

# The Development of a Mobile Application for Older Adults for Rehabilitation Instructions After Hip Fracture Surgery

Geriatric Orthopaedic Surgery  
& Rehabilitation  
Volume 12: 1-7  
© The Author(s) 2021  
Article reuse guidelines:  
sagepub.com/journals-permissions  
DOI: 10.1177/21514593211006693  
journals.sagepub.com/home/gos



Youngji Ko, PhD, RN<sup>1</sup> , Jong-Moon Hwang, MD, PhD<sup>2</sup>,  
and Seung-Hoon Baek, MD, PhD<sup>1</sup>

## Abstract

**Introduction:** Older patients with hip fractures require a long time to rehabilitate and recover after surgery. Although effective discharge instructions for long-term recovery are important, the discharge instructions of most acute-care hospitals are often presented as a brochure, which is difficult for older adults to follow. The purpose of this study was to develop rehabilitation instructions in the form of a mobile application for the physical recovery of older adults after hip fracture surgery.

**Materials and Methods:** A mobile application for rehabilitation instructions after hip fracture surgery was developed in ADDIE order of analysis, design, development, implementation, and evaluation. The contents of the mobile application composed of rehabilitative exercises, activities of daily living, pain and nutrition management, fall prevention, and hospital visits. Nine experts evaluated the application and SPSS version 23.0 program was used for data analysis. **Results:** In the mobile application evaluation by the experts, the average score of the contents was 2.22 out of 3 points. The average score of understanding was the highest at 2.42, while accuracy was the lowest at 2.00 in the contents. The average score of the interface design was 2.32 out of 3 points. The average score of consistency was the highest at 2.42, while design suitability was the lowest at 2.25 in the interface design. The experts perceived the mobile application as simple and easy to understand while also suggesting some improvements.

**Conclusion:** The average scores were highest for understanding of contents and consistency of the interface design and lowest for accuracy of contents and design suitability of the interface design. The mobile application was easy to understand and had consistency in design.

## Keywords

older adults, hip fracture, mobile applications, rehabilitation, education

Submitted November 21, 2020. Accepted March 9, 2021.

## Introduction

The incidence of fragility fractures is increasing globally due to the progressive aging of the population.<sup>1</sup> Among fragility fractures, hip fractures often result in the most adverse consequences, including a higher rate of disability, higher healthcare costs, morbidity and mortality<sup>2</sup> and surgery has been reported as the standard treatment.<sup>3</sup> However, short hospital stay due to the burden of medical expenses<sup>4</sup> often lead to considerable burden on physical recovery for older adults and their families after discharge considering that rehabilitation is performed in the hospital where they received their operation depending on the healthcare providing system.<sup>5</sup>

The discharge instructions from most acute-care hospitals are often presented as the form of brochure without any interaction with the patients.<sup>6</sup> Because older adults with hip

fractures require a long time to rehabilitate and recover after surgery,<sup>5</sup> effective discharge instructions for long-term recovery are mandatory. Smartphones, with the advancement of mobile technology, can be used anytime and anywhere as a part of health-care education system<sup>7</sup> and the use of healthcare

<sup>1</sup> Department of Orthopedic Surgery, School of Medicine, Kyungpook National University, Department of Orthopedic Surgery, Kyungpook National University Hospital, Daegu, Korea

<sup>2</sup> Department of Rehabilitation Medicine, School of Medicine, Kyungpook National University, Kyungpook National University Hospital, Daegu, Korea

### Corresponding Author:

Youngji, Ko, Department of Nursing, Daegu Haany University, Daegu 38610, South Korea.

Email: yjko@dhu.ac.kr



applications on it has increased exponentially.<sup>8</sup> Older people has been reported to show significant interest in how to access health-related information<sup>9</sup> and multimedia applications on smartphone devices<sup>10,11</sup> and iPads<sup>12</sup> was reported as effective tools for healthcare education in older adults. Moreover, a recent study<sup>13</sup> showed that understanding of how to use smartphones had significantly improved not only the life satisfaction, but self-esteem, and self-efficacy.

