MEDINFO 2017: Precision Healthcare through Informatics
A.V. Gundlapalli et al. (Eds.)

doi:10.3233/978-1-61499-830-3-136

Promotion of Adequate Exercise for Chronic Disorders' Elderly Through Paced Music

Gi-Ryong Kang[c], Il Kon Kim[a], Woo Jin Kim[b], Do-Youn Lee[a]

[a] *School of Computer Science &Engineering, Kyungpook National University, Daegu, Republic of Korea,*
[b] *Center of Self-Organizing Software-Platform, Kyungpook National University, Daegu, Republic of Korea*
[c] *Samsung Electronics Co., Ltd. Mobile Comm., Gumi, Republic of Korea*

Abstract

South Korean population has been aging at an accelerated rate in recent years and the country will be a hyper-aging nation at 2020. One important issue in an aged society is higher rates of chronic disorders among the population. One of the best means to prevent an increase in severity of chronic disease is making patients exercise regularly. In this paper, we present a mobile app for senior citizens that provides daily exercise recommendations an receive tailored service related to a chronic disorder. In this app, pace (BPM) of played music is regulated to encourage patients to fulfill their daily exercise goal. The combination was constrcuted by using suggestions of World Health Organization and Korea Sports Promotion Foundation. Through our app, users are guided to exercise daily and regularly with appropriate exercise intensity. Patients can deal with their chronic disorders via our mobile application with increased physical activities.

Keywords:

Elderly; Chronic disease; Physical Activity; Mobile Health

Introduction

The Organization for Economic Cooperation and Development (OECD) reported that life expectancy at birth and the amount of increase in life expectancy generally have been on the rise globally. For example, the life expectancy of a newly-born baby in 2009 is 11.9 years longer than that of a baby born in 1960 [1].

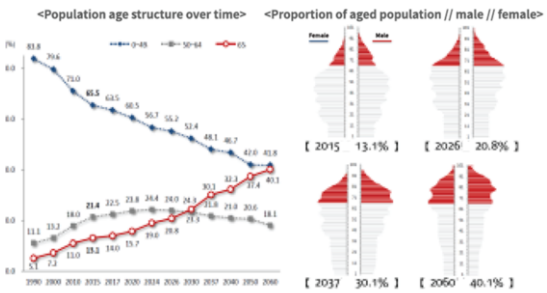

Figure 1 – South Korea's population age structure between 1990 and 2060 (Estimation)

The explosion of older population in South Korea let the rate of chronic disorders increases well as the number of years people live with health issues. Cardiovascular problems, chronic obstructive pulmonary disease, and diabetes are mostly chronic and these chronic diseases plus cancers are responsible for two-thirds of human death in the world [2].

WHO reports that people over 65 comprises 11.8% of South Korea's population and 88.5% of this population suffers from one or more diseases or disorders that are chronic [2].

Explosion of aged population let the rate of chronic disease in the population increase and would pose challenge to medical services, social welfare system, and the economy of South Korea.

This paper proposes a funny app that could help reduce chronic disorder among elderly population. It helps the user to define their exercise goals and work out with songs at measured BPM. We conducted experiments to verify if this app is effective in increasing user's exercise activity.

Methods

In 2010, World Health Organization presented Global Recommendations on Physical Activity for Health, which promotes physical activities for world's population to reduce cancer, strengthen cardiovascular system, metabolism, and musculoskeletal system.

Figure 2 – An excerpt from World Health Organization's health recommendation.

In the Recommendation, people older than 65 years of age are assumed to have limited bodily capabilities and it explicitly recommends to do as much exercise as possible although the recommended amount of exercise cannot be achieved [3].

Based on the Recommendation, South Korean government launched an organization called by'Korea National Fitness Award 100' through Korea Sports Promotion Foundation (KSPO) and published a catalog of physical activities that help with chronic disorders [4].

Table 1 lists a few disorders that can be alleviated with exercises as recommended by WHO and KSPO. Medical research supports the selection of exercises.

Table 1 – KSPO Recommendation-based Exercise program for a few chronic disorders/diseases.

