

Effects of the Tele-Monitoring With the Speech-to-Text Application on Occupational Balance in Healthy Adults : Feasibility Study

Na, Nam Heui^{*}, M.S., O.T., Lee, Seong A^{**}, Ph.D., O.T.,
Lee, Yeong Hyun^{**}, Ph.D., O.T., Lee, Sang-Heon^{**}, Ph.D., O.T.,
Hwang, Do-Yeon^{***}, M.S., O.T., Park, Jin-Hyuck^{****}, Ph.D., O.T.

^{*}Dept. of ICT Convergence, Graduate School, Soonchunhyang University, M.S. Course, Student

^{**}Dept. of Occupational Therapy, College of Medical Science, Soonchunhyang University, Professor

^{***}Dept. of Occupational Therapy, Cheonan Soonchunhyang University Hospital, Occupational Therapist

^{****}Dept. of Occupational Therapy, College of Medical Science, Soonchunhyang University, Assistant Professor

Abstract

Objective : The COVID-19 pandemic has brought non-face-to-face healthcare service delivery system. Research into telehealth system and its efficacy remains unclear.

Methods : Seven healthy adults participated in this study to investigate effects of tele-monitoring with the speech-to-text (STT) application to induce changes in occupational activities on occupational balance in healthy adults. Subjects were requested to choose occupational activities they wanted to have researched and then register them to the STT application. The STT application provided an alarm to check whether the pre-registered activities were performed on time, and whether the subjects performed it by their voice. The subjects were followed for 1 week, with assessments at baseline, and after 1-week's tele-monitoring.

Results : Our findings showed that the subjects were willing to participate in tele-monitoring with the STT application with high adherence and satisfaction. In addition, there was a significant improvement in occupational activities related to health ($p < .05$). Specifically, adherence, satisfaction, and efficacy of the tele-monitoring with the STT application could successfully bring occupational balance in short-term periods.

Conclusion : These findings highlight that tele-monitoring with a smartphone could be considered as one promising way to restore occupational balance in lockdown after the COVID-19 outbreak.

Keywords : COVID-19, Occupational therapy, Speech-to-text, Telehealth, Tele-monitoring

교신저자 : 박진혁(roophy@naver.com)

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I. Introduction

The Coronavirus Disease-19 (COVID-19) has changed the lifestyle of people around the world (Kumari et al., 2020). In particular, it has a significant impact on healthcare, and due to the outbreak of group infections, there is a restriction on care services in nursing facilities. As a result, the community activities of the elderly ceased, and they spend more time alone at home (Kumari et al., 2020). In particular, the ratio of the elderly living alone, the most vulnerable group among the elderly, accounts for about 19.5% of the total older population, and since there is no family members with them, they tend to feel more depressed or lonely, resulting in decreased quality of life (Jeon & Suh, 2004). Therefore, in order to increase the healthy lifespan of the elderly population, preventive intervention is required, and for this purpose, by modifying the lifestyle that negatively affects health conditions, health levels of the older people can be improved and maintained (Won et al., 2019).

Recently, the convergence of information and communication technologies (ICT) supporting health in daily life without face-to-face has been highlighted (Michaud et al., 2021). In the field of occupational therapy, telehealth has been implemented by providing health-related services using ICT when clients are in a different physical location from therapists. Indeed, client's health condition could be supported by tele-rehabilitation, tele-evaluation, tele-consultation, and tele-monitoring (Nobakht et al., 2017). Specifically, tele-monitoring can play a crucial role in maintaining a healthy lifestyle of older people (Michaud et al., 2021). A

previous study indicated that regular home-based tele-monitoring supports older population in their self-management such as weight maintenance and healthy diet, resulting in that older adults could remain independent daily life in their home environment (Verloo et al., 2020). Furthermore, since tele-monitoring might help individuals to feel more secure, it provides emotional stability. In addition, tele-monitoring was provided using a time management intervention based on the Model of Human Occupation (MOHO). The key to a time management intervention is to evenly distribute time within occupation areas in terms of time usage in order to maintain an occupational balance (Kim, 2014; Park & Song, 2015).