Although a recent report<sup>14</sup> showed the level of access to digital information to 91.7% for the elderly in their 60 s and to 79.4% for those in their 70 s or older, the level of digital literacy which represents the actual ability to use computers and mobile devices, fell sharply to 41.3% in older adults in their 60 s and to 16.2% in those in their 70 s or older. Several problems in smartphone use such as unfamiliarity with terms, small letters and screens, and the burden of cost have been reported to contribute to this low digital literacy levels, which implies the necessity for smartphone designed for easier use, with larger letters, and with less cost for older adults. Therefore, we developed rehabilitation instructions in the form of a mobile application for the physical recovery of older adults after hip fracture surgery, so that they could use it at home or in the community at any time after discharge. This study aimed to present preliminary data on the development and validation of a mobile application for older adults after hip fracture surgery.

## Methods

We developed a mobile application in the analysis-design-development-implementation-evaluation (ADDIE) order<sup>15</sup> for rehabilitation instructions after hip fracture surgery.

## Analysis

Previous studies were analyzed through academic search engines, including PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Research Information Sharing Service (RISS), to identify the educational content of rehabilitation instructions after hip fracture surgery. The key words were hip fracture, surgery, management, rehabilitation, rehabilitative exercises, and discharge planning. We referred to the "Rehabilitation Treatment Guide for Hip-Fracture Surgery Patients" developed in a teaching hospital.

## Design

All the authors took part in periodic meetings, and a literature review was conducted to develop the contents. The contents of the mobile application include rehabilitative exercises, activities of daily living (ADL), pain management, nutrition management, fall prevention, and hospital visits. The selection of rehabilitative exercises and ADL was evidence-based after the first and second authors reviewed the literature and discussed the exercises required after hip fracture surgery. The rehabilitative exercises are divided into bed, standing, and walking

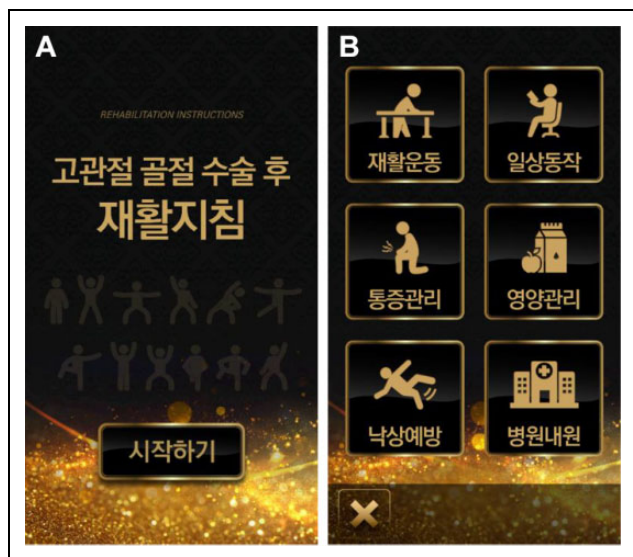
exercises, and we decided on a video format. The rehabilitative exercises also include goal setting in which older adults can set a count for bed and standing exercises and a duration for walking exercises for every day. For example, when they walk with their mobile phones in their pockets, the application is able to monitor the duration of the exercise. When the target time is reached, they can check the achievement of the goal. The ADL includes advice on how to use a bed and a toilet, correct posture, and postures to avoid while sitting in a chair, picking up things, taking a shower, cleaning, lying down, wearing pants, washing hair, and sitting in a car. We also decided to illustrate the actions of using a bed and a toilet using a video format, and correct postures and postures to avoid in the form of pictographs for easier understanding. The information on pain and nutrition management, fall prevention, and hospital visits was based on literature reviews and designed as static images and concise, large-sized characters.

