

헬스케어 재활훈련기 디자인 평가 요소 개발에 관한 연구

A Study of Evaluation Index Development of Healthcare Rehabilitation Device Design

조재상* · 권대규** · 홍정표***†

Jae Sang Cho* · Tae Kyu Kwon** · Jung Pyo Hong***†

*호원대학교 건축학과

*Department of Architecture, Howon University

**전북대학교 바이오메디컬 공학부

**Department of Biomedical Engineering, Chonbuk National University

***전북대학교 산업디자인과

***Department of Industrial Design, Chonbuk National University

Abstract

Due to the increase of the aged population and population of the disabled today, there is a growing demand for rehabilitation medical instruments. Furthermore, there is a growing demand for evaluation indices for services that should be provided for uses of the rehabilitation medical instruments. In order to evaluate rehabilitation medical instrument designs in this study, the basic index for design evaluations shall be identified to search for assessment plans. Through this, new evaluation indices will be deduced through discussions and analysis of rehabilitation medical experts, biomedical engineers, and designers. The results of this study are summarized as follows. First, the existing design evaluation indices were collected and analyzed to construct 10 rehabilitation medical instrument design evaluation indices and 44 sub-evaluation items. These will be important evaluation standards for designing rehabilitation medical instruments in the future. Second, the design evaluation indices that must be taken into consideration when developing health care rehabilitation medical instruments are the 10 design evaluation indices of usability, cognition, safety, learning, motility, durability, economic feasibility, space, aesthetics and environmental aspects. Third, design evaluation indices of environment, space, cognition, usability, economic feasibility and aesthetics are indices that must be taken into consideration for product design, while learning, safety, motility and durability are factors that must be given special consideration for rehabilitation medical instrument design evaluation indices. Fourth, if existing product design evaluation indices placed importance on environment, space, cognition, usability, economic feasibility and aesthetics of products for design evaluation indices, rehabilitation medical instrument design evaluation indices placed importance on learning, safety, motility and durability on top of usability and economic

* This work was supported by Ministry of Trade, Industry and Energy Republic of Korea (No. 10048880)

This work was supported by Ministry of Knowledge Economy (QoLT Technology Development, No. 10036494)

† 교신저자 : 홍정표 (전북대학교 산업디자인과)

E-mail: hongjp1@hanmail.net

TEL: 063-270-3758

FAX: 063-270-2237

feasibility, which are the differences between the design evaluation indices of rehabilitation medical instrument and other product designs. The 10 rehabilitation medical device design evaluation indices and 44 sub-evaluation items were carried out in this study. This research is only on the overall rehabilitation medical device design evaluation indices. In future research, the evaluation indices will be applied in the actual rehabilitation medical design device through production of prototypes, while making revisions and supplementations where necessary.

Key words: Healthcare Design, Medical Instrument Design, Rehabilitation Device Design, Design Evaluation, Rehabilitation Device Design Evaluation Index

요약

오늘날 고령인구의 증가와 장애인 인구의 증가로 인해 재활훈련기의 수요가 증가하고 있고, 재활훈련기와 사용자간의 제공받아야 할 서비스에 대한 평가 요소의 요구가 커지고 있다. 본 연구에서는 재활훈련기 디자인 평가에 있어서 평가 방안을 모색하기 위해 디자인 평가를 위한 기본 요소를 파악하고 이를 통하여 재활의료전문가, 의공학자, 디자이너들의 토의 및 분석, 실험을 통하여 새로운 평가 요소들을 도출하였다. 연구의 결과는 다음과 같이 요약된다. 첫째, 기존 디자인 평가 요소들을 수집, 분석하여 10가지의 재활훈련기 디자인 평가요소와 44개의 세부 평가항목을 구축하였다. 이는 앞으로 재활훈련기를 디자인하는데 있어서 중요한 평가 기준이 될 것이다. 둘째, 헬스케어 재활훈련기 디자인 개발 시 고려해야 할 디자인 평가요소로는 사용성, 인지성, 안전성, 학습성, 운동성, 내구성, 경제성, 공간성, 심미성, 환경성의 10가지 디자인 평가요소가 있다. 셋째, 환경성, 공간성, 인지성, 사용성, 경제성, 심미성의 디자인 평가요소는 제품디자인에서 공통적으로 고려해야 할 요소들이고, 학습성, 안전성, 운동성, 내구성의 요소는 재활훈련기 디자인 평가요소에서 매우 중요하게 고려해야 할 요소이다. 넷째, 재활훈련기 디자인 평가요소는 제품디자인요소에서 중요하게 고려되는 환경성, 공간성, 인지성, 사용성, 경제성, 심미성에 학습성, 안전성, 운동성, 내구성을 의 요소를 더해 중요하게 생각한 것이 기존 제품디자인 평가요소와 재활훈련기 디자인 평가요소의 차이점이다. 본 연구에서는 10개의 재활훈련기 디자인 평가요소와 44개의 세부 평가항목 구축에 대한 연구를 진행하였다. 이는 전체적인 재활훈련기 디자인 평가요소만을 연구한 것으로, 향후연구에서는 시 제품 제작을 통하여 평가요소들을 실제 재활훈련기 디자인에 적용해 보고, 미진한 점들을 수정 보완할 예정이다.

주제어: 헬스케어 디자인, 의료기 디자인, 재활훈련기 디자인, 디자인 평가, 재활훈련기 디자인 평가요소

1. 서론

1.1. 연구 배경 및 목적

오늘날 고령 인구의 증가와 장애인 인구의 증가로 인해 재활훈련기의 수요가 증가하고 있고, 재활훈련기와 사용자간의 제공받아야 할 서비스에 대한 평가 요소의 요구가 커지고 있다. 현재 일반적으로 통용되고 있는 디자인 평가요소는 제품에 대한 사용자의 접근과 효율성 등에 대한 일반적인 요소이다. 즉, 재활운동용 제품에 대한 디자인 평가 요소는 기존 제품에 대한 개념으로 접근하기에는 무리가 있다. 현재 가전

제품, 일상용품, 건축물, 웹사이트 등의 분야에서 디자인 평가 요소가 다양하게 이루어지고 있으나 재활훈련기 산업의 경우 그에 맞는 평가요소가 없어 보다 객관적이고 체계적인 디자인 평가가 이루어지지 못하고 있다. 또한, 재활훈련기 제품 개발 시 재활치료 전문가, 엔지니어, 디자이너 등의 협업이 중요시 되고 있지만, 그룹간의 관점 차이에서 의견의 충돌이 일어난다. 이러한 문제점을 해결할 수 있는 재활훈련기 디자인 평가요소의 개발이 필요하다.

따라서, 본 연구에서는 재활훈련기 디자인 평가에 있어서 평가 방안을 모색하기 위해 디자인 평가를 위한 기본 요소를 파악하고 이를 통하여 재활의료전문

2.1.2. 굿 디자인 평가 분석

제품 디자인 평가요소를 알아보기 위하여 세계 각국의 굿 디자인의 선정기준을 조사해 보았다. 분석해본 결과 굿 디자인의 선정 기준은 생산성과 재료와 자원의 효과적인 이용 측면, 소비자 입장에서 사용성의 편리성, 제품의 외관을 구성하는 형태, 색상 등의 요소가 전체적으로 얼마나 멋있고 아름다운지를 선별하는 심미성, 제품의 혁신적 요소 등이 굿 디자인 제품 평가에서 중요한 요소로 작용하고 있다.