According to the purpose of use, tele-monitoring can be classified into one used as a part of tele-rehabilitation programs or another used for motivating and notifying self-care management behaviors (Lee et al., 2017). The former requires continuous monitoring to provide an intervention tailored to the client's level by observing a client in real time and presenting feedback. On the contrary, the latter can reduce the physical burden of therapists as they can notify an appointed time or provide feedback later after confirming a client's performance. However, in latter form of tele-monitoring, a reliability of client's performance is low because it can be confirmed only through client's subjective response (Shin & Park, 2018).

In order to overcome this subjectivity, with advances in the accuracy of speech-to-text (STT), STT enabling the recognition of verbal information into text has been adopted to record client's response and improve the adherence of clients in the medical field (Kim et al., 2015). Communication

with STT can take place easily on a cell phone or mobile device and STT has become a means of communication for not only young adults but also older adults. Indeed, in a previous study, a telehealth program with STT technology was effective in maintaining healthy conditions in elderly people with chronic disease such as chronic heart failure and diabetes mellitus (Lee et al., 2017). Specifically, a previous study reported that clinical benefits were achieved by enhancing motivation to engage in self-management in subjects with chronic heart disease (Guo et al., 2019). Considering that STT technology can facilitate the recording of data that are difficult to retrieve, as it enables individuals to easily access tele-monitoring system and input their data without additional equipment to collect data, a telehealth program with STT technology might be a way for improving clinical outcomes in individuals with chronic disease. However, even though, telehealth could be also useful in healthy subjects, data regarding the role of this its delivery system in the self-management of healthy individuals are scarce (Lee et al., 2017).

Given that there is great potential for telehealth services to bring benefits to general population, it is necessary to investigate the applicability of telehealth through STT technology for healthy adults in the current situation such as COVID-19. This study was to exam effects of tele-monitoring with STT application on occupational balance by developing the STT application and applying it to community-dwelling healthy adults.

II. Methods

1. Design and setting

This study was to develop a STT application for tele-monitoring and to evaluate its efficiency in healthy adults. For this purpose, this study included two major steps. In the first step, a STT application for tele-monitoring was developed by designing an alarm function to which the STT system was applied. In the second step, tele-monitoring using the STT application was implemented for seven healthy adults to manage their life and its efficacy was investigated. Prior to this study, all subjects received oral and written information about the study and written informed consent was obtained from each subject. This study was approved by the Institutional Review Board of Soonchunhyang University (Approval number: 1040875-202005-SB-038).

2. Participants

Seven healthy adults dwelling in local communities were recruited. The inclusion criteria were as follows: 1) intact global cognitive function, as confirmed by a score ≥ 24 on the Korean version of the Mini-Mental Status Examination (MMSE-K), 2) independent activities of daily living, and 3) the absence of a disease requiring medical care. Exclusion criteria were as follows: 1) the presence of a visual or auditory impairment, 2) experience of a sudden change in life within 3 months, 3) residents of nursing facilities such as a nursing home and sanatorium, and 4) those who refused to use a mobile device.

3. Speech-to-text application and its usability for tele-monitoring in occupational therapy

An application using STT technology was developed for a telehealth service and specifically targeted at healthy adults. This application was designed to enable voice notification according to a schedule set by a subject and voice recognition to record subject's response to the notification (Figure 1). All voice data were automatically stored, and an experimenter can analyze the data to confirm subject's performance. The developmental language for this application was Java 1.8, Kotlin, and the targeted platform was Android API (Android 5.0 Lollipop+). This application was developed using IntelliJ 2020.2. All subjects were provided with a mobile device with this application installed and learned how to use it.

4. Tele-monitoring in occupational therapy

All subjects participated in the tele-monitoring service using the STT application installed in a smartphone for a week. All subjects were already handling a smartphone well enough and sufficient practice time and education were provided to learn how to use the application. Before using the application, to analyze subject's occupational balance and time usage, the Occupational Questionnaire (OQ) and the Korean version of the Life Balance Intervention (K-LBI) were used. After then, desired occupational activities presented in the K-LBI were selected through an interview, and the experimenter registered the selected occupations in the STT application. Daily recording for a week confirmed whether the occupations were performed according to the designated plan. On the last day, subject's satisfaction and effectiveness of the