## Development

The main screen of the application was shown in Figure 1. We recorded videos of medical personnel doing rehabilitation exercises and ADL, and added a voice recording of the narration so that older adults can watch the videos and follow the actions. In rehabilitation exercises, bed exercises include lifting the leg, lifting the hip, lifting the leg to the side, and lifting the leg in a sitting position (Figure 2). Standing exercises include raising the leg forward, extending the leg backward, and pulling the leg sideways while in a standing position. Each exercise was recorded as a video with 5 repetitions. Walking exercises include a video of walking using a walker. This application was designed so that older adults set their rehabilitative exercise goals by clicking on an item and to check whether the daily goals were achieved in a rehabilitation journal.

The actions of ADL were also recorded as a video of medical personnel demonstrating how to use a bed and a toilet. The video of using a bed demonstrates going to bed and moving from a wheelchair onto the bed. The video of using the toilet includes moving from the wheelchair onto the toilet seat and vice versa. Each correct posture and postures to avoid are represented in the form of pictographs (Figure 3). The contents of pain and nutrition management, fall prevention, and hospital visits are simple, with large, widely spaced characters (5 mm) (Figure 4). When pointing at the triangular button indicating "next" at the bottom right of the screen, the next screen opens with a sound feedback.

The mobile application was developed based on the Android programming environment and we created a storyboard that determined how the screen should be structured with the help of professional application developers. We took into consideration visibility, such as color, font shape, and large-sized characters, and usability, such as minimal cost for Internet use. The name of the organization that developed this mobile application was indicated. The mobile application was developed with the name "rehabilitation instructions after hip fracture



**Figure 1.** Main screen. **Figure 1-A.** Introduction screen **Figure 1-B.** Initial screen.

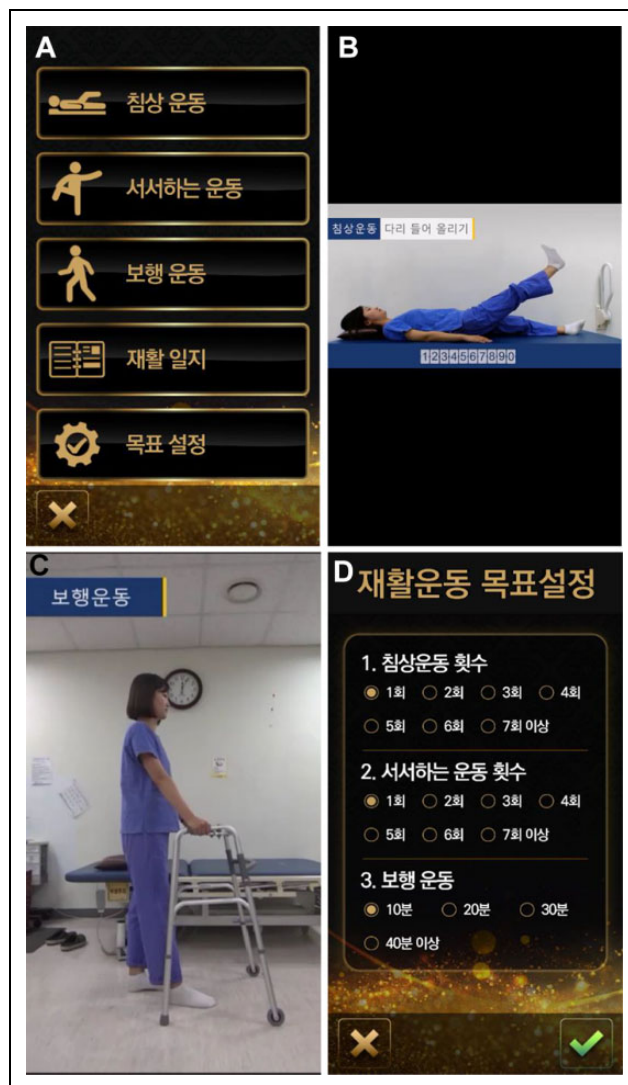
surgery,” in Korean from June to August 2018. This application can be downloaded free from Google Play Store.