Table 3. Evaluation Standards of Global Good Design Selection Programs

Good Design Selection Program	Evaluation Index
British Design Award	Product concept's design innovation, advantages of manufacturing, effective use of materials and resources, excellent exterior, human engineering characteristics, inclusion of user manual, ease of use and maintenance, excellent performance and sufficient reliability proven through user reports, excellent commercial performance, price
US Industrial Design Excellence Awards	Innovation of design concept, appropriate materials and economic production process, usefulness, benefits to clients, exterior that appeals to consumers, social influence (responsibilities for universal design environments)
Italy Compasso d'Oro	Appeal of exterior, aesthetics, creativity, innovation, new materials, use of appropriate materials, suitability to production, benefits of manufacturing, social suggestion
Sweden Utmarkt Svensk Form	Design, technology, function, quality
Finland Pro Finish Design Award	High quality and innovative thinking in product development, manufacturing and design
Norway Good Design Award	New ideas, economic feasibility by selecting superior materials, functionality for users, quality reflected in product and aesthetic harmony
Japan Selection of Good Design Products	Exterior, functions, quality, safety, others (manufacturing method and price), mass production, feasible price
Taiwan Good Design Products Selection	Creativity, functionality, practicality, economic feasibility, quality, exterior, marketability
Korea Good Design Products Selection	Exterior, function, safety, quality, economic feasibility, interaction, material, form, integrated design, quality, innovation, realistic possibility, environment-friendliness, aesthetics, universal design, new technology, marketability, practicality, expression, creativity
Korea PIN UP Design Awards	Product innovation, human-friendliness, aesthetic harmony, improvement of quality, sociability of values
Germany IF Designpreis	Usefulness in life, environmental protection, usefulness, safety, durability, human engineering consideration, creativity, harmony with surrounding environment, resource conservation and recycling, use, visualization of functions, high quality design, sensual and intellectual stimulation, etc
Germany Design Plus	Creativity of design concept, functionality, manipulation, safety, durability, continuity, consideration of environment, harmony of design and functions

Germany Design Innovation (Red Dot)	Innovation of design, functionality, human engineering consideration, ecological consideration
Singapore Singapore design Award	Innovation, productivity, marketability
Netherlands Good Industrial Design Award	Consideration of environmental aspect, functionality, safety, durability, human engineering consideration, exterior, uniqueness

2.2. 운동기구 디자인 평가요소

소라(2013)의 ‘청소년을 위한 스트레칭 운동 기구 디자인에 관한 연구에서는 운동기구 디자인의 평가요소로 접근성, 안전성, 조작성, 운동성, 경제성, 심미성의 6가지 요소를 다음과 같이 제시하였다.

Table 4. Design Index of Exercise Equipment

Design Evaluation Index	Definition
Accessibility	· Increased functions of exercise equipment seats · Two-sided accessibility
Safety	· Prevent injuries due to loss of upper-body balance · Safety of center of gravity of product
Manipulability	· Consideration of physical characteristics of users · Direct and easy to understand interface
Motility	· Increased exercise efficiency · Motivate to enhance motility
Economic Feasibility	· Self-based method not requiring outside power · Usability by various users
Aesthetics	· Flexible and refined design

2.3. 재활기구 디자인 평가요소

한국보건산업진흥원과 대구보건대학교(2011)에서 연구한 고령친화제품 사용성 평가 요소 개발에서는 안전성, 조작성, 만족도의 3가지 디자인 평가 요소를 가지고 보행 보조차, 목욕 의자, 수동 휠체어, 욕창 예방 매트리스, 전동 침대의 사용성을 평가 하였다.

2.4. 기타 디자인 평가요소

2.4.1. ISO/IEC Guide 71

Guide 17은 2011년 11월, 국제표준화기구(ISO)와 국

제전기표준회의(IEC)에 의한 제 71번째 가이드라인으로 발행된 규격이다. 제조자, 디자이너, 서비스 제공자 및 교육자와 같은 사람들에게 고령자 및 장애인들의 요구를 어떻게 반영할 것인가에 대한 지침을 제공하고 있으며 7가지 분야의 고려사항을 제정하였다. 7가지 분야의 고려사항은 ① 정보, 표시, 지침서 및 경고 ②포장: 개봉, 사용 및 폐기 ③재료 ④설치 ⑤사용자 인터페이스, 취급, 관리 피드백 ⑥유지 관리, 저장 및 폐기 ⑦건축 환경이다.

2.4.2. KS C 6532

KS C 6532는 국내용 가전제품의 조작성을 높이기 위한 제품 디자인 설계 지침으로 실제 사용자와 가장 유사한 평가자가 실제와 유사한 상황에서 평가를 하는 것이 바람직하다. 요약된 가전제품의 조작성에 관한 설계 지침에 관한 고려사항은 다음과 같다.

Table 5. Considerations Proposed in KS C 6532

Convenience of Indication	The control part of the product should be easy to see in the actual usage environment and should be easily identifiable.
Convenience of Terms	Terms used for control indication marked for detailed instructions such as each part of the product control part, movements, etc should be easy for the user to understand.
Location of Control Part	The spatial arrangement of the control part should be easy to manipulate by the user.
Arrangement of Manipulation Factors	Arrangement of manipulation factors should be in a way that it is easy to find the necessary parts in the control part for the user
Manipulation Direction	Direction of rotation of handle or operation direction of switches should in a way that the user can naturally know and be suitable to the movement
Convenience for Use of Buttons and Handles	Buttons and handles that the user manipulates shall be easy for the user to understand how to use and it should be appropriate to the physical characters during operation, and the targeted manipulation shall be easy.
Convenience of Order	① When the user approaches the product, the functions of the product should be easily understood. ② Complex function manipulation orders shall be simplified as much as possible and it should be set so that the user can easily identify the overall control.
Appropriate Feedback	The user should be able to clearly check the results of manipulation to go on to the next manipulation.
Convenience of Manipulation Noise	Method for conveying information to notify feedback of control and product status, and the visual tools and sound features should be used for easy recognition.
Erroneous Control Response and Prevention	The user does not always control accurately so it should be designed to prevent erroneous control.

Other Precautions	In order to enhance manipulability of design of household appliances, the following must be taken into consideration. ① Easy to install and connect. ② Easy to store ③ Easy to open and close doors and caps ④ Easy to carry ⑤ Easy to handle
--------------------------	--

2.4.3. Jakob Nielsen의 사용성 평가

Jakob Nielsen의 연구에 따르면 시스템의 사용자들이 처음 시스템을 접하여 사용법을 얼마나 쉽게 익힐 수 있고 기억할 수 있는지, 사용법에 익숙해졌다면 사용자가 원하는 작업을 얼마나 능률적으로 지원할 수 있는지, 실수가 발생했을 때 어떤 효과적인 방법으로 대처하는지, 사용자들의 시스템에 대한 주관적인 만족도는 어떤지에 대한 평가를 통해서 그 시스템의 사용성을 평가할 수 있다.