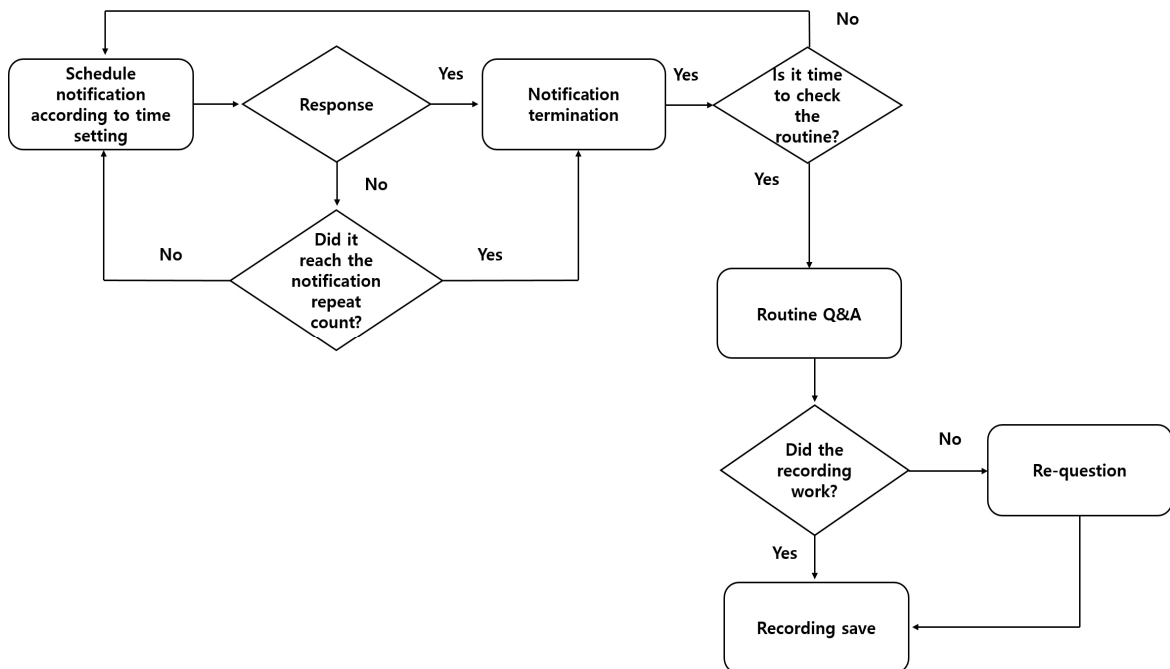


Figure 1. The Process of the Telehealth Service With the Speech-to-Text Application

Table 1. Tele-Monitoring in Occupational Therapy Contents

Order	Program	Content
1	Time usage and occupational balance analysis	<ul style="list-style-type: none"> • Time usage analysis • Pre-occupational balance
2	Occupational activity selection	<ul style="list-style-type: none"> • Occupational activity selection through interview
3	Intervention	<ul style="list-style-type: none"> • Meaningful occupations placement in insignificant time confirmed by time usage analysis • Notification for newly placed occupations registration in the speech-to-text application
4	Analysis	<ul style="list-style-type: none"> • Subject's performance confirmation through a voice recording • Subjective satisfaction and effectiveness investigation

telemonitoring service using the STT application were measured through an interview. The whole process of tele-monitoring in occupational therapy was indicated in Table 1.

5. Outcome measurements

1) Occupational Questionnaire (OQ)

The OQ was developed to measure volition and activity patterns based on the MOHO. The OQ divides 24 hours into 30-min from 5 am, and a subject is asked to fill out what kind of activities he or she usually engages. Each activity written by the subject is classified into 4 types (self-care, work, leisure, and rest), and his or her perceived ability, importance, and enjoyment relative to activities were scored on a scale of 1 to 5. The OQ's reliability and validity were verified, and it has been widely used in several studies to evaluate time usage and occupational participation (Smith et al., 1986). In this study, the original OQ was translated into Korean and used to analyze time usage and to place meaningful occupations in insignificant time periods.