### Implementation and Evaluation

Nine experts, including a clinical instructor in orthopedic surgery, 3 orthopedic surgeons, 2 head nurses, and 3 orthopedic ward nurses with more than 5 years’ experience downloaded the application onto their mobile phones and used it for one week. Next, they evaluated the application using a healthcare smartphone application evaluation tool developed by Jin<sup>16</sup> which was approved by the original author via email. The validated healthcare smartphone application evaluation tool consists of 3 categories including contents of 9 items, interface designs of 11 items, and skills of 3 items. The 3 categories are divided into 7 sub-factors: accuracy of 2 items, understanding of 3 items, objectivity of 4 items for content, consistency of 3 items, design suitability of 5 items, vocabulary accuracy of 3 items for interface design, and security of 3 items for skill. The tool consists of a total of 23 questions with a four-point Likert scale, with a higher score indicating a higher quality. The mobile application developed in this study did not require personal information and security associated with skill. Accordingly, the healthcare smartphone application evaluation tool was modified by deleting a skill category that consisted of 3 questions.

### Data Analysis

All data were analyzed using SPSS version 23.0. (SPSS, Inc., Chicago, IL, USA). The 2 categories and 6 sub-factors of the health-care smartphone application evaluation tool are indicated with means and standard deviations.



**Figure 2.** Rehabilitative exercises screen. **Figure 2-A.** Initial exercise screen. **Figure 2-B.** Bed exercise. **Figure 2-C.** Walking exercise. **Figure 2-D.** Rehabilitation exercise goal setting.

### Results

The mobile application evaluation of the experts was shown in Table 1. In the healthcare smartphone application evaluation, the average score of the contents was 2.22 out of 3 points. The average score of understanding was the highest at 2.42, while accuracy was the lowest at 2.00. The average score of the interface design was 2.32 out of 3 points. The average score of consistency was the highest at 2.42, while design suitability was the lowest at 2.25.

Here are some of the experts’ comments and feedback: 1) The application is concise and simple, 2) The video of rehabilitation exercises is easy and helpful for older adults to follow, 3) A function to replay the rehabilitation exercise video is needed, 4) It is necessary to reorganize the exercises by dividing bed exercises into lying and sitting exercises, 5) Goal setting can be difficult for older adults. It is necessary to maximize



**Figure 3.** ADL screen. **Figure 3-A.** Moving from wheelchair to bed. **Figure 3-B.** A correct posture and a posture to avoid.

the font size for goal setting, 6) Some of the video quality needs to be improved, 7) The background color of the application is suitable, but the yellow text is not easy to read.

## Discussion

This study adopted the ADDIE model to develop the mobile application-based rehabilitation instructions for older adults after hip fracture surgery. While rehabilitative education after hip fracture surgery is important for older adults, it is often provided in the form of a brochure without an explanation during the short hospital stay<sup>17,18</sup> and is difficult for low-literate, older adults to read and follow once they are discharged.<sup>18</sup> Thus, effective implements to educate older adults are needed to develop<sup>12</sup> and mobile applications gain popularity to provide health-care education.<sup>8</sup> Since most older adults in many countries<sup>14</sup> are possessing mobile devices, rehabilitative instructions in the form of a mobile application might be effective for physical recovery if some of the problems that older adults may experience when using mobile phones are resolved.

