wearing sports bras for shoulder, neck, and back pain. Prototype and trial test was missing in the research.
Singh (2019) [32].	Kurta pattern design	A Study on Adaptive Clothing for Females with Arthritis (Adaptive garment).	Old women, Rheumatoid arthritis.	Limited geographical representation of participants. The research lacked a prototype and trial test.
Chandra, & Anand, (2016) [33].	Saree design	Adaptive clothing for Rheumatoid arthritis patients, Easy to drape saree.	Women, Type of JIA Rheumatoid arthritis.	Limited geographical representation of participants, the trial test was missing in research.
Azher (2012) [34].	Three set clothing	Adaptive clothing for rheumatoid impairment.	Women with Rheumatoid Impairment.	Only focused on ethnic wear. A limited demographic approach was used in the study.

Table 1. *Cont.*

Authors	Garment Type	Nature of Work	Type of Patient	Limitations
Sperling & Karlsson (1989) [35].	Clothing fastners	Clothing fasteners for long-term-care patients: Evaluation of standard closures and prototypes on test garments.	Both Elderly men and women, Osteoarthritis and Rheumatoid.	Small sample size, limited diversity.
Fang (2020) [36].	Glove	Responsive wearables for rheumatoid arthritis. Customization for individual pain point, support in affected area (Smart wearable).	Both men and women, Type of JIA Rheumatoid arthritis.	Wearing gloves in varying seasons is not feasible.
Nasir,(2014); Socher (2018) [37,38].	Smart Glove	Wearable Smart Glove Offering Custom Support for People with Rheumatoid Arthritis, monitor the hand movement and provide support.	Both men and women have rheumatoid arthritis.	Wearing gloves across various seasons is not viable
Underwood (2009) [39].	Glove	Smart clothing and disability: wearable technology for people with arthritis.	Both men and women have rheumatoid arthritis.	The glove lacks the capability to track hand activities and provide feedback to the patient and doctor.

4. Problem Statement

Despite the existence of general adaptive clothing options and smart glove options for arthritis, there is a lack of holistic solutions that cater to the unique needs of this demographic group. Patients with JIA currently face a scarcity of research and viable solutions for smart and therapeutic garments to support their condition.

5. Methodology

The methodology used is exploratory research, research is an attempt to discover something new and interesting and is considered the essence of high-quality research. Within exploratory research, exploratory studies can be categorized into two types: those that conduct initial analyses of fresh topics and those that propose innovative ideas or generate new hypotheses pertaining to established subjects [40]. By utilizing this method, the research aims to gain deeper insights, identify potential challenges, and explore novel solutions to address the garment requirements of individuals dealing with JIA. The combination of exploratory research and a holistic approach, the study endeavors to pave the way for innovative and patient-centered smart garment solutions. In the study, three stages were conducted, which involved a literature review, and semi-structured interviews with JIA patients to understand their garment requirements, Based on the findings, specific design elements and strategies for arthritis-targeted garments were proposed using Adobe Illustrator (depicted in Figure 2).

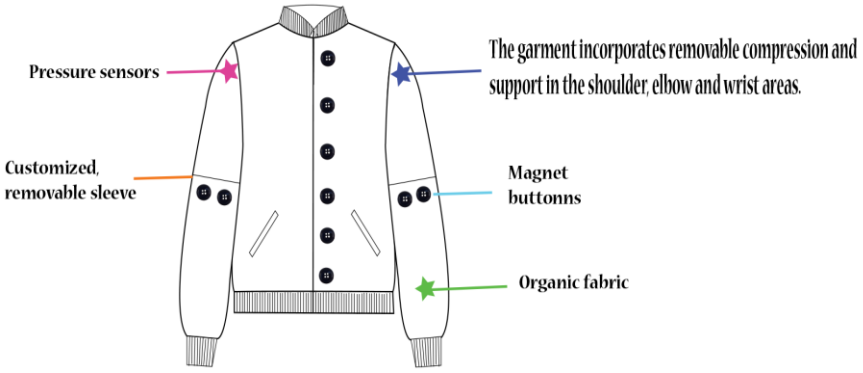

Figure 2. Proposed Smart street-wearable design of the upper garment for arthritic young women.