2) Korean Life Balance Inventory (K-LBI)

The LBI is a self-assessment questionnaire to measure life balance developed by Kathleen Matuska based on the life balance model and consists of a list of 53 activities in occupation areas such as activities of daily living (ADL), work and play (Matuska, 2011). The Korean version of the LBI (K-LBI) was developed, and its Cronbach's α was 0.875 for healthy adults. The K-LBI requires a subject to select activities he or she want or is doing out of 53 activities based on the last month and check the satisfaction according to how much time he or she spend on activities matches he or she desired time. The 53 activities are classified into 4 sub-scale (health: 6, identity: 15, challenge and interest: 20, and relationship: 10, etc: 2), and subject's occupation balance status can be evaluated by measuring the level of a sub-scale score (Park & Park, 2019). The degree of agreement between the desired time and the actual time is scored from a maximum of 3 points (usually as much as I want) to a minimum of 1 point (always less than or more than I want). The closer the score is to 3, the better the balance between occupations is interpreted (1.00-1.49: very unbalance; 1.50-1.99: unbalanced;

2.00-2.49: moderately balanced; 2.50-3.00: very balanced). The K-LBI was performed before and after the intervention by one occupational therapist.

3) Satisfaction and efficacy

The satisfaction and efficacy questionnaire consist of three items asking about satisfaction with the telehealth and four items asking about subjective effectiveness. Each item was on a Likert 4-point scale (very negative, negative, positive, very positive). In addition, general opinions about the telehealth service were recorded through an interview after the intervention.

6. Data analysis

All data were analyzed with SPSS Statistics for

Windows 25.0 version (SPSS Inc., Chicago, IL, USA). The general characteristics of subjects were analyzed using frequency analysis. To investigate the efficacy of the telehealth service on life balance, the Wilcoxon signed rank test was used. The subjective satisfaction and effectiveness were analyzed with descriptive statistics. All statistical significance was set at $p < .05$.

III. Results

1. Participant characteristics

Subjects were 7 healthy older adults over 50 years old and their general characteristics are presented in Table 2.

Table 2. General Characteristics of Subjects

(N=7)

Characteristics		n (%)
Sex	Male	2 (28.6)
	Female	5 (71.4)
Age (years)	< 65	2 (28.6)
	≥ 65	5 (71.4)
Education period (years)	6	4 (57.1)
	9	2 (28.6)
	12 ≥	1 (14.3)
Religion	Presence	3 (42.9)
	Absence	4 (57.1)
Job	Presence	1 (14.3)
	Absence	6 (85.7)
Subjective health condition	Satisfied	1 (14.3)
	Neutral	4 (57.1)
	Dissatisfied	1 (14.3)
	Very dissatisfied	1 (14.3)

2. Adherence

Adherence by each subject was analyzed by the time and contents of the recording files for a week. Adherence was calculated as a percentage of the number of response based on the number of alarms asking if a designated activity was performed. Subject 1, 3, and 6 had 100% adherence, followed by subject 4(95%), 2(88%), 5(86%), and 7(86%). The average adherence of 7 subjects was 93.57%, suggesting that overall adherence rates were high.

3. Subjective satisfaction and effectiveness

The average score for subjective satisfaction with

the telehealth service was 3.00 points, and the average score for subjective effectiveness was 2.53 point (Table 3). The average scores of subjective satisfaction and effectiveness were close to 3.00 point, indicating subjects' positive response.

4. Occupational balance

The average of the K-LBI score at pre- and post-intervention was compared. As a result, a significant improvement was observed in the health scale ($p=.027$). The overall score on the K-LBI increased by 0.12 points, and the sub-scale score improved by 0.26 points in the health, 0.09 points in the identity, and 0.18 points in challenge and

Table 3. Subjective Satisfaction and Effectiveness Results (N=7)

Variable	Very negative		Negative		Positive		Very positive	
	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)
Satisfaction	0	0	5	24	11	52	5	24
Effectiveness	3	11	8	28	16	57	1	4

Table 4. Changes in the K-LBI Score at Pre- and Post-Intervention (N=7)

Variable	Pre-intervention <i>Mean (SD)</i>	Post-intervention <i>Mean (SD)</i>	<i>p</i> -value
Overall (score)	2.31 (0.29)	2.43 (0.32)	.108
Health	2.38 (0.30)	2.64 (0.25)	.027*
Identity	2.30 (0.46)	2.39 (0.39)	.671
Challenge & Interest	2.28 (0.38)	2.46 (0.39)	.176
Relationship	2.29 (0.51)	2.06 (0.82)	.674
Activity (number)	25.14 (9.78)	25.43 (10.16)	.746
Health (max: 6)	5.28 (1.49)	5.42 (0.53)	.788
Identity (max: 15)	8.00 (4.50)	8.28 (4.92)	.736
Challenge & Interest (max: 20)	4.85 (2.11)	4.57 (2.50)	.172
Relationship (max: 10)	6.00 (3.55)	6.28 (3.25)	.631