Through literature reviews and experts meetings, the content of the mobile application was developed to include rehabilitative exercises, ADL, pain management, nutrition management, fall prevention, and hospital visits. The content was similar to a previous study<sup>12</sup> that included exercises specific to hip fracture surgery, precautions when moving such as how to transfer safely onto and off a bed or a chair. Notably, rehabilitative exercises and ADL were developed in a multimedia format, allowing older adults to watch and follow instructions sequentially. The multimedia format of rehabilitative exercises and ADL was also found in another study<sup>17</sup> that developed a health-education Compact Disc (CD) regarding pre- and post-operative care, pain control, rehabilitative exercise, methods for safely rising from a bed, and the use of



**Figure 4.** Pain and nutrition management, fall prevention, and hospital visit screen.

walking aids for patients with total knee replacement. It is likely to contribute to a high score for easy-to-understand healthcare contents in the mobile application evaluation conducted by the experts of this study. Multimedia-based materials can be viewed repeatedly, cost-effectively, and are suitable for patients with a low level of education.<sup>17</sup> Goal setting and watching its achievement as a strategy for improving confidence in rehabilitative exercises in this study can be useful to manage self-care effectively.<sup>19</sup>

As evaluated by experts, the healthcare contents are more accessible and may connect ADL effectively through this mobile application's pictographs. The pictographs are explained as simple line drawings of full-body figures with no distracting background to state actions as "DOs" and "DON'Ts".<sup>18</sup> Visual materials are suitable to low-literate older adults for easier learning.<sup>18,20</sup> Choi<sup>21</sup> found that 15 low-literate older adults who participated in a focus group after hip replacement surgery perceived that pictograph-based instructions were

**Table 1.** Experts' Evaluation of the Mobile Application for Rehabilitation Instructions After Hip Fracture Surgery.

Category	Sub-factor	Details of contents	(N = 9) M ± SD
Contents	Accuracy	Healthcare information is reliable	2.22 ± 0.38
		Healthcare information is clear	2.00 ± 0.54
		Total accuracy	2.00 ± 0.54
	Understanding	Healthcare information is easy to understand	2.50 ± 0.54
		Health-related terms are familiar to the public	2.38 ± 0.52
		The level of healthcare information is easy to read by the public	2.38 ± 0.52
		Total understanding	2.42 ± 0.43
	Objectivity	Healthcare information is professional	2.25 ± 0.46
		Healthcare information is systematic and specific	2.25 ± 0.46
		There is a sign indicating that the information is provided by an authoritative organization	2.13 ± 0.64
		The healthcare professionals provide health information	2.13 ± 0.84
		Total objectivity	2.19 ± 0.44
Interface design	Consistency	Consistent in color, placement and presentation	2.32 ± 0.36
		The arrangement of icons is unified with the overall application design	2.25 ± 0.46
		Icons are grouped consistently	2.50 ± 0.54
		Total consistency	2.50 ± 0.54
	Design suitability	It is easy to understand logically by arranging the contents in order	2.42 ± 0.46
		Clearly expresses what the icon means	2.38 ± 0.52
		The font and size are easy to read	2.63 ± 0.52
		The visual components are comfortable for the users	2.38 ± 0.52
		You can understand the structure of the application at a glance	1.88 ± 0.64
		Total design suitability	2.00 ± 0.54
	Vocabulary accuracy	The phrases used in the application are concise	2.25 ± 0.40
		The phrases used in the application are accurate	2.25 ± 0.46
		The application uses correct phraseology	2.50 ± 0.54
		Total vocabulary accuracy	2.50 ± 0.54
			2.33 ± 0.44

helpful in understanding the step-by-step procedures of discharge actions.

Information on pain, fall prevention, and hospital visits, including potential complications, were included briefly in this application with text and static images as they have been reported as the most important learning needs of patients after hip fracture surgery.<sup>22</sup> Although this information was similar to the booklet by Lin et al<sup>23</sup> educating postoperative issues and home self-care with copious pictures for hip fracture patients, it was difficult to compare this study with previous studies because of few relevant studies on the development of mobile applications for those with hip fracture surgery. Malnutrition has been reported to increase mortality rates<sup>24</sup> and thus, nutrition management is important in the rehabilitation of frail older adults after osteoporotic hip fracture.<sup>25</sup> However, nutrition management was addressed in some mobile applications for patient with colorectal cancer<sup>26</sup> or kidney transplantation,<sup>27</sup> but not for those with hip fracture surgery. Thus, we believe that our study to develop the mobile application and validate it might be meaningful to improve rehabilitation in older adults after hip fracture surgery.

