Effectiveness of a Korean Smart Home Modification Program: Focused on People with Physical Disabilities

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Abstract. The purpose of this study was to investigate the effects of the Korean Smart Home Modification Program (KSHMP) on the activities of daily living and health-related quality of life of people with physical disabilities. The study used a single-group pre-post design with 10 people with physical disabilities living at home. During the intervention period, the KSHMP was implemented, which included occupational profile, smart home installation, setup, training, task-based feedback, and monitoring. Post-intervention changes in activities of daily living and health-related quality of life were assessed with the Canadian Occupational Performance Measure (COPM) and EuroQual-5 Dimensions (EQ-5D). After the KSHMP, all 10 subjects improved their activities of daily living and quality of life. In addition, the occupational performance of all subjects was maintained. These results show that a customized smart home has a positive impact on improving the activities of daily living and quality of life of people with retardation and is an efficient alternative.

Keywords: Smart Home · Home Modification · Quality of Life · Disabled Persons · Korea

1 Introduction

People with physical disabilities (PwPD) frequently have difficulty managing and accessing their homes, depend on a caregiver for assistance in completing their daily-life activities [1]. Based on the Institute of Medicine model published by Pope and Brandt, the degree of disability was reported to vary depending on the individual's ability and support for the physical-social environment [2]. The per-son-environment-occupation-performance model is a measurement of the degree of occupational performance, and it changes with the appropriate interaction of the person, environment, and occupation [3]. It is important to note that an increase in occupational performance can create meaningful occupations, promote occupation participation, and improve quality of life [4, 5]. Their study suggested that PwPD, with increased occupation-al performance, were associated with creating and satisfying independent activities of daily livings (ADL) that could further improve their quality of life [6]. Home modification programs include improved

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housing structure, relocation of furniture, installation of amenities, efficient moving space, and education for changing environmental adaptation, and Advanced technologies such as smart homes, enable PwPD to improve their ADL and participate more in life [7, 8]. The medical rehabilitation system in Korea consists of multidisciplinary teams, including doctors, occupational therapists, and social workers, in rehabilitation medical institutions, and is implementing a home modification program as part of the discharge plan [9]. However, it is difficult to reflect sensor lighting, access outlets, control brightness, and use auto doors, or people with stroke and spinal cord injury; ADL independency limitations remain in homes [10, 11]. In addition, the requirement for a home environment that meets the physical functions and needs of PwPD is increasing [12, 13]. A smart home is defined as a technology and service environment that combines in-formation and communication technology with human space and devices to provide value, such as safety, convenience, economy, and pleasure [14]. Based on research on people using smart homes, controllers, such as voice recognition, tablets, and remote controls, are key technologies for improving the quality of life of PwPD and can remotely control home appliances, phone use, alarm settings, lighting on/off, windows, doors, and applications for daily activities. However, this has mainly been conducted abroad [15, 16]. In Korea, owing to different barriers that limit the use and effectiveness of smart homes, such as complex use, high cost, lack of institutional maintenance, and opinions deeming smart homes unnecessary, the only available studies that apply smart homes to a testbed; clinical studies that apply smart homes to actual homes are limited [9, 17]. The objective of this study is to gather information on the applicability, effectiveness, and limitations of providing a Korean Smart Home Modification Program (KSHMP) to community practice areas. This is the first step in developing programs that promote quality of life, occupational performance, and home management.

2 Method

2.1 Participants

From December 2022 to May 2023, we visited ten participants at home and provided KSHMP. The characteristics of the participants were 5 men and 5 women, with an average age of 46.7 years, five spinal cord injuries, two strokes, and three cases of cerebral palsy.

2.2 Korean Smart Home Modification Program (KSHMP)

The KSHMP consisted of three phases: occupational profile, intervention and monitoring, and follow-up. In the first phase, researchers visited participants' homes to collect baseline information, identify key needs and smart devices in use, assess the occupation space, observe, and analyze occupational performance, and explain and discuss home modifications. In the second phase, researchers installed and set up the smart home in each participant's home. Researchers trained participants and caregivers on how to use the smart home and provided task-oriented feedback and monitoring. In the third phase, we conducted a post-test and interviewed participants about their experiences with the smart home. The KSHMP was determined by space through a literature review of the impact of smart homes on daily life [18]. The applications and contents of the smart home in this study are shown in Table 1.

Table 1. Smart home by space

Space	Contents
Living room and bedroom	Smart home appliances [TV, air conditioner, refrigerator, etc.], Smart plug, Smart light switch, Get news and weather alerts with voice speaker, Listen to radio with voice speaker, Smart window opener, Electric lift for wardrobe, Smart curtains/blinds, Smart remote control hub, Motion sensor, Temperature and humidity sensor, Turn on sleep background music, Smart mood light, Smart heating controller, Smart air purifier, Smart humidifier, AI motion tracking camera
Kitchen	Gas Detection Sensors, Smart Gas Blocker
Entryway	Smart Door Opener, Smart Doorbell, Smart Door Lock
Other	Smart Speaker, Smart Medicine Box, Pet Robot, Home Smart Farm, turn on/off all lights and appliances, Notify parents of emergencies

2.3 Occupational Profile

The occupational profile is summary of a participant's occupational history and experiences, patterns of daily living, interests, values, needs, and smart home relevant contexts. Using a client-centered approach, the occupational therapist collected information to understand what participants want and need through SHT and to identify past experiences and interests that can help them understand current problems and problems. The researcher evaluated the participants' occupational performance, satisfaction, and health-related quality of life before and after KSHMP. Canadian Occupational Performance Measure (COPM) was used for occupational performance and satisfaction, and EuroQol-5 dimension (EQ-5D) was used for health-related quality of life [19, 20].