* $p < .05$

interest scales but not in the relationship scale (Table 4). These findings suggested that the subjects showed a significantly improved their occupational balance in health-related activities. Specifically, changes in a score on the K-LBI by each subject were shown in Figure 2. In subject 1, the relationship scale changed from a moderately balanced level to a very balanced level. Subject 3 had changes in all

sub-scale except for the health scale, and the identity and challenge & interest scales rose from an unbalanced level to a moderately balanced level, but a balance decreased in the relationship scale. Subject 4 showed a very balanced level in the health, identity, and challenge & interest scales, and subject 5 had a very balanced level in the health scale. Subject 7 had a very balanced level in the health

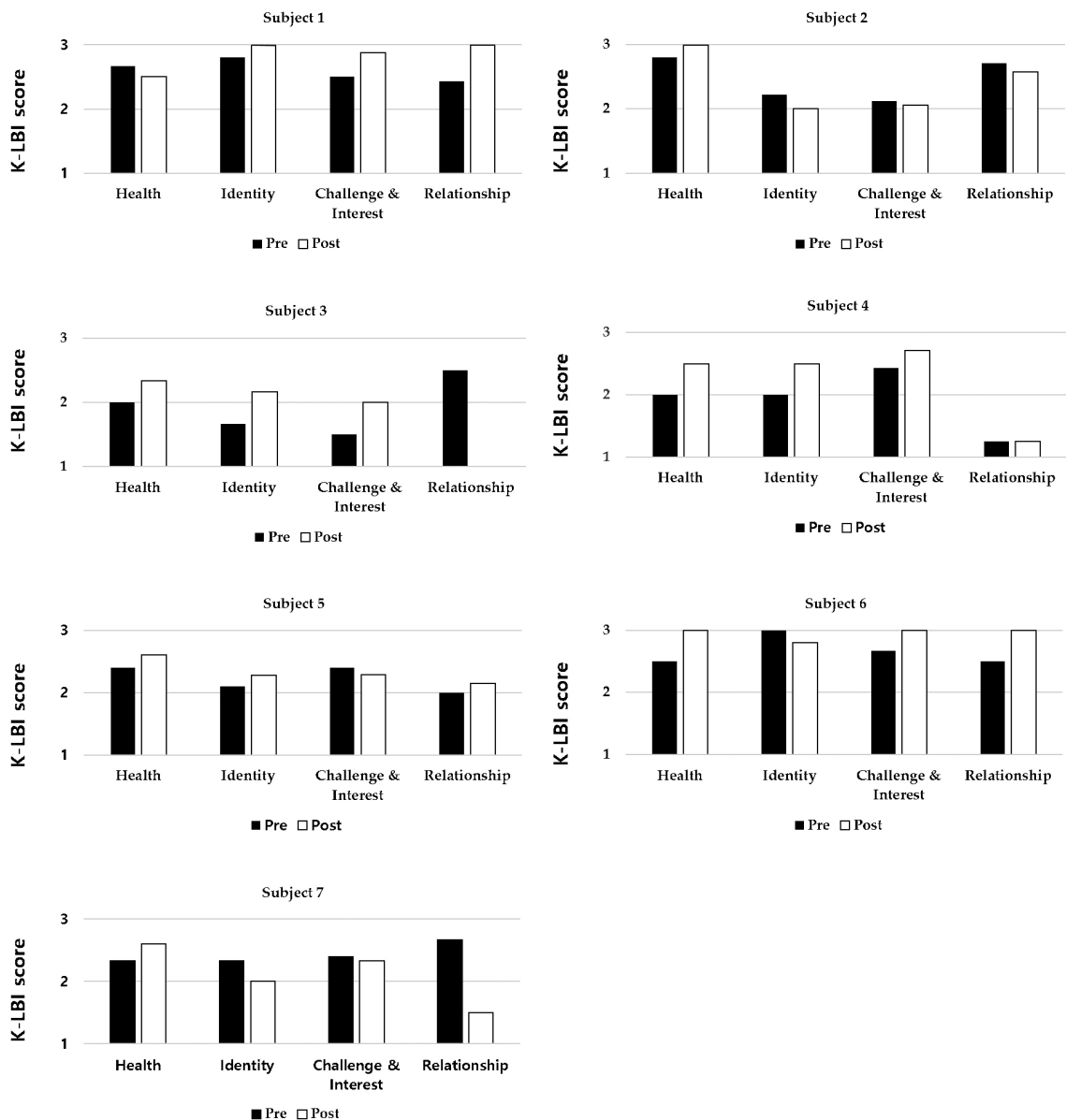


Figure 2. Changes in the K-LBI Score at Pre- and Post-Intervention

scale whereas a change from a very balanced level to an unbalanced level in the relationship scale was observed. Subject 3 and 6 maintained the same balance level at the pre- and post-intervention.