Meanwhile, the score was lowest for the accuracy of the contents. We speculated that this low accuracy might originate from the person responsible for the accuracy and verification of the data was not indicated in the mobile application. A study<sup>28</sup>

found that the criteria for evaluating accuracy of health information on the Internet included the source notation, responsibility, and verification as well as the accuracy of the contents. For the reliability and clarity of healthcare information, it is necessary to specify not only the organizations that developed this mobile application but also information providers and data verification.

The interface design of the mobile application consists of consistency, design suitability, and vocabulary accuracy. Consistency scored the highest, while design suitability scored the lowest. Consistency has been reported the most important when evaluating a design, and includes the unified arrangement of the contents, use of a single color in the graphics, and grouping.<sup>16</sup> Meanwhile, the visual components in the design suitability scored the lowest at 1.88 and was comparable to the results of post-operative self-care application evaluation for those after kidney transplantation.<sup>27</sup> The visual components in the design suitability were connected with a comment from experts that the yellow letters on a black background were difficult to read despite the significant difference in color and brightness.<sup>29</sup> A study found that bright letters on a dark background facilitated readability for older adults.<sup>30</sup> Further validation is necessary with the end users to maximize their relevance.<sup>18</sup> Additionally, some comments from experts, including a function to replay the rehabilitation exercise video, subdividing bed

exercises, the font size of the goal settings, and video quality, indicate areas for improvement.

Our study was limited because the mobile application was evaluated by experts in a teaching hospital, but not by end-users including patients themselves and further evaluation by end-users are needed to validate its clinical value.

## Conclusion

Our findings showed that the average score was highest for understanding of contents and consistency of the interface design and lowest for accuracy of contents and design suitability of the interface design. The mobile application was easy to understand and had consistency in design. It might be helpful for older adults to manage their rehabilitation status after hip fracture surgery.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT, and Future Planning (NRF-2017R1C1B5075973).