Table 6. Jakob Nielson of usability evaluation

Learnability	· How quickly and easily can a user who did not experience the UI learn it? · Rather than simply measuring the time it takes to become completely familiarized with the system UI, the time it takes to become familiar with the system to complete the task desired by the user is measured.
Efficiency	· How quickly does a trained person who experienced the system complete the task? · Is it an efficient system where experienced users can carry out more advanced work than beginners?
Memorability	· How easy is it for a user who has experience using the system but is not completely familiar with it, or a user who has not used the system for a long period of time to remember how to use the system?
Error	· How often do errors occur while using the system and are the errors easily resolved?
Satisfaction	· What is the subjective level of satisfaction felt by the user?

3. 재활훈련기 디자인 평가요소 개발

3.1. 집표 수집 및 분석

앞에서 문헌연구를 통하여 조사한 디자인 요소들을 디자인 전공자 10명, 재활치료 전문가 10명, 의공학자 10명이 분석 및 토론을 통하여 90개의 키워드를 추출하였다.

Table 7. Investigation Method using KJ Method

Target of Survey	10 design majors, 10 rehabilitation treatment experts, 10 medical engineers
Survey Method	Rehabilitation medical instrument design index analysis using the KJ method

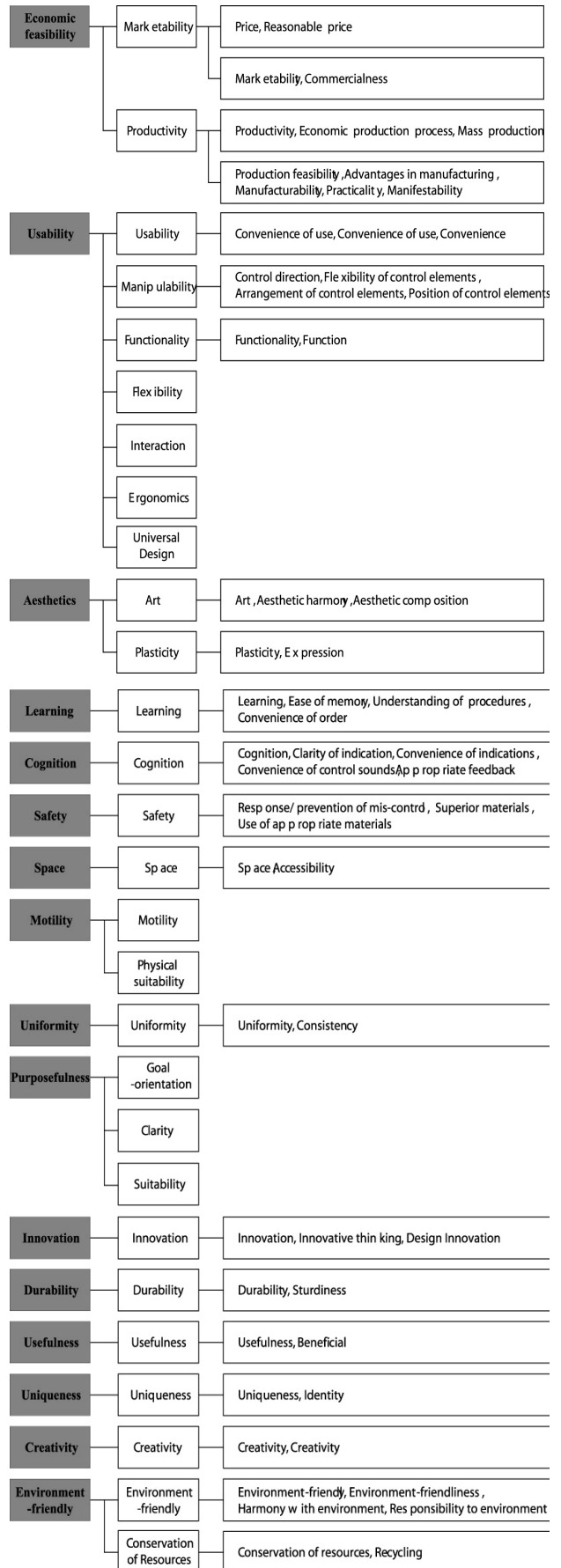
추출한 키워드들을 바탕으로 KJ법을 통한 그룹화 과정을 통하여 37개의 집단으로 나눌 수 있었고, 37개의 집단을 다시 그룹핑하여 경제성, 사용성, 심미성, 인지성, 학습성, 안전성, 공간성, 운동성, 통일성, 합목적성, 실용성, 상징성, 친화성, 만족성, 효율성, 혁신성, 내구성, 유용성, 독창성, 창조성, 환경성의 21개의 디자인 요소를 추출하였다.

추출한 21개의 디자인 평가요소들을 재활의학전문가, 의공학자, 디자이너의 세 그룹 30명이 토의를 통해 최종적으로 사용성, 인지성, 안전성, 학습성, 운동성, 내구성, 경제성, 공간성, 심미성, 환경성의 10가지 재활훈련기 디자인 평가요소로 확정되었다. 이를 통하여 재활훈련기 디자인을 평가하는 기준으로 활용할 수 있는 틀을 만들었다.

Table 8. Design Index Keywords

Selection of Design Keywords			
Functionality	Reliability	Environment-friendly	Use of appropriate materials
Convenience	Safety	Ergonomics	Production feasibility
Plasticity	Durability	Sturdiness	Function Quality
Aesthetics	Satisfaction	Commercialness	Purposefulness
Marketability	Manufacturability	Innovation	Innovative thinking
Goal-orientation	Suitability	Economic production process	Art
Friendliness	Emotion	Usefulness	Price
Economic feasibility	Design	Beneficial	Creativity
Uniqueness	Innovation	Responsibility to environment	Universal design
Manifestability	Advantages in manufacturing	Appeal	Convenience of order
Harmony with environment	Environmental-friendliness	Identity	Appropriate feedback
Accessibility	Recycling	Position of control part	Convenience of control sounds
Manipulability	Physical suitability	Arrangement of control elements	Response/prevention of mis-control
Motility	Satisfaction	Control direction	Space
Flexibility	Symbolism	Convenience of use	Clarity of indication
Cognition	Usability	Control direction	Usefulness of control elements
Productivity	Convenience of indications	Convenience of use	Aesthetic
Conservation of resources	Superior materials	Mass production	
Clarity of indication	Functionality	Reasonable price	
Usefulness of touch	Aesthetic harmony	Practicality	
Learning	Expression	Interaction	
Clarity	Efficiency	Convenience of use	
Consistency	Composition	Understanding of procedures	
Ease of memory			
Uniformity			