IV. Discussion

This study investigated the effects of the telehealth service in occupational therapy with STT application on occupational balance in community-dwelling healthy adults. The findings of this study indicated that the telehealth service in occupational therapy induced improved occupational balance after 1-week's intervention, which is in line with previous studies (Cha et al., 2018; Sakakibara et al., 2017; Taraldsen et al., 2020; Zhang et al., 2016).

In previous studies, a telehealth service in occupational therapy was applied to individuals with various conditions via a method using communication equipment, and it was found that it is effective in improving their health status (Cha et al., 2018; Sakakibara et al., 2017; Taraldsen et al., 2020; Zhang et al., 2016). However, it has been consistently reported that it is difficult for clients to independently use equipment including a web camera and a conference platform for video conferencing for telehealth. Thus, a technician is recommended to provide technical help to effectively deliver telehealth (Park, 2021). Unfortunately, there are many restrictions on having a technician on every client, so an easy-to-use way is required.

One of telehealth delivery ways that requires the least help from a technician is STT which can recognize voice, allowing to simply conduct commands without complicated procedures. In this

study, by using the STT application, the schedule was recorded by voice, and after receiving an alarm about the schedule, subjects easily managed their occupation schedule by giving feedback by voice. Indeed, in a prior study on user experience for STT, the majority of respondents (85%) reported that they were satisfied with STT, which could increase their telehealth adherence (Lee et al., 2017). In this study, tele-monitoring was performed using the STT application, and high adherence was achieved, supporting the findings of a previous study. In addition, as the result of the survey on the satisfaction and effectiveness of the telehealth service with the STT application, positive answers were given to all questions. This result indicated that subjects were generally satisfied with and feel the efficacy of using the STT application, which has also a positive effect on high adherence. Considering the therapeutic alliance plays a crucial role in clinical outcomes (Glueck, 2013), the high adherence in this study highlights on the way with the STT application to deliver tele-monitoring.

On the other hand, in a previous study, older people tend to decrease their acceptance of technological environment, which would have a negative effect on telehealth delivery (Le Deist & Latouille, 2016). Accordingly, an acceptance of technology of older people over 65 years old needs to be investigated before tele-monitoring with a technology system. Nevertheless, since this study adopted a smartphone for tele-monitoring which could be relatively easy to use and the subjects were already using a smartphone in their life and sufficiently trained to use it, it could be said that their technological acceptance was unlikely to have a significant effect on the findings of this study. A

previous study indicated that a system using a smartphone to deliver telehealth is realistic to older adults, supporting our results (Taraldsen et al., 2020).

The main findings of this study showed that most of subjects reported well balanced occupation in health-related with activities after the 1-week intervention, which is consistent with prior studies (Sakakibara et al., 2017; Taraldsen et al., 2020; Zhang et al., 2016). However, there was no significant changes in occupational balance in remain domains'activities. This disparity could be attributed by differences between occupational activities subjects chose. While health-related with activities consist of hygiene, managing health needs, eating nutritiously, relaxing, exercising regularly, and getting adequate sleep which subjects can easily access, the rests of domains (Identity, Challenge & Interest, and Relationship) consists of activities such as meeting new people, participating in education, or making crafts that are relatively less easily accessible to subjects.

Indeed, in previous studies, although subjects in prior studies were mostly individuals with chronic diseases, they could successfully manage chronic diseases through telehealth and showed results of health improvements. In addition, in another previous study on healthy seniors, a telehealth service delivered by a smartphone and a smartwatch induce a significantly positive health-related activity change without serious adverse events (Taraldsen et al., 2020). These findings suggested that activities in a health area could be changed more easily and positively through tele-monitoring than other areas, and supports the results of this study. These clinical benefits could be attributed by the fact that the time devoted to health-related activities via telehealth

was sufficiently adjusted to the extent desired by subjects (Park & Lee, 2019). Indeed, in this study, although not statistically significant, the number of activities performed by subject 3 and 5 increased by 4, compared to the previous one, which could be interpreted as more diverse activities or interest through telehealth.