Disorder	Details
High Blood pressure	_Exercise Strength: Over 60% of PssMAX, Rating of Perceived Exertion(RPE): from 11 to 13 _40 min. per session, one session per day (10 min. exercise followed by 5 min. break)

	_Goal: steady increase of exercise amount based on Korea National Fitness Award 100 Exercise Recommendation for Different Disorders.
Hyperlipidemia	_Exercise Strength: Above 75% of PssMAX,RPE: 12 to 16 _30 min. per session, two sessions per day _Goal: steady increase of exercise amount based on Korea National Fitness Award 100 Exercise Recommendation for Different Disorders.
Type 1 diabetes	_Exercise Strength: Above 50% of PssMAX, RPE: 10 to 11 _30 min. per session, one session per day _Goal: steady increase of exercise amount based on Korea National Fitness Award 100 Exercise Recommendation for Different Disorders.
Type 2 diabetes	_Exercise Strength: Above 75% of PssMAX, RPE: 12 to 16 _50 min. per session, one session per day _Goal: steady increase of exercise amount based on Korea National Fitness Award 100 Exercise Recommendation for Different Disorders.

In Table 1, PssMAX (Personal Speed Step MAX) is a scale to measure subjectively experienced exercise exertion, and it is calculated based on the speed, distance, time, and the number of steps measured via Samsumg SmartPhone health App.

To measure PssMAX accurately and reliably, advanced medical instruments are necessary along with trained professionals.

However, this is costly, time-consuming, and hardly practical for the majority of elderly population, hence we opted for PssMAX, which can be readily estimated with a simple smartphone. Instruments that measure such indices are not only expensive but also requires trained professionals for measurement of these criteria in indices, hence RPE (rating of perceived exertion) is popularly used as an alternative.

Borg's table as shown in Figure 3 can be adopted for RPE scores. It offers the benefit of subjectively experienced exertion of exercise and it could supplement heartbeat rate-based scales. In short, RPE score can easily be used for general public to rate how strenuous a given exercise is.

The goal of the proposed app is promoting sustainable physical activities customized for those who suffer from chronic disorders. Presenting a simple fact alone that physical activities could alleviate chronic disorder does not automatically increase physical activities. This is true not only for elderly people but also most of the people in general.

This point could be addressed with elements that are entertaining. 'Entertainment' is defined as 'the action of providing with amusement or enjoyment' according to Oxford English Dictionary. Entertainment enriches life and helps sustain it meaningfully.

Entertainment is one major benefit that elderly take from information technology [5], and if an element of entertainment could be added to exercise, users are more likely to use the service. With this line of thought, we added music to help users get motivation.

The relation between the tempo of given music during aerobics exercises and change in the body of exercising individuals has been explored among elderly women living in Seoul [6].

One participant group exercised with slower songs of 66 BPM (Andante), another group with faster songs of 132 BPM (Allegro), and the control group exercised 3 times a week for 12 weeks. At the end of the period, both exercising groups had reduced body weight and body fat and increased muscle mass while the control group showed less significant body fat reduction and increased body weight.

During aerobics exercises, adequate BPM of music was found to improve oxygen uptake, respiratory exchange rate, minute ventilation, and carbon dioxide exhalation [6].

The issue is that measuring exercise capabilities requires various physiological indices. Among them, heart beat rate and maximal oxygen uptake are most widely used.

[Rating]	[Perception of effort]	
6 7 8 9 10 11	Very, very light Very light Fairly light	How you feel when lying in bed or sitting in a chair relaxed. Little or no effort.
12 13 14 15 16	Somewhat hard Hard	Target range: How you should feel with exercise or activity.
17 18 19 20	Very hard Very, very hard Maximum exertion	How you felt with the hardest work you have ever done. Don't work this hard!

Figure 3 – Borg forRPE (Rating of Perceived Exertion) Scale.

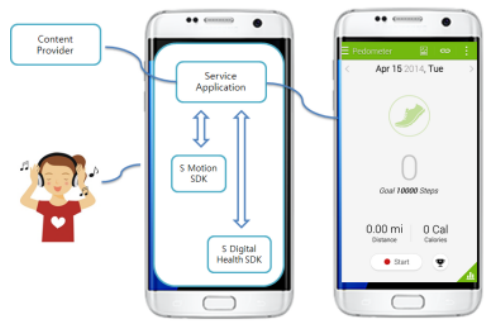

Figure 4 – Service Architecture.

The overall structure of the proposed app is depicted in Figure 4. The Application consists of the following modules: Content Provider Server, S Motion, S Digital Health, and the app itself. Service Application is the core of the service, the external Content Provider Server is responsible for providing music lists when the user is exercising, and the Application requests appropriate music list based on user's current exercise data, which is stored in the S Health DB. S Health Tracker helps browsing exercise data for hour of the day or for each date. The Content Provider offers 'oldies' songs popular among senior citizens at a low cost. Each song is tagged with BPM for different levels of exercises.

By default on the app, two music lists are created: one for songs with lower BPM and the other with high BPM. As the service gains user attraction, we believe more songs could be provided.