Table 9. Design evaluation index grouping via KJ rule



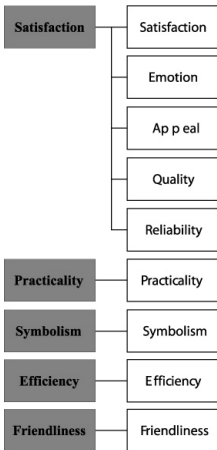


Table 10. Rehabilitation Device Design Evaluation Index

Index	Definition
Usability	Design that can be used by any rehabilitation patient regardless of gender, age, stature and physical conditions
Cognition	Design in which the rehabilitation patient can easily identify information needed for the rehabilitation medical instrument
Safety	Design that minimizes potential risk when rehabilitation patient uses the rehabilitation medical instrument
Learning	Design where rehabilitation patient can intuitively use the rehabilitation medical instrument and easily learn how to carry out the rehabilitation treatment
Motility	Efficient design with exercise effects when the rehabilitation patient uses the rehabilitation medical instrument
Durability	Design that is easy to maintain and manage when the rehabilitation patient uses the rehabilitation medical instrument in various conditions
Economic Feasibility	Design with economic feasibility and marketability for the rehabilitation medical instrument
Space	Design with easy installation and connection of rehabilitation medical instruments
Aesthetics	Design that does not have any resistance against the color or form of the rehabilitation medical instrument and that is friendly and comfortable to rehabilitation patients
Environmental	Design that considers the natural environment during use and disposal by using materials that are not harmful to the body when the rehabilitation patient uses the rehabilitation instruments

3.2. 재활훈련기 평가요소 개발

디자인 전공자 10명, 재활치료 전문가 10명, 의공학자 10명이 전북대학교 헬스케어센터와 성남 고령친화 체험관을 방문하여 여러 가지 재활제품들과 시스템을 체험해보고 연관규칙탐사기법을 적용 및 분석하여 문제점들을 추출하였다.

Table 11. Experience Test of Rehabilitation Products

Investigation Location	Chonbuk National University health care center, Seongnam Senior Experience Complex
Investigation Subject	10 design majors, 10 rehabilitation treatment experts, 10 medical engineers
Investigation Method	After experiencing product, association rule exploration method ⁵⁾

연관 규칙 탐사기법 조사 결과 체험자가 공통적으로 문제점으로 인식하고 있는 항목은 다음과 같이 25개의 항목으로 분류되었다.

Table 12. Experience Test Results of Rehabilitation Products

Rehabilitation System Evaluation Results	
<ul style="list-style-type: none"> Product form is inappropriate for use by elderly or disabled. Size too small when using product. The form and structure of most products for the elderly are complex. Difficult to control the material of the products being used. Height and length adjustment of products for the elderly and disabled are difficult. Unfriendly and repulsive in terms of form and structure. Product form, color and materials lack user friendliness. Inconvenient to use wheelchair and some products. Difficult to adjust control box and posture is unstable. Control and LCD is difficult and complicated to control. Joints on products are exposed, thus being a risk. Icons on control box are unfamiliar. Difficult to adjust angle and move product. 	<ul style="list-style-type: none"> Instructions in manual are difficult and complex. LCD is too small or is hard to understand on most products. When using or getting on or off the product, posture is unstable and is difficult to use. When controlling, the handle is slippery and there is risk of fall. Some products are boring and difficult to use. Some products are unstable as they are used while lying down. Difficult to adjust and control when using without an assistant. Exhausting and difficult when moving. Many products are repulsive in its formative aspect. When using products, space is limited and boring. Difficult to use for those with more physical disabilities. Some parts protrude out making it inconvenient to use.

선행 연구된 10가지의 재활훈련기 디자인 평가 요소와 연관탐사기법의 재활 시스템의 문제점 결과를 가지고 디자인 전공자 10명, 재활치료 전문가 10명, 의공학자 10명이 희망열거법을 통한 체크리스트 기법으로 44개의 세부 평가항목을 만들었다.

Table 13. 10 Evaluation Indices and 44 Sub-evaluation Items of Rehabilitation Device Designs

Usability: Design that can be used by any rehabilitation patient for rehabilitation treatment instruments regardless of gender, age, stature or physical abilities	
1	Can be used by anybody regardless of the stature or physical ability of the rehabilitation patient.

5) The association rule exploration method measures the association level between products and users to find elements with high association, which are then grouped as a data mining method.

2	Has various ways to use (how to grab, hold and control) that the user can choose from.
3	No motion or control requiring precision so there is no burden in use.
4	Anyone can use at their appropriate pace (speed or performance).
5	Does not cause problems to the living environment (temperature, humidity, leaks, bright or darkness, noise, etc) during use.
6	Usage, appearance, structure, etc does not confuse user and is not complex that might confuse the user.
7	How to use can be intuitively known by various users so mistakes are not made.
8	Does not cause excessive physical load and can be used with little force.
9	Unnecessary movements or repeated movements are not required during use.
10	When the user uses a supplementary device or assistant, there is enough space to use the product.
Cognition: Design in which the rehabilitation patient can perceive necessary information of the rehabilitation medical instrument easily	
11	Illustrations, tables, images, lights, signals, sound or vibration are used to convey information.
12	It is set so that information needed by the rehabilitation patient can be conveyed clearly to the user.
13	Information needed by user is arranged well and is easy to know.
14	It is possible to distinguish important parts such as the control indicator and operation parts and it can be easily explained to third persons as well.
15	It is easy to use in environments with visual or hearing disabilities such as glasses, hearing aids or sign language.
Safety: Design that minimizes possibilities of risk when the rehabilitation patient uses the rehabilitation medical instrument	
16	Parts or switches needed for production structure or composition shall be considerate of safety accidents.
17	Control parts are be separated from risk factors for use.
18	It is set so that dangers or control mistakes are not made to prevent accidents.
19	Has two or more ways to convey messages such as noise and lights in preparation of unexpected situations.
20	Set so that in the event of mistakes or accidents, there is no damage to the user or surrounding environment.
21	Consideration given so that even if there is mistakes during control, the problem can be resolved.
22	Pursues safety in order to predict situations that may occur during use.
23	Does not use materials harmful to the body.
Learning: Design for rehabilitation patients to easily learn how to carry out rehabilitation treatment by knowing how to use the rehabilitation medical instrument	
24	Easy to learn to carry out rehabilitation treatment by understanding how to use or its functions regardless of the user's language, knowledge or comprehension abilities.
25	Easy to understand to learn to carry out rehabilitation treatment as the order or feedback in the course of operating does not cause confusion.
26	It is easy to learn and remember for users when having to enter many numbers by the rehabilitation patient such as timer reservation and course settings.
Motility: Design with efficient exercise effects when the rehabilitation patient uses the rehabilitation medical instrument	
27	Effects of exercise of rehabilitation treatment are effective.
28	System that motivates to enhance motility of rehabilitation

