Design and ergonomic evaluation of nursing clothing for disabled people with one side of body

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Abstract. In order to explore the relationship between the degree of nursing difficulty and the opening and closing modes of clothing, three style of clothing with different opening and closing modes were designed and its ergonomic performance was investigated with help of objective experimental data and subjective comfort evaluation. Experimental results showed that the opening and closing modes of nursing clothing could significantly affect the difficulty of nursing. And found the newly designed clothing (NO.2 and NO.3) had better ergonomic performance in clothing style and structure than the in-service one (NO.1*). In addition, fuzzy comprehensive evaluation method was applicable to ergonomic evaluation of clothing. Therefore, this finding is not only helpful to understand the effect of the opening and closing modes of clothing on nursing difficulty, but also provided reference for consumers in their decision making for buying clothes for disabled people with one side of their body.

1. Introduction
Recently, ergonomic evaluation and comfort performance of protective clothing for special protection or emergency rescue have been extensively investigated by numerous researchers [1-3]. And it's easy to found that these studies focus on normal people or people who freely move body [1-3]. However, there have been few studies published in the literature into ergonomic evaluation and comfort performance of nursing clothing for disabled people with one side of body. While clothing for disabled people with one side of body has special requirements and needs due to the human body [4-6]. The complexity of clothing development process and the difficulty of structure design were improved because of special requirements and needs, and thus leads to the market related to these people not well covered [4-6]. In addition, the consumer market for clothing is gradually increasing with the increase of number of disabled people with one side of body result from injury or illness [4,5]. Therefore, it is necessary to investigate the relationship between the degree of nursing difficulty and the opening and closing modes of clothing, with the help of subjective and objective evaluation experiment of nursing clothing with different opening and closing modes. The present study is thus concerned mainly with assessing related indicators of nursing difficulty. In addition, since there is no clear definition or boundary between comfort and discomfort, the fuzzy comprehensive evaluation method was used in this study. This finding provided effective guidance for consumers in their decision making for buying clothes for disabled people with one side of their body.
2. Experimental design and evaluation methods

2.1 Experimental sample
In order to explore the relationship between the degree of nursing difficulty and the opening and closing modes of clothing, three types of clothing with different opening and closing modes were designed and used as experimental samples for ergonomics evaluation. Sketch and detailed specifications of new design clothing with different opening and closing modes are listed in Figure 1. And three types of nursing clothing were numbered as NO.1*, NO.2, NO.3 (from left to right). In addition, in order to eliminate the influence of relaxation amount on nursing difficulty, the dimensions of each part of the three types of nursing clothing are all equal, but the opening and closing modes are different.

![Figure 1. Detailed specifications of new design clothing with different opening and closing modes.](image)

2.2 Experimental subject
Six elderly people (at the ages of 55-75 years) who were unable to move one side of their bodies because of illness or injury were used as the dressed subjects for the study of comfort performance and ergonomics evaluation of nursing clothing. Family members or caregivers who are primarily responsible for taking care of people who were unable to move one side of their bodies were invited to participate in an evaluation test. Before the evaluation tests, testing procedures, notices and implications of the subjective evaluation indexes, were introduced to all evaluation subjects. Moreover, six dressed subjects were asked to wear uniformed cotton underwear with short sleeves and trousers inside the experiment garments. Discussions among different subjects were not allowed.

2.3 Evaluation methods
In order to evaluate the ergonomic performance of the newly designed nursing clothing for disabled people with one side of their body, the multi-level joint evaluation method based on the fuzzy comprehensive theory was applied to evaluate ergonomic performance of nursing clothing for disabled people with one side of their body. In evaluation test, two grades factors were used in this study. The first grade factor sets included Nursing convenience level (NC) and Comfort and beauty (CB). And Nursing convenience level (NC) and Comfort and beauty (CB) were given 0.6 and 0.4 based on survey results, respectively. The second grade factors were Take-off time (X1), Number of nursing workers (X2), Sense of restraint (X3) and Aesthetic feeling (X4). Among these second evaluation indicators, X3 and X4 belongs to subjective evaluation indicators, comfort values were assessed using a five-level
subjective scale (numerical variables of subjective scale was 1, 2, 3, 4, 5). Additionally, it should be pointed out that the intensity increased from 1 to 5. Moreover, all second grade evaluation indicators were set the equal weight value (namely 0.25). Finally, the comfort evaluation maximum (M) and assessment evaluation formula of nursing clothing for disabled people with one side of body used in the evaluation tests were listed as follows:

\[
M_1 = 0.15 \quad 0.15 \quad 0.1 \quad 0.1 \\
M_2 = 0.15 \quad 0.15 \quad 0.1 \quad 0.1 \\
M_3 = 0.15 \quad 0.15 \quad 0.1 \quad 0.1
\]

Where M is comfort evaluation maximum, M1, M2, and M3 is weight set for clothing styles NO 1, 2, 3, respectively.

\[
P_n = \sum_n X_i/V_i Q_n
\]

Where P is evaluation value, n=1 or 2, X is the second evaluation factor, i=1, 2, 3, 4, V is weight value of the second grade factors, Q is the weight value of the first grade factors.

3. Result and discussion

The data on ergonomic evaluation value of the three types of nursing clothing for disabled people with one side of body were shown in Table 1. It can be noted that the Take-off time and Number of nursing workers of new designed clothing significantly reduced compared with the in-service patient clothing (NO.1*), indicating the nursing convenience level (NC) of the newly designed garments (NO.2 and NO.3) were improved compared with the in-service patient clothing (NO.1*) with normal open-and-close mode. This is because the newly designed clothing obviously reduced the nursing difficulty, the nursing time, the putting on and taking off difficulty, and thus the nursing convenience of new design clothing was friendly more than the in-service ones. In addition, with the help of the comfort evaluation maximum and assessment evaluation formula, the comprehensive ergonomic evaluation value of three types of nursing clothing were as follow: 93.43, 49.38 and 62.73. This suggests that the overall acceptance degree of the newly designed clothing was improved.

Table 1. Ergonomic evaluation value of nursing clothing for disabled people with one side of body.

| The first grade factors | The second grade factors | 1* | 2 | 3 |
|-------------------------|--------------------------|----|---|---|
| Nursing convenience level(NC) | Take-off time (X1) | 587 | 323 | 412 |
|                         | Number of nursing workers(X2) | 2 | 1 | 1 |
| Comfort and beauty (CB) | Sense of restraint(X3) | 4.67 | 3.83 | 3.92 |
|                         | Aesthetic feeling(X4) | 4.07 | 3.98 | 3.97 |

*is control sample, namely in-service patient clothing with normal open-and-close mode.

4. Conclusions

Experimental results showed that the opening and closing mode of nursing clothing for disabled people with one side of their body can significantly affect the difficulty of nursing. And it found that the newly designed clothing (NO.2 and NO.3) had better ergonomic performance in clothing style and structure than the in-service one (NO.1*). Moreover, results also showed that fuzzy comprehensive evaluation method accurately reflects the different influence level of the open-and-close mode on nursing difficulty, and thus is an effective method in the evaluation of the comfort performance of nursing clothing and other functional clothing to improve the comfort. In the future, more attention is paid to the clothing design and performance optimization of special groups, and corresponding criteria evaluation system should be established.

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