No known commercial music service exists that fits our description, however, as the elderly population explodes and they become more comfortable with using mobile devices, we expect to see in the future these music service apps on the market. S Motion is the solution to collect motion information from the device. It collects from the device sensors raw data related to pedometer or activity recognition or the motions associated with answering the phone.

Figure 5 shows the S Motion architecture [7], involving the following components:

- Applications: One or more applications that use Motion.
- Motion: Motion components for managing specific pedometer and activity events.
- MREngine: Motion components for providing Motion with call motion events.
- SContext: Motion components for providing Motion with pedometer and activity events.

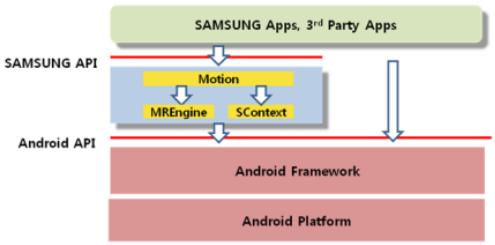

Figure 5 – Motion Architecture.

S Motion is controlled by the Application module. It takes exercise data from SensorHub module via Motion SDK Interface. The exercise data contains the number of steps taken, moved distance, time, speed, and so on. Whenever there is an update to the exercise data, the data is transmitted to the Application through Motion SDK Interface. The following modules were used in implementing our service: Smotion, SmotionPedometer, SmotionPedometer.Info Class, and SmotionPedometer.ChangeListener Interface

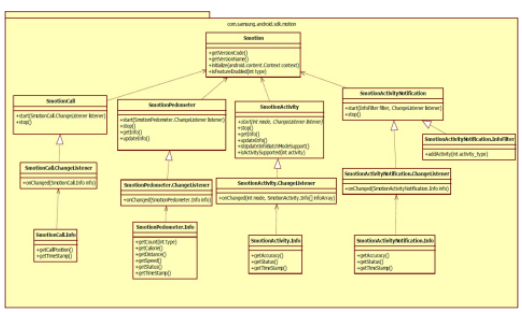

Figure 6 – Motion classes and interfaces diagram.

Samsung Digital Health helps developers to synchronize health data with S Health 4.x safely and to create useful health applications.

The health data framework keeps and provides users health data of various data types safely. Health data from a specific source device that has various sensors such as pedometer, accelerator, or heart rate sensor is inserted based on the unified data unit, read, updated, or deleted through the health data framework.

The S Health Service package provides the tracker feature to show users health data information appropriately on S Health 4.x.[8].

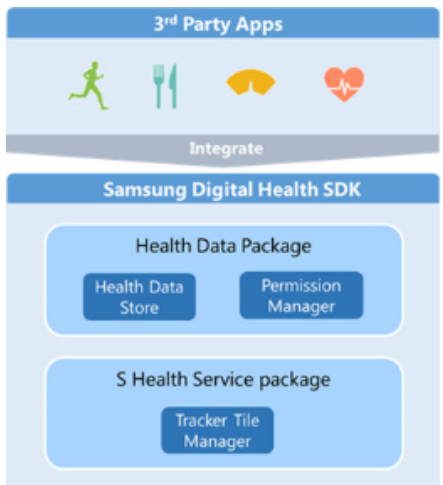

Figure 7 – Samsung Digital Health Service.

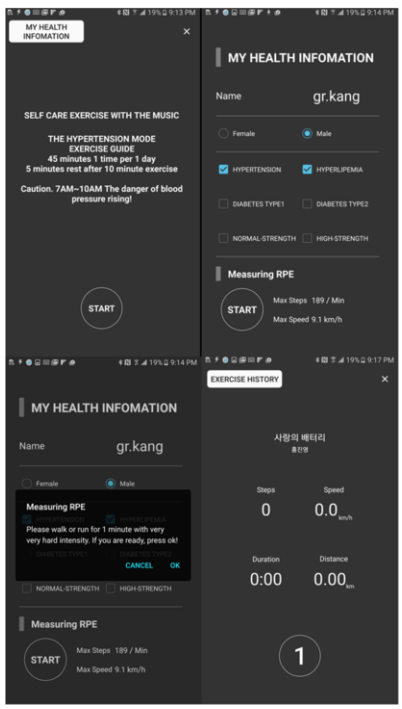

Figure 8 – App screen of Self-Care Exercise with Music.