	treatment.
Durability: Design that is easy to maintain and manage when the rehabilitation patient uses it in various conditions	
29	Prolonged use in various conditions does not cause malfunctions or problems and can be used safely.
30	Security, inspection and repair is easy during use, including repairs, parts exchange and purchasing consumable parts.
31	When spoiled, it is easy to remove the spoils.
Economic Feasibility: Designs in which rehabilitation medical instruments are economically feasible and have marketability	
32	Product price and expenses are appropriate for its performance and quality.
33	Pursues optimization and reduction of manufacturing expenses and strives to lower product price as much as possible.
34	Considerations are made so that there are no running costs such as power consumption or purchasing consumable parts during use.
Space: Design of size that is easy to install and connect the rehabilitation medical instrument	
35	Reflects appropriate size for use, portability and storage, and has convenience of storage.
Aesthetics: Designs in which the rehabilitation medical instrument has no repulsiveness for color form and has a friendly and pleasant beauty for rehabilitation patients	
36	No repulsiveness against the color, form or impression of the product and has a friendly and pleasant beauty to many users.
37	Has both practicality and functionality, as well as beauty.
38	Texture and appeal of materials are maximized in the product.
39	Product is applied to all five senses of the user to give a pleasant feeling to the user.
Environmental: Design that uses materials not harmful to the body and considers the natural environment when using or discarding the rehabilitation equipment by the rehabilitation patient	
40	Consideration taken so that there is no hygienic issues during use and discarding of product and can be used cleanly.
41	Uses recycled and reused materials as much as possible in the main unit and parts of the product.
42	Product does not waste resources or energy during use.
43	No possibility of environmental destruction during use.
44	Does not use materials harmful to the natural environment.

4. 재활훈련기 디자인 평가요소 분석

4.1. 장애에 따른 재활치료 및 운동기 분석

재활치료 시 일반적으로 대부분의 모든 병원에서 사용하는 재활훈련기를 알아보기 위하여 재활의학과 전문의 및 전공의 5명과 장애인복지법시행령 제2조 장애인의 장애인 등급표 및 장애인 분류표를 참고한 개별인터뷰 과정을 통하여 장애에 대하여 분류해보았다. 장애는 크게 외부 신체기능 장애와 내부기관 장애로 크게 두 부분으로 나누고, 중분류, 소 분류하여 최종 36개의 장애로 분류하였다. 다음과정으로 장애에

따른 재활운동 방법에 대하여 조사를 하였고, 마지막으로 재활치료에 맞는 재활훈련기를 조사하였다.

Table 14. Rehabilitation Treatment and Rehabilitation Medical Instrument Survey Method

Classification	Category	Sub-category	Rehabilitation Treatment Method	Rehabilitation Treatment Instrument				
Physical Function Disability	Amputation Disability	Upper Limb	Finger	Pain control treatment	X			
		Amputation Disability	Wrist or higher	Pain treatment, rehabilitation with prosthetic hand, daily life activity movement exercise	Prosthetic hand			
			Lower Limb Amputation Disability	Amputation of ankle or lower	Pain treatment, walking training wearing prosthetic leg	Prosthetic leg		
		Amputation of knee or lower		Pain treatment, walking training wearing prosthetic leg				
		Amputation above knee		Pain treatment, walking training wearing prosthetic leg				
		Joint Disability	Upper Limb Joint Disability	Finger joint	Passive, active joint exercise	Arm Skate, Rotary Wrist Machine, Figure-8 Board System, Graded ROM Arc, Shoulder Wheel, Shoulder Abduction Ladder		
				Wrist joint	Passive, active joint exercise			
				Elbow joint	Passive, active joint exercise			
			Lower Limb Joint Disability	Shoulder joint	Passive, active joint exercise	Knee CPM		
				Ankle joint	Passive, active joint exercise			
				Knee joint	Passive, active joint exercise			
		Physical Function Disability	Upper Limb Function Disability	Finger function	Muscular training, daily life activity motion exercise	Finger grip, upper body bicycle, velcro hand resistance equipment, cant board, Power-Web Exercisers, Over Head Pulley, Dumbbells, Weight cuffs, Two-Tiered Horizontal Bolt Board, Graded Pinch Exerciser, 25-Hole Pegboard with Colored Pegs, Stacking Cones, Easy Grip Cutlery - Built-Up Handles, Manipulation Board		
	Elbow or lower function			Muscular training, daily life activity motion exercise				
				Muscular training, daily life activity motion exercise				
	Shoulder or lower function			Muscular training, daily life activity motion exercise				
	Lower Limb Function Disability		Ankle or lower function	Muscular training, walking exercise	Leg extension machine, Leg press machine, NK table, Q-Board, seated bicycle, parallel bars, stair walker, Bobath table			
			Knee or lower function	Muscular training, walking exercise				
			Hip or lower function	Muscular training, walking exercise				
				Spinal function		Muscular training, walking exercise		
			Brain Lesion Disability	Cognitive Disability		Cognitive treatment	Pattern Blocks & Boards, Bead Sequencing Set, Beads and Pattern Cards	
				Swallowing Disability		Swallowing treatment	Electric stimulation treatment	
	Time/Space Cognitive Disability			Prism glasses treatment, audio/video stimulation treatment, visual	X			

Paralysis	Speech Disorder	scanning treatment		
		Speech treatment	X	
	Limb paralysis	Left-side hemiplegia	Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment	Arm Skate, Rotary Wrist Machine, Figure-8 Board System, Graded ROM Arc, Shoulder Wheel, Shoulder Abduction Ladder, Leg extension machine, Leg press machine, NK table, Q-Board, Power-Web Exercisers, Over Head Pulley, Dumbbells, Weight cuffs, Two-Tiered Horizontal Bolt Board, Graded Pinch Exerciser, 25-Hole Pegboard with Colored Pegs, Stacking Cones, Easy Grip Cutlery - Built-Up Handles, Manipulation Board, Finger grip, Velcro hand resistance equipment, can board, seated bicycle, treadmill, parallel bars, stair walker, Bobath table
			Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment	
	Right-side hemiplegia	Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment		
		Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment		
	Paralysis	Paralysis	Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment	
			Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment	
	Lower limb paralysis	Lower limb paralysis	Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment	
			Passive and active joint exercise, muscular strength exercise, daily life activity exercise, walking treatment	
	Sensory function disability	Sensory stimulation treatment	Feel ball, Fine Motor Exercise Kit	
		Balanced treatment	Exercise ball, balance board	
Drug treatment		X		
Facial Disability	Central nerve disability	Facial exercise, electric stimulation treatment	X	
	Peripheral nerve disability	Facial exercise, electric stimulation treatment, drug treatment	X	
Internal Organ Disability	Heart Disability	Heart rehabilitation treatment (only at few large hospitals)	X	
	Respiratory Disability	Respiratory rehabilitation treatment (only at few large hospitals)	X	

앞에서 조사한 장애의 분류에 따른 재활치료법과 재활훈련기 분류를 보면 11개의 치료법으로 재활치료가 분류되었고, 11개의 재활훈련기 제품군 38개의 가장 보편적이고, 기본적인 재활훈련기 제품을 샘플로 선정하였다. 선정된 샘플은 모든 재활훈련기관에서 치료에 이용되는 제품들이다.

