

A Case Study on the Physical and Psychological Health Design Requirements of Postoperative Female Breast Cancer Patients

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Abstract

While existing rehabilitation products for breast cancer survivors primarily focus on compression therapy, they often neglect the integrated physical and psychological needs of patients, leaving a critical gap in holistic home-based care. Therefore, this study integrates Quality Function Deployment (QFD) and the Theory of Innovative Problem Solving (TRIZ) to systematically address this gap. Through a questionnaire survey and expert evaluation, patient requirements were gathered, prioritized, and translated into design specifications using QFD, while TRIZ was employed to resolve technical contradictions among them. Based on these findings, an exploratory rehabilitation apparel system is proposed that integrates an adaptive structure, functional materials, embedded hardware for physiological monitoring, and an interactive platform. Potential validation approaches are outlined to assess its safety, functionality, and practical implications in future research.

Keywords: Breast cancer; Apparel design; Health; Quality Function Deployment; Theory of Innovative Problem Solving

1 Introduction

Breast cancer is a prevalent disease among women, with approximately 300 000 new cases diagnosed annually in China [1]. Unfortunately, breast cancer treatment often involves procedures such as breast removal, hair loss, chronic pain from medication side effects, and negative psychological effects such as self-abasement, anxiety, and annoyance [2], thereby experiencing significant dual burdens. Following hospital discharge, patients typically require long-term rehabilitation care, which is predominantly conducted at home. In hospitals, treatment and nursing care for postoperative female breast cancer patients are highly professional. However, rehabilitation at home can be challenging due to the lack of proper guidance and devices for the disease. Currently, the most common method for postoperative female breast cancer patients to rehabilitate at home is compression therapy, which involves using either compression bandaging or compression apparel

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for breast cancer-related lymphedema [3]. Compression bandaging can cause bandage displacement during breast compression, impaired upper extremity function, and respiratory discomfort if compression is excessive [4]. Compression apparel avoids these issues but may not reduce lymphedema volume as effectively due to improper compression, and it is inconvenient for patients to put on and take off themselves [5]. It can be noted that while compression bandaging and compression apparel are often used for physical rehabilitation after breast cancer surgery, they have the aforementioned disadvantages and do not allow for smart control of compression, which can lead to reduced lymphedema volume [6]. Moreover, current compression therapy focuses solely on physical rehabilitation. Still, mental counseling is also important for postoperative breast cancer patients who often experience pressure and negative emotions when they return home after treatment due to a lack of professional support. While existing research has extensively explored the breast geometry of healthy populations to inform the design of foundational apparels such as sports bras and personalized bras [7-10], and has explored smart textiles for early breast cancer detection [11], there remains a significant gap in addressing the specific rehabilitation needs of postoperative female breast cancer patients. These patients require not only apparel that accommodates their altered anatomy but also integrated solutions for physical therapy and psychological support.

To address these challenges systematically, user requirements must be accurately translated into product design specifications. Quality Function Deployment (QFD) enables systematic translation of user requirements into design objectives through its House of Quality (HoQ) tool [12]. However, while QFD identifies contradictions among design requirements, it lacks tools for resolving them. The Theory of Inventive Problem Solving (TRIZ) provides systematic methodologies for generating innovative solutions by transforming negatively correlated requirements into technical contradictions and applying 40 Inventive Principles [13]. The integration of QFD and TRIZ ensures design directions align with user requirements while systematically addressing technical contradictions [14].

The integrated application of QFD and TRIZ has exhibited remarkable value in the design of rehabilitation assistive devices. Simarmata et al. [15] combined QFD, TRIZ, and AHP to develop 3D-printed insoles for flat-foot patients, optimizing the structural design via TRIZ to reduce plantar load and improve wearing comfort. Yu et al. [16] integrated improved QFD and TRIZ to design a hand spasticity assessment exoskeleton, thereby realizing the dual diagnosis-and-treatment functions of rehabilitation robots. Hung et al. [17] adopted the QFD-TRIZ integration method to optimize the design of general and Parkinson's disease-specific walkers, respectively, resolving design conflicts to elevate user satisfaction. Xi et al. [18] developed a QFD-TRIZ integrated model for wheelchair design for the elderly with disabilities, balancing user demand satisfaction and product technical feasibility. These studies collectively confirm that the QFD-TRIZ integration method effectively guides the innovative design of rehabilitation assistive devices to meet diverse user needs.

Despite this progress, research has focused mainly on motor impairments, offering limited guidance for products addressing the combined physical and psychological needs of postoperative female breast cancer patients. While notable work exists on general bra design for specific populations [19] and smart textiles for cancer detection [11], these studies do not address the complex design contradictions inherent in rehabilitation apparel that must simultaneously deliver therapeutic compression, monitor physiological data, and support mental well-being. Therefore, a research gap exists in the systematic design of rehabilitation apparel that addresses both the physical and psychological needs of postoperative breast cancer patients, particularly in resolving