6. Observation and Interviews

After conducting surveys and observing juvenile idiopathic arthritis (JIA) patients, it became evident that their limited range of motion affects their elbow, wrist, shoulder, knee, and hip areas. Consequently, dressing and other essential activities cause additional suffering due to joint inflammation and stiffness. However, upon introducing the concept of smart garments to the arthritic patients and their parents, it was observed that they expressed a keen interest in adopting these new ideas to improve their health and functionality. The data was collected by utilizing a semi-structured interview with 13 arthritis patients.

7. Feasibility Analysis

The research takes a holistic approach with the aim of designing smart garments specifically designed for individuals with Juvenile Idiopathic Arthritis (JIA). This approach involves considering the various aspects and needs of individuals with JIA, beyond just the physical challenges they face. The approach addresses overall well-being, comfort, and fashion preferences. By acknowledging challenges beyond physical symptoms, including self-esteem, independence, health, and social inclusion, the smart garment aims to empower individuals with JIA. The garments feature easy dressing, gentle fabrics, adjustable closures, curative qualities, and aesthetically appealing designs to enhance daily life and promote a sense of normalcy and inclusivity, features of the upper garment elaborated in Table 2. and depicted in Figure 2. The holistic approach seeks to improve their quality of life, allowing confident participation in daily activities and social interactions.

Table 2. Key Features of the Smart street-wearable.

Sensor Integration	Adaptive Support	Interactive Interface	Connectivity	Organic
1. Incorporation of sensors to monitor joint movement and inflammation. 2. Real-time data collection and analysis for accurate insights. 3. Pressure sensors function similarly to a massaging action, offering alleviation from joint discomfort and stiffness.	1. Adjustable compression, magnet buttons, customization, removable sleeves, and support based on individual needs. 2. Enhances joint stability and reduces pain during movement.	1. User-friendly interface for patients to interact with the garment. 2. Visual feedback on joint mobility, inflammation levels, and usage patterns.	1. Wireless connectivity to smartphones or healthcare devices. 2. Allows seamless data sharing with healthcare providers for remote monitoring.	1. Utilization of organic fabric to enhance joint comfort for patients. 2. Contribution to sustainability through support for eco-friendly practices.

8. Conclusions

The research on requirement for smart garments for arthritic patients has shed light on the significant challenges faced by affected individuals. JIA's impact on joint inflammation, stiffness, and limited range of motion affects multiple joints, leading to difficulties in dressing and other essential activities causing additional suffering. Nevertheless, this research significantly contributes to gaining a deeper insight into the distinct needs of JIA patients and designing illustrations that consider their specific requirements. The smart garment will offer relief from JIA's joint pain, stiffness, and limited mobility through pressure sensors. Its interactive features empower patients with real-time data, enhancing control, reducing anxiety, and fostering positive social engagement for improved well-being. As we progress towards developing a prototype in the future, the integration and adoption of smart garments bring forth a promising prospect for enhancing the lives of these individuals, fostering a future characterized by enhanced functionality, and overall well-being.

Limitations: While the research has provided valuable insights into the challenges faced by individuals with JIA, there are certain limitations to be acknowledged. The study lacked prototype development and trial tests, limited sample size and duration to collect data may influence the generalizability of the findings.

Future Scope: As medical and technological advancements continue, there is potential for further research and innovation in the development of smart garment solutions for individuals with JIA. The integration of advanced materials, therapeutic features, and sensors can lead to more sophisticated garments that provide personalized support to patients.

Author Contributions: Conceptualization, C.S. and K.J.P.S.; collection of data, R.P.; statistical calculations, analysis, C.S.; corresponding author, typesetting, H.C.S.P. and K.J.P.S., formal analysis, C.S.; investigation, C.S.; resources, R.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Approved.

Informed Consent Statement: Not applicable.

Data Availability Statement: This is a conceptual paper hence no data is generated, once prototype is tested data will be provided.

Conflicts of Interest: The authors declare no conflict of interest.

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