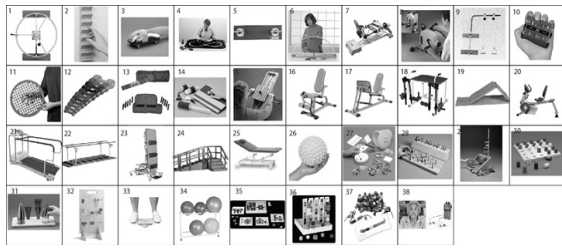


Figure 1. 38 rehabilitation medical instruments most commonly used for rehabilitation treatment

4.2. 재활훈련기 디자인 평가요소 분석 및 결과

4.2.1. 재활훈련기 디자인 평가요소 설문조사

11개 재활치료군의 샘플로 선정한 38개 재활훈련기 제품에 대하여 재활의학과 전문의, 전공의, 직업치료사 등 재활치료 전문가 33명, 디자이너 20명, 의공학자 20명 재활치료환자(Table 16 참조)를 선정 연구되어진 10개 요소 44개 세부 평가항목을 가지고 설문하였다.

Table 15. Rehabilitation Medical Instrument Design Evaluation Index Survey Method

Survey Target	33 rehabilitation treatment experts such as rehabilitation medicine doctors, specialists and work therapists, 20 designers and 20 medical engineers, 00 rehabilitation treatment patients (See Table 27)
Survey Method	Rehabilitation medical instrument design evaluation index (7 point scale) survey and design preference through interviews and questionnaires

Table 16. Number of persons who took questionnaire according to the 11 product groups

No.	Product Group	Experts	Designers	Medical Engineers	Patients
1	Upper limb active-passive joint exercise	33	20	20	15
2	Lower limb active-passive joint exercise	33	20	20	18
3	Upper limb muscle strengthening training	33	20	20	15
4	Lower limb muscle strengthening training	33	20	20	18
5	Walking treatment	33	20	20	12
6	Central nervous system treatment	33	20	20	9
7	Sensory stimulation treatment	33	20	20	16
8	Upper limb daily exercise motion exercise	33	20	20	11
9	Balance exercise	33	20	20	13
10	Cognitive treatment	33	20	20	7
11	Swallowing disorder treatment	33	20	20	2

본 연구에서는 제한된 재활환자의 표본수로 인하여 장애별 재활치료 군의 환자 수 차이가 크다. 삼킴 장애치료의 경우 의료보험의 혜택이 없어 치료비용이 많이 발생하여 환자군의 표본 수 모집에 어려움이 있어 단 2명의 환자에게만 설문조사가 가능했다. 이는 본연구의 한계점이라 할 수 있겠다. 설문지의 항목은 Table. 13의 재활훈련기 디자인의 10개 평가요소 와 44개 세부 평가항목과 같다.

4.2.2. 재활훈련기 디자인 평가요소 분석

38개 재활훈련기의 디자인 선호도를 분석한 결과 평균 4.39가 나왔다. 4.39의 디자인 선호도를 기준으로 디자인 선호도가 높은 재활훈련기 제품군과 낮은 제품군으로 분류 하였다.

Table 17. (Top) Product groups with high design preference (Bottom) Product groups with low design preference

No.	Usability	Cognition	Safety	Learning	Motility	Durability	Economic feasibility	Space	Aesthetics	Environment-friendly
2	6.12	5.14	6.21	6.72	6.28	6.28	5.29	5.25	6.16	5.24
6	6.19	5.29	6.02	6.21	6.31	6.27	5.37	5.81	6.21	5.27
8	6.17	6.07	6.23	6.72	6.39	6.02	4.97	5.56	6.23	5.87
12	6.03	5.02	6.01	6.53	6.07	6.89	5.48	3.91	6.19	5.27
14	6.19	5.09	6.23	6.61	6.31	6.04	5.19	5.59	6.28	5.78
19	6.19	5.09	6.29	6.37	6.61	6.27	5.73	5.76	6.12	5.74
20	6.11	6.32	6.16	6.21	6.49	6.01	5.05	5.48	6.17	5.12
26	6.08	5.21	6.72	6.27	6.25	6.09	5.21	5.69	6.27	5.03
27	6.17	5.51	6.51	6.43	6.28	6.05	5.04	5.29	6.14	5.27
28	6.21	5.72	6.28	6.29	6.41	6.25	5.28	5.71	6.21	5.11
29	6.19	5.18	6.15	6.31	6.38	6.39	5.19	5.87	6.13	5.27
30	6.11	5.83	6.51	6.38	6.61	6.46	5.15	5.39	6.11	5.30
31	6.27	5.70	6.39	6.40	6.30	6.25	5.31	5.80	6.15	5.17
35	6.21	5.23	6.27	6.69	6.33	6.25	5.41	5.29	6.18	5.29
36	6.10	5.71	6.19	6.48	6.47	6.30	5.28	5.36	6.11	5.71
37	6.12	5.47	6.40	6.50	6.71	6.51	5.31	5.71	6.10	5.80
Total	6.15	5.47	6.29	6.45	6.39	6.27	5.27	5.47	6.17	5.39
1	4.41	2.89	6.33	5.24	5.71	6.30	3.38	3.51	4.71	3.12
3	4.19	2.98	5.77	5.13	5.48	5.63	3.97	4.27	4.17	3.18
4	3.98	3.08	5.90	5.41	5.46	5.08	3.61	2.91	4.79	3.28
5	4.98	3.11	6.48	5.37	5.39	5.21	3.37	3.26	4.51	3.11
7	4.90	3.09	5.91	5.26	5.98	4.97	3.71	3.48	4.07	3.72
9	3.74	3.01	5.81	5.15	5.12	5.78	3.83	3.28	4.79	3.12
10	4.08	3.18	6.37	5.62	5.10	4.81	3.60	3.97	4.58	3.51
11	4.21	2.98	5.69	6.47	5.47	4.59	3.41	3.86	4.17	3.19
13	4.09	2.98	5.61	5.18	5.45	5.27	3.59	3.41	4.91	3.42

15	4.78	3.52	5.56	5.27	5.83	5.38	3.27	2.94	4.94	3.71
16	4.54	3.19	5.74	5.21	5.49	6.31	3.96	2.81	4.07	3.28
17	4.71	3.61	5.47	5.61	5.75	6.37	3.85	2.79	4.99	3.31
18	4.40	3.38	5.45	5.69	5.39	5.61	3.69	2.85	4.17	3.25
21	4.58	3.87	5.97	5.87	6.42	5.56	3.97	2.98	4.71	3.62
22	4.14	2.57	5.91	5.70	5.74	5.76	3.59	2.71	4.89	3.51
23	4.87	2.91	5.61	5.27	5.49	5.49	3.79	2.41	4.64	3.26
24	4.94	3.09	5.86	5.88	6.40	5.41	3.88	2.70	4.98	3.19
25	4.81	3.27	5.23	5.69	5.70	5.69	3.73	2.85	4.27	3.25
32	4.59	3.77	5.27	6.47	5.38	5.31	3.27	3.12	4.72	3.29
33	4.21	3.04	5.74	5.27	5.71	5.71	3.71	3.58	4.27	3.51
34	4.27	3.17	5.87	5.51	5.40	5.89	3.29	3.49	4.30	3.63
38	4.44	3.13	5.57	5.71	5.97	5.70	3.18	3.91	4.81	3.84
Total	4.45	3.17	5.78	5.54	5.63	5.54	3.62	3.23	4.57	3.38

Table 17의 디자인 선호도가 낮은 제품군에 1번 제품의 안전성 6.33, 5번 제품의 안전성 6.48, 10번 제품의 안전성 6.37, 11번 제품의 학습성 6.47, 16번 제품의 내구성 6.31, 17번 제품의 내구성 6.37, 21번 제품의 운동성 6.42, 24번 제품의 운동성 6.40, 32번 제품의 학습성 6.47의 값은 디자인의 선호도가 높은 제품군의 평균 평가요소 값보다 더 높게 나왔다. 재활훈련기는 안전성, 학습성, 운동성, 내구성의 요소가 중요한 요소의 제품으로 디자인 선호도가 낮은 제품군 중에서도 평가요소가 높은 경우가 있는 것으로 예상된다.