2.4 Home Modification

Home modification was performed to improve the participants' indoor ADL. After checking the participants' bedroom environment, the researcher installed controllers and smart devices based on the participants' physical functions to lower environmental barriers and increase convenience [21]. The researcher monitored and supplemented this to adapt to the changed smart home environment and improve ADL during the study period.

2.5 Smart Home Education

The researchers taught participants and guardians to understand and use smart homes. It supplemented the manual provided by smart device manufacturers and provided it to individuals in an easy-to-understand manner.

2.6 Task-Oriented and Simplify Occupational Performance Skills

In this study, the task-oriented approach is a training method focused on special functional tasks that combine musculoskeletal for nervous systems, providing occupation-based routines for participants rather than repeatedly practicing normal patterns [22]. The researcher prioritized meaningful activities for each topic to build a task based on the smart home, which was changed for each participant based on the occupational profile. However, if the participants first performed a task or failed to perform it independently, they could learn how to perform the task accurately by referring to the error-free four-step learning in Thivierge et al. [23]. We modified the participants' fewer effective skills to make them efficient and allow them to perform their occupations with less physical effort [24].

2.7 Statistical Analysis

Statistical analyses in this study were performed using JAMOVI version 2.3.26.0 software. Participants' general characteristics and pre-post assessments were presented as means and standard deviations. Due to the small sample size ($n = 10$), a non-parametric test, the Wilcoxon signed-rank test, was used to test whether there was a central difference between the pre- and post-tests between the two groups. The level of significance was set at $P < 0.05$.

3 Results

3.1 Participants and Intervention

Study participants were recruited based on selection criteria through the Gangwon-do Regional Health & Medical Center for People with Disabilities and the Seoul Northern Regional Health & Medical Center for People with Disabilities. A total of 10 people participated in the study, and their pre- and post-assessment results are shown in Table 2. All participants were treated at the Department of Family Medicine and Rehabilitation, and the intervention began after they agreed to participate in the study. This study was conducted with the approval of Yonsei University Wonju Institutional Review Board (1041849-202211-SB-218-02). After receiving training on the application of the smart home intervention, a licensed occupational therapist visited the participants' homes from December 2022 to May 2023 to implement the smart home modification program.

Table 2. COPM, EQ-5D change Scores for Participants Who Had a KSHMP.

Evaluation		*M (SD)*		
		Initial Assessment (n = 10)	Reassessment (n = 10)	Change (n = 10)
COPM	Performance	2.7(0.8)	7.5(1.6)	5.0
	Satisfaction	3.2(0.5)	8.1(1.5)	4.9
EQ-5D	Quality of life	0.47(0.07)	0.78(0.03)	0.3

4 Discussion

A smart home is a new home environment for people with physical disabilities in the New Normal era and is important for health-related quality of life [12]. However, rehabilitation experts feel that the smart home is cumbersome and has limitations in its application compared to the development of fourth industrial technology. The fast-developing smart home is a promising new model for the satisfactory daily lives of physically handicapped people. PwPD can experience daily comfort when using a smart home, which coincides with a study indicating that an environment suitable for physical ability tends to lower the dependence on daily life and increase the health-related quality of life [25]. Participants in this study applied the smart home technology to remain in their home environment for as long as possible. The occupational therapist evaluated the occupational performance in the bedroom based on the occupational profile. Through the occupational profile and occupational performance evaluation, uncomfortable activities due to the physical limitations of the study participants were observed, and the strengths and barriers of the environment were identified and modified. These points were similar to the existing home modification procedures [26]. Based on previous studies, home modification has been reported to reduce parental burden and housing support costs through the improvement of housing structure, relocation of households, installation of convenience facilities, secured movement, application of auxiliary devices, changed environmental adaptation, and housing applications [27]. In this study, education and tasks related to the smart home were provided to allow the research participants to adapt to the smart home; occupational performance skills were simplified. All study participants experienced the difficulty of learning how to use a smart house; however, they noted that it was essential as they became accustomed to it. As can be observed from previous studies, it was initially evaluated as cumbersome because of the limitations of smart home applications for physically disabled people. However, they became accustomed to the smart home and could participate in limited activities despite uncomfortable hands and walking [28, 29]. Owing to these changes, it was confirmed that they participated in the occupation by controlling the lights, stands, fans, heaters, air conditioners, and curtains in the bedroom, even with their physical restrictions.

5 Conclusion

The study identified interventions and home modifications that can assist PwPD in managing their condition within their homes. Implementing the KSHMP has the potential to encourage the development of cost-effective service delivery models. Utilizing the KSHMP to improve occupational performance and health-related quality of life for PwPD may broaden the scope of research and interventions used in practice, eventually extending to the community for occupational therapists.

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