The overall architecture of S Digital Health is shown in Figure 7. Permission to access S Health Data Type and S Health Data Store is managed with Health Data Package. The Application is granted access permission and processes the exercise data in the form of S Health Data Type when the user has paused or finished exercise and stores the data in Health Data Store database module. Our mobile app includes a service module that provides exercise data recorded through S Health Service Package. To implement this service, we used the following classes: *HealthDataStore, HealthPermissionManager, TrackerManager, TrackerInfo, HealthDataResolver,* and*HealthDevice*.

When the app is launched (Figure 8), an exercise guide is presented based on user preference as specified in the Preference menu. The user could save basic user information,

the type of chronic disease/disorder, and maximum limit for exercise exertion in 'My health data'.

Results

To test the effectiveness of our mobile app, we contacted a local church and asked elderly congregation members to participate in our experiment. A male and a female seniors aged between 65 and 70, and also a male and a female between 71 and 75 participated. Three of them had a different chronic disorder. Their profiles are shown below.

The result showed that music contributed to an increase in physical activities by the participants.

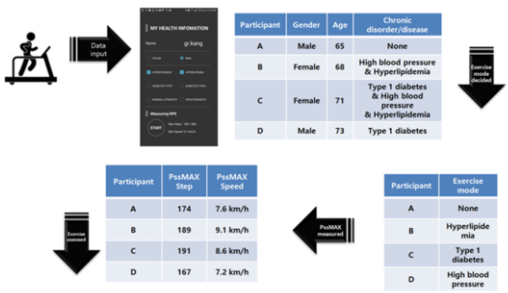

Figure 9 – PssMax data measured for participants.

Table 2 – Application usage data for participants.

Participant	RPE	Recommended pace per minute	Recommended speed	Target steps
A(Healthy)	80%	139	6.08 km/h	5560
B(High blood pressure)	80%	113	5.46 km/h	4520
C(Type 1 diabetes)	80%	96	4.3 km/h	2880
D(Type 1 diabetes	80%	84	3.6 km/h	2520
Before using app (proportion to target steps			**After using app (proportion to target steps)**	
4809 (-13.5%)			5716 (+2.8%)	
4091 (-9.5%)			5058 (+11.9%)	
3110 (+8%)			3395 (+17.9%)	
2144 (-14.9%)			2432 (-3.5%)	

As shown in Figure 9, we had our participants either run or walk fast strenuously for one minute and measured PssMAX with the our app.

Participant B had chronic high blood pressure and hyperlipidemia at the time of experiment, and we set the exercise mode to the easiest one, tailored for high blood pressure patients.

To maintain exercise exertion at 60% of PssMAX, then the person has to take 113 steps per minute at the speed of 5.46 km/h. The person has to take 4,520 steps for 40 minutes.

Participant B took 4,091 steps, which is 9.5% lower than recommended amount, without running our app, while this person took 5,058 steps, 11.9% more than recommended amount.

Table 2 shows recommended exercise goals based on each participant's PssMAX value as determined by the type of chronic disorder the participant has.

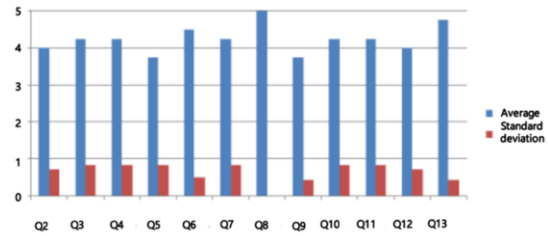

Figure 10 – Summary of PssMax survey results.

The participants were asked how satisfied they were with the service on a 1-to-5 Likert scale, where 5 means most satisfied and 1 means not satisfied at all.

Our participants responded that walking while listening to music is an effective way of exercise, and combining exercise and music makes them energetic and happy.

They also indicated that measuring maximum exercise exertion with their own smartphone rather than advanced instruments is very convenient.

Discussion

Accurate measurement of maximal exercise exertion requires costly instruments and trained professionals. In addition, the average income of elderly population is not high enough to

Table 3 – Survey items about PssMax applied experiment.