4.2.3. 재활훈련기 디자인 평가요소 분석 결과

38개 재활훈련기를 디자인 선호도가 4.39를 기준으로 높은 제품군과 낮은 제품군을 분류하여 10개의 재활훈련기 디자인 평가 요소를 분석한 결과 선호도가 높은 제품군 쪽이 10개의 디자인 평가 요소에서 대부분 높은 값을 얻었다. 따라서 사용성, 인지성, 안전성, 학습성, 운동성, 내구성, 경제성, 공간성, 심미성, 환경성의 10개 재활훈련기 디자인 평가요소는 유의하다 판단된다.

5. 디자인 평가요소 비교 실험

5.1. 샘플 선정

가전제품군으로 2013년 판매순위 1위 쇼핑몰에서 제품이 판매순위 20위까지 제품을 샘플로 선정하였다.



Figure 2. 20 Dehumidifier Samples

운송기기군으로 2013년 국산 및 수입 세단 판매순위 20위 까지 제품을 샘플로 선정하였다.



Figure 3. 20 Sedan Samples

재활훈련기군으로 2013년 싸이클형 하지 근력강화 운동기 매출 순위 상위 5개사 20개 제품을 샘플로 선정하였다.



Figure 4. 20 Rehabilitation Medical Instrument Samples

5.2. 제품군에 따른 디자인 평가요소 실험

Table 18. Design Evaluation Index Test according to Product Group

Survey Target	15 design majors, 15 rehabilitation therapy experts, 15 biomedical engineers
Survey Method	Individual interviews and questionnaires
Survey Contents	Design evaluation index survey using 7 point scale on household appliances (dehumidifiers), transportation equipment (sedans), rehabilitation medical instruments (cycle-type lower body muscular exercise equipment)

디자인 전공자 15명, 재활치료 전문가 15명, 의공학자 15명이 가전제품군의 20개의 제품기 샘플, 운송기기군의 20대의 승용차 샘플, 재활훈련기군의 20대의 싸이클형 하지 근력운동기 샘플을 21개의 디자인 평가요소 Table 9(경제성, 사용성, 심미성, 인지성, 학습성, 안전성, 공간성, 운동성, 통일성, 합목적성, 실용성, 상징성, 친화성, 만족성, 효율성, 혁신성, 내구성, 유용성, 독창성, 창조성, 환경성)를 가지고 개별 인터뷰 및 설문평가를 하였다. 21개 디자인 평가요소의 평균값

은 Table 19와 같다.

Table 19. Average Value of Design Evaluation Indices according to Product Groups

Design Evaluation Index	Household Appliances (Dehumidifiers)	Transportation Equipment (Sedan)	Rehabilitation Medical Instrument (Lower Body Muscular Strength Exercise Equipment)
Economic feasibility	6.37	6.51	6.41
Usability	6.28	6.37	6.17
Aesthetics	6.53	6.57	6.48
Cognition	6.06	6.17	6.12
Learning	2.21	2.10	6.73
Safety	3.15	4.18	6.92
Space	6.38	6.43	6.27
Motility	1.39	1.46	6.73
Uniformity	4.23	4.63	4.76
Purposefulness	4.58	4.28	4.45
Practicality	6.28	6.42	4.27
Symbolism	3.17	3.31	3.19
Friendliness	3.14	4.10	3.38
Satisfaction	6.18	6.21	4.27
Efficiency	6.22	6.48	4.19
Innovation	6.20	5.15	3.49
Durability	4.25	4.51	6.78
Usefulness	6.07	6.25	3.27
Uniqueness	6.14	4.63	4.05
Creativity	4.33	4.58	4.11
Environment-friendly	6.04	6.18	6.10

5.3. 디자인 평가요소 실험

Table 20. Design Evaluation Index Test

Survey Target	15 design majors, 15 rehabilitation therapy experts, 15 biomedical engineers
Survey Method	Individual interviews
Survey Contents	Homogeneity analysis according to free grouping of the 21 design evaluation indices (Economic feasibility, Usability, Aesthetics, Cognition, Learning, Safety, Space, Motility, Uniformity, Purposefulness, Practicality, Symbolism, Friendliness, Satisfaction, Efficiency, Innovation, Durability, Usefulness, Uniqueness, Creativity, Environment-friendly)

디자인 전공자 15명, 재활치료 전문가 15명, 의공학자 15명이 개별 인터뷰를 통하여 디자인 평가요소 21개(경제성, 사용성, 심미성, 인지성, 학습성, 안전성,

공간성, 운동성, 통일성, 합목적성, 실용성, 상징성, 친화성, 만족성, 효율성, 혁신성, 내구성, 유용성, 독창성, 창조성, 환경성)를 가지고 프리 구롭핑을 통한 데이터를 SPSS 통계프로그램을 통하여 동질성 분석을 하였다. 분석결과는 Figure 5와 같다.

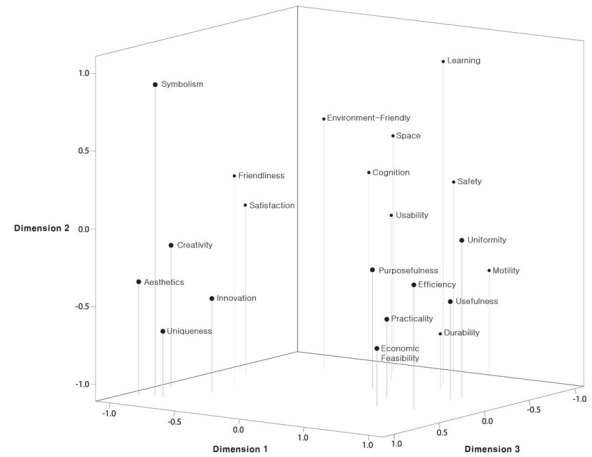


Figure 5. 21 Design Evaluation Indices Homogeneity Analysis Results

5.4. 실험 결과

가전제품군, 운송기기군, 재활훈련기기군의 제품을 샘플로 뽑아 제품군에 따른 디자인 평가요소 실험과 디자인 평가요소의 동질성분석 실험 결과는 Figure 6와 같다. 디자인 평가요소의 값이 6.0이상인 요소들만 동그라미 표시를 하였다.(Table 19 참조) 녹색은 가전제품군(제습기), 파란색은 운송기기군(세단), 빨간색은 재활훈련기기군(싸이클링 하지근력강화운동기) 이다.