A prior study reported that behavioral change is the key to alter individual's lifestyle, supporting our findings. Therefore, the tele-monitoring using the STT application induced a positive effect on lifestyle by restoring occupational balance in healthy adults.

This study has a considerable implication given that the effects of tele-monitoring with the STT application on occupational balance in healthy adults have been rarely investigated. Specifically, even though no subjects had chronic diseases, occupational balance related to health was improved by monitoring occupational activities, which shed new light on the importance of tele-monitoring in healthy subjects. In addition, tele-monitoring has been found to be a future solution to fully protect subjects at home in non-face-to-face ways with the COVID-19 crisis. Nevertheless, a telehealth service could be a complementary tool according to a situation as some studies reported that not all subjects have opportunity to benefit from telehealth and some subjects still prefer to have face-to-face care (Sánchez-Guarnido et al., 2021).

A major limitation is the lack of the number of subjects and the inclusion of a relatively healthy group of young seniors, which would limit generalization of our findings. In addition, subjects were not excluded based on their technology literacy, which might have an effect on the findings

of this study (Park, 2021). Although, subjects with sufficient smartphone experiences participated in this study, future studies need to investigate its effect to clarify the effects of tele-monitoring. In addition, this study confirmed that tele-monitoring could be promising and showed a positive short-term effect on occupational balance, but long-term effects on sustained well balanced occupation have yet to be established as positive findings were induced by only 1-week's intervention, limiting in forming subject's habituation. Therefore, in the future, studies need to be conducted with a larger number of subjects with diverse health status, and it is necessary to verify the effects of tele-monitoring with STT application through a randomized controlled trial design.

V. Conclusion

In conclusion, the tele-monitoring with the STT application has shown that it is possible to deliver telehealth in occupational therapy to healthy adults. Adherence and efficacy of the tele-monitoring with the STT application to bring occupational balance were successful. The tele-monitoring was shown to have the potential to change subjects' occupational activities related to health. If face-to-face care cannot be implemented like the outbreak of COVID-19, tele-monitoring with the STT application could be considered to restore occupational balance. Possibilities for future interventions targeting a larger number of subject with diverse health conditions include longer follow up periods with a randomized controlled trial design.

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음성-텍스트 변환 어플리케이션을 이용한 원격 모니터링이 건강한 성인의 작업균형에 미치는 효과

나남희*, 이성아**, 이영현**, 이상현**, 황도연***, 박진혁****

*순천향대학교 일반대학원 ICT융합학과 석사과정 학생

**순천향대학교 의료과학대학 작업치료학과 교수

***순천향대학교 천안병원 작업치료실 치료사

****순천향대학교 의료과학대학 작업치료학과 조교수

목적 : 본 연구의 목적은 음성-텍스트 변환 어플리케이션을 이용한 원격 모니터링이 건강한 성인의 작업균형에 미치는 효과를 알아보기 위함이다.

연구방법 : 총 7명의 건강한 성인을 대상으로 연구를 진행하였다. 대상자는 실험에 참여 전, 원하는 작업 활동을 선택하였고 이를 스마트폰에 설치한 음성-텍스트 변환 어플리케이션에 등록하였다. 음성-텍스트 변환 어플리케이션은 미리 등록된 작업 활동을 시간에 맞춰 수행 여부를 확인할 수 있도록 알람을 제공하였고 대상자는 음성으로 수행 여부를 등록하였다. 원격 모니터링은 일주일 동안 진행하였고 일주일 뒤, 작업 활동의 변화를 살펴보았다.

결과 : 대상자 모두 일주일 동안 어플리케이션 사용에 높은 순응도와 만족도를 보였다. 또한 일주일 뒤, 건강과 관련된 작업 활동의 균형이 유의하게 향상되었다($p < .05$).

결론 : 본 연구 결과는 스마트폰을 이용한 원격 모니터링이 코로나19로 인한 봉쇄 기간 동안 작업 균형을 회복하는 방법으로 사용 가능성을 시사한다.

주제어 : 원격 모니터링, 원격의료, 음성-텍스트 변환, 작업치료, 코로나19