- Age:	- Gender:	
①Not likely at all ②Not likely ③Neutral ④Likely ⑤Most likely		
1	I have used an exercise management app on the smartphone.	① ② ③ ④ ⑤
Answer the questions if you answered 'No' in Question 1		
2	This service is unique	① ② ③ ④ ⑤
3	This service is easy to use	① ② ③ ④ ⑤
4	Exercise management service using music is effective in this service	① ② ③ ④ ⑤
5	Tailoring exercise for chronic disorder is effective in this service	① ② ③ ④ ⑤
Answer the following questions if you answered 'Yes' in Question 1		
2	This service is different from other exercise management services	① ② ③ ④ ⑤
3	This service is easier to user than other services	① ② ③ ④ ⑤
4	Exercise management service using music is more effective in this service than other similar services	① ② ③ ④ ⑤
5	Tailoring exercise for chronic disorder is effective in this service in comparison with other services	① ② ③ ④ ⑤
6	Walking while listening to music with this service is enjoyable	① ② ③ ④ ⑤
7	Walking as an exercise becomes more effective while listening to music with this service	① ② ③ ④ ⑤
8	Setting the maximum exercise exertion level with this service is convenient	① ② ③ ④ ⑤
9	Maximum exercise exertion level seems accurately measured	① ② ③ ④ ⑤
10	This service can help me achieving daily exercise goal and forming a daily habit of exercising	① ② ③ ④ ⑤
11	I will sign up for this service when it is officially launched	① ② ③ ④ ⑤
12	I will use this service every day after it is officially launched	① ② ③ ④ ⑤
13	I will recommend this service to others.	① ② ③ ④ ⑤
14	Your comment:	

justify the cost, hence such devices are not easily accessible in everyday use for them. PssMAX offers only a ballpark figure, which is its most obvious limitation.

Just with a smartphone, numbers such as heartbeat rate, blood sugar level, and blood pressure cannot be easily measured. However, many tools that measure these metrics are on the market as wearable devices. Once such devices are connected with smartphones, health apps such as ours could utilize them for improved measurements. Speed, distance, and time can be obtained with the sensors built in smartphones. Certain metrics can be measured more accurately in the future with further development of smartphones.

It is true that short time heavy exercise is more effective than continuous light load exercise, and it is also included in ACSM's physical activity recommendation (over 65 years old) [9].

However, it is important that ACSM recommends increasing the maximum amount of exercise load and time that elderly can do if they are unable to perform heavy exercise because of chronic disease and physical limitations.

Conclusion

The main contribution of our research is that users are guided to exercise with sufficient exertion by using an easy-to-measure scale of PssMAX.Eventually, users' chronic disorders can be managed properly through increased physical activities.

Our mobile app is different from other existing health apps by providing exercise plans that reflect the user's exercise profile and chronic disease/disorder.

In the future work, more sensors could be added to collect user's exercise data. Music selection could be further tailored for different types of chronic disease/disorder.

Acknowledgements

This work was supported by the Technology Innovation Program (10053584, Standardization of Human Genome Sequencing Report in Electronic Medical Record System) funded By the Ministry of Trade, industry & Energy (MI, Korea) and the BK21 Plus project (SW Human Resource Development Program for Supporting Smart Life) funded by the Ministry of Education, School of Computer Science and Engineering, Kyungpook National University, Korea (21A20131600005)

References

[1] Mistry of Health and Welfare, OECD Health Data 2015 (2015), 4-6.
[2] World Health Organization, Increasing Levels of Physical Activity (2010), 10.
[3] World Health Organization, Increasing Levels of Physical Activity (2010), 15.
[4] Korea Sports Promotion Foundation, Korea National Fitness Award 100- Exercise Program for Purpose (2016),
[5] J.U. Ko and J.O. Chang, A Research View of Developmental Task on the Entertainment Industry through the Internet Use of the Old (2011), 299.
[6] B.G.Choi and H.K. Yoon, The Influence of Music Tempo on Body Composition and Functional Fitness for Elderly Women during Aerobic Exercise, *Korean journal of sports science* **21 (2)** (2012), 1061-1062.
[7] Samsung, Motion Programming Guide, http://developer.samsung.com/galaxy/motion (Mar 25, 2016).
[8] Samsung, S Health Branding Guidelines with Samsung Digital Health SDK, http://developer.samsung.com/health (Sep 7, 2016).
[8] Samsung, S Health Branding Guidelines with Samsung Digital Health SDK, http://developer.samsung.com/health (Sep 7, 2016).
[9] ACSM's Exercise is Medicine (2009), 10.

Address for correspondence

Corresponding author:

Il Kon Kim

Computer Science and Engineering Graduate School, Kyungpook National University, Daegu, Republic of Korea

E-mail: ikkim@knu.ac.kr

Author:

Gi-Ryong Kang

Computer Science and Engineering Graduate School, Kyungpook National University, Daegu, Republic of Korea

E-mail: kgr9601@daum.net

Woo-Jin Kim

Center of Self-Organizing Software-Platform, Kyungpook National University, Daegu, Republic of Korea

Daegu, Korea Republic of,

E-mail: yunaloving@gmail.com

Do-Youn Lee

Computer Science and Engineering Graduate School, Kyungpook National University, Daegu, Republic of Korea

E-mail: keveni@naver.com