## ORCID iD

YoungJi Ko, PhD, RN  <https://orcid.org/0000-0002-1961-2678>

## References

- Veronese N, Maggi S. Epidemiology and social costs of hip fracture. *Injury*. 2018;49(8):1458-1460.
- Ensrud KE. Epidemiology of fracture risk with advancing age. *J Gerontol A Biol Sci Med Sci*. 2013;68(10):1236-1242.
- Zhao Y, Fu D, Chen K, et al. Outcome of hemiarthroplasty and total hip replacement for active elderly patients with displaced femoral neck fractures: a meta-analysis of 8 randomized clinical trials. *PLoS One*. 2014;9(5):e98071.
- Clari M, Frigerio S, Ricceri F, Pici A, Alvaro R, Dimonte V. Follow-up telephone calls to patients discharged after undergoing orthopaedic surgery: double-blind, randomised controlled trial of efficacy. *J Clin Nurs*. 2015;24(19-20):2736-2744.
- Yoo J, Lee J, Kim S, et al. Length of hospital stay after hip fracture surgery and 1-year mortality. *Osteoporosis Int*. 2019;30(1):145-153.
- Puls SE, Guerrero KS, Andrew DA. Facilitating safe patient transition of care: a qualitative systematic review. *J Nurs Educ Pract*. 2014;4(6):37.
- Wang Q, Zhao J, Huo X, et al. Effects of a home care mobile app on the outcomes of discharged patients with a stoma: a randomised controlled trial. *J Clin Nurs*. 2018;27(19-20):3592-3602.
- Reyes A, Qin P, Brown CA. A standardized review of smartphone applications to promote balance for older adults. *Disabil Rehabil*. 2018;40(6):690-696.
- Kim M, Kang Y, Jung D, Lee G. Older adults' smart phone use and access to health information. *J Qual Res*. 2013;14(1):13-22.
- Haeger M, Bock O, Zijlstra W. A smartphone based approach to enhance older persons' mobility in daily life. *Gerontechnology*. 2017;16(2):109-114.
- Hong YA, Goldberg D, Ory MG, et al. Efficacy of a mobile-enabled web app (iCanFit) in promoting physical activity among older cancer survivors: a pilot study. *JMIR Cancer*. 2015;1(1):e7.
- Dallimore RK, Asinas-Tan ML, Chan D, Hussain S, Willett C, Zainuldin R. A randomised, double-blinded clinical study on the efficacy of multimedia presentation using an iPad for patient education of postoperative hip surgery patients in a public hospital in Singapore. *Singapore Med J*. 2017;58(9):562-568.
- Han J, Kim S, Suh J. The effect of mobile phone education for the elderly to eliminate the digital divide between generations. *Korean J Educ Gerontol*. 2019;5(1):43-61.
- The report on the digital divide. *Ministry of Science and ICT*. 2017 Dec; NIA-RER-C-17004.
- Seels B, Richey R. *Instructional Technology: The Definition and Domains of the Field*. Association for Educational Communication & Technology; 1994.
- Jin M. *Development and Evaluation of Health Care Smart Phone Application Evaluation Tool [dissertation]*. Seoul National University; 2014.
- Chen S, Chen C, Lin P. The effect of educational intervention on the pain and rehabilitation performance of patients who undergo a total knee replacement. *J Clin Nurs*. 2014;23(1-2):279-287.
- Choi J. Pictograph-based discharge instructions for low-literate older adults after hip replacement surgery: development and validation. *J Gerontol Nurs*. 2011;37(11):47-56.
- Bowen PG, Clay OJ, Lee LT, Vice J, Ovalle F, Crowe M. Associations of social support and self-efficacy with quality of life in older adults with diabetes. *J Gerontol Nurs*. 2015;41(12):21-29.
- Guez J, Lev D. A picture is worth a thousand words? Not when it comes to associative memory of older adults. *Psychol Aging*. 2016;31(1):37.
- Choi J. Older adults' perceptions of pictograph-based discharge instructions after hip replacement surgery. *J Gerontol Nurs*. 2013;39(7):48-54.
- Şendir M, Büyükyılmaz F, Muşovi D. Patients' Discharge information needs after total hip and knee arthroplasty: a quasi-qualitative pilot study. *Rehabil Nurs*. 2013;38(5):264-271.
- Lin P, Wang C, Chen C, Liao L, Kao S, Wu H. To evaluate the effectiveness of a discharge-planning programme for hip fracture patients. *J Clin Nurs*. 2009;18(11):1632-1639.
- Wakabayashi H, Sakuma K. Rehabilitation nutrition for sarcopenia with disability: a combination of both rehabilitation and nutrition care management. *J Cachexia, Sarcopenia Muscle*. 2014;5(4):269-277.
- Ko Y, Baek S, Ha Y. Predictive factors associated with mortality in Korean elderly patients with hip fractures. *J Orthop Surg*. 2019;27(2):2309499019847848.
- Kim K, Park W. Effects of mobile navigation program in colorectal cancer patients based on uncertainty theory. *J Korean Acad Nurs*. 2019;49(3):274-285.

27. Noh SH, Park JS. Development of postoperative self-care mobile app for kidney transplantation patients. *J Korea Acad Industr Coop Soc.* 2016;17(12):316-326.
28. Jung YC, Park HA. Development of a health information evaluation system on the Internet. *Healthc Inform Res.* 2000; 6(1):53-66.
29. Park HS, Kim CM. The effects of color tone and brightness on recall and recognition while information presented in e-learning environment. *J Educ Media Mem Soc.* 2008;14(2):55-79.
30. Lee J, Sung J, Min H, Park Y. Senior readability characteristics of smartphones based on color. *J Korea Soc Color Stud.* 2015;29(1): 83-92.