실험 결과를 보면 환경성, 공간성, 인지성, 사용성, 경제성, 심미성의 디자인 평가요소는 제품디자인에서 공통적으로 고려해야 할 디자인 요소들이고, 가전제품군에서는 효율성, 유용성, 실용성, 만족성, 혁신성, 독창성을 중요하게 고려해야하고, 운송기기군에서는 효율성, 유용성, 실용성, 만족성의 요소를 중요하게 고려해야한다. 마지막으로, 학습성, 안전성, 운동성 내구성의 요소는 재활훈련기 디자인 평가요소에서 매우 중요하게 고려해야 할 요소라는 것을 알 수 있었다. 실험결과를 보면 가전제품을 구매할 때 소비자는 개성과 혁신에 많이 민감하고, 운송기기 같은 경우 자동

차는 쉽게 구매하기 힘든 제품이기 때문에 소비자가 자동차를 구매할 때 효율이나, 실용적인면, 만족도를 많이 고려하는 것 같고, 마지막으로 재활훈련기 같은 경우는 병원에서 많은 환자들이 쓰는 제품이기 때문에 안전성, 내구성을 고려하고, 재활훈련의 학습성 및 운동성을 많이 고려하는 것으로 추측이 된다.

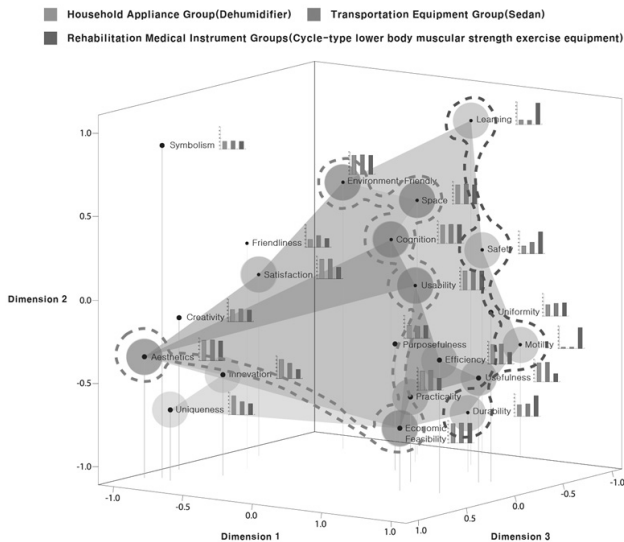


Figure 6. Test Results

Table 21. Design Evaluation Indices Comparisons for Household Appliance, Transportation Equipment and Rehabilitation Medical Instrument Groups

Product Groups	Common Design Evaluation Indices	Individual Design Evaluation Indices
Household Appliances (Dehumidifiers)	Environment-friendly, Space, Cognition, Usability, Economic feasibility, Aesthetics	Efficiency, Usefulness, Practicality, Satisfaction, Innovation, Uniqueness
Transportation Equipment (Sedans)		Efficiency, Usefulness, Practicality, Satisfaction
Rehabilitation Medical Instrument Groups (Cycle-type lower body muscular strength exercise equipment)		Learning, Safety, Motility, Durability

6. 결론 및 향후연구

6.1. 결론

본 연구에서는 고령자장애인 및 재활이 필요한 환자를 위한 재활훈련기를 헬스케어 디자인의 관점에서

재활훈련기의 디자인 평가요소를 정립하기 위해 기존 디자인 평가 요소들을 수집 및 분석하여 재활치료 전문가, 재활환자, 의 공학자, 디자이너들이 10개의 재활훈련기 디자인 평가요소와 44개의 세부 평가항목을 구축하였다. 또한, 재활치료에서 가장 많이 사용하는 보편적인 38개의 제품을 샘플로 뽑아 실험을 통하여 10개의 재활훈련기 디자인 평가요소를 검증하였고, 가전제품 군, 운송기기 군, 재활훈련기 군의 디자인 평가요소를 실험을 통하여 비교 평가하였다. 이와 같이 본 연구에서 진행한 재활훈련기 디자인 평가요소 구축에 관한 연구는 다음과 같은 결론을 얻을 수 있다.

첫째, 기존 디자인 평가 지표들을 수집, 분석하여 10가지의 재활의료기 디자인 평가요소와 44개의 세부 평가항목을 구축하였다. 이는 앞으로 재활의료기를 디자인하는데 있어서 중요한 평가 기준이 될 것이다.

둘째, 헬스케어 재활훈련기 디자인 개발 시 고려해야 할 10가지 디자인 평가요소는 사용성, 인지성, 안전성, 학습성, 운동성, 내구성, 경제성, 공간성, 심미성, 환경성이다.

셋째, 환경성, 공간성, 인지성, 사용성, 경제성, 심미성의 디자인 평가요소는 제품디자인에서 공통적으로 고려해야 할 요소들이고, 학습성, 안전성, 운동성, 내구성의 요소는 재활훈련기 디자인 평가요소에서 매우 중요하게 고려해야 할 요소이다.

넷째, 재활훈련기 디자인 평가요소는 제품디자인요소에서 중요하게 고려되는 환경성, 공간성, 인지성, 사용성, 경제성, 심미성에 학습성, 안전성, 운동성, 내구성을 의 요소를 더해 중요하게 생각한 것이 기존 제품디자인 평가요소와 재활훈련기 디자인 평가요소의 차이점이다.

6.2. 향후연구

본 연구에서는 10개의 재활훈련기 디자인 평가요소와 44개의 세부 평가항목 구축에 대한 연구를 진행하였다. 이는 전체적인 재활훈련기 디자인 평가요소만을 연구한 것이다. 향후연구에서는 시 제품 제작을 통하여 평가요소들을 실제 재활훈련기 디자인에 적용해 보고, 미진한 점들을 수정 보완 할 예정이다.

REFERENCES

- Guide 71. (2011). Guideline for Standards Developers to Address the Needs of Older Persons and Persons with Disabilities. *International Organization for Standardization*.
- Jakob, N. (1994). Usability Engineering. *Morgan Kaufmann*, 26.
- Kim, S. C. (2011). A Senior-friendly Product Usability Evaluation Index Development. *Korea Health Industry Development Institute, Daegu Health College*, 73-74.
- Kim, Y. C. (2000). A Study on Design Evaluation Methods for New Product Development Processes. *Kookmin University Graduate School Master's Course*, 9-10.
- KS C 6532. Design Guideline on Manipulability of Household Appliances. *Korean Agency for Technology and Standards*.
- So, R. (2013). A Study on design of Stretching Exercise Equipment for adolescent. *Seoul National University of Science and Technology*, 38.

원고접수: 2014.07.15

수정접수: 2014.09.17

게재확정: 2014.09.29