# Development and Implementation of Mobile Apps for Skier Training System

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Keywords: Skier Training System, Mobile Apps.

Abstract: Most skiers who use smartphones carry them when they ski. Lately internet connection is getting better and there can be active information exchanges between applications installed in smartphones and online operating servers. In addition, with the use of GPS, smart phones can precisely track skier's locations and record the real time information of the gyroscope sensors connected to the Bluetooth of smart devices. This study aims to design and develop a mobile application which can monitor ski trails and analyze ski postures with the help of smartphones technology. For this reason, our mobile application was developed based on Android SDK 4.2 version using Java, and C-language. To measure the information of the skier's posture, a belt with several gyroscope sensors was developed. It records the postures of the skiers who wear the belt when they move their body from side to side and back and forth. Through the application's calculations of the skier's speed and directional turning track data, skiers can know what modifications they need to make in order to improve their techniques and adjust their postures. This mobile application can exchange information with online operating servers with the use of 3G and Wi-Fi. In addition, it operates as a background program in smartphones and starts recording and analyzing when skiers start skiing at designated ski resorts.

## 1 INTRODUCTION

Since the development of computers and their practical uses in a daily life, many studies have been found particularly in the sports training sector. The computer has been used helpfully in finding the most effective method to accurately measure and improve the exercise ability of an elite athlete. As computers develop, various scientific sports programs are being developed to measure and record the physical ability of athletes and manage their conditions. Recently, the current existing research environments have been expanded along with the emergence of smartphones. In the past, a number of sensors were attached to an athlete's body, and then the sensors needed to be connected to a computer by wire in order to measure, in detail, the exercise records of elite athletes. Such devices, however, posed some issues, such as uncomfortable or unnatural movement of athletes, and network disconnection while recording.

Now smartphones can replace the computer. Smartphones use a 'Mobile Communication Network' and are connected to other computers anytime and everywhere if connected to internet network. In addition, GPS, gyroscope sensors, acceleration sensors, illuminance sensors, and other sensors embedded in smartphones can collect various types of information (Dobkin and Bruce, 2013). Therefore, smartphone-based information collecting can be free from the location limits. Also wired smartphone connections can be resolved through various sensors in the Bluetooth wireless module. Along with the development of various equipment including smartphones, many developments and studies are on-going to improve the athletic skills of elite athletes (Chardonnens and Julien, 2014). The studies requiring massive human resources and investments as to improve the athletic skills of an elite athlete are, of course, important. However, additional studies on 'Sports Training Apps' are also needed to boost simple and convenient uses in ordinary people. The studies on mobile apps helpful to improve users' lifestyles are also performed in medical sector as well. Various apps are developed for the purpose of treating or adjusting the patients, such as mobile apps for correcting patient's incorrect posture or for inducing an active lifestyle in teenagers (Gefen et al., 2015; Lubans and David, 2014; Hidalgo-Mazzei et al., 2015). If users use the above mobile apps well, it definitely helps to achieve users' treatment or adjustment purposes (Recio-Rodríguez et al., 2014;



Wook, K. and Yong, K..
Development and Implementation of Mobile Apps for Skier Training System.
In *Proceedings of the 3rd International Congress on Sport Sciences Research and Technology Support (icSPORTS 2015)*, pages 214-221
ISBN: 978-989-758-159-5

Al-Hadithy et al., 2012). Smartphones are considered a convenient device for users since users can install and use various mobile apps in their smartphones. In other words, users can use various mobile apps by simply downloading apps from the app store and installing it into their smartphones (Chittaro et al., 2014).

If users have a strong will for training, 'Sports Training APPS' can achieve their desired training performance without temporal or location limitations. Through these apps, users can control their own skill and check their exercise logs to get a self-feedback. Usually athletes had to check their training logs monitored by a third person, but app users can achieve their skill improvements themselves through a self-report (self-feedback) (Saw et al., 2015). If skiers have access to a monitoring tool that enables them to check their downhill record, it would be helpful to improve their skiing skills. Therefore, the purpose of this study is to design mobile apps that are required for skiers and to explore the applicability and effectiveness of mobile apps at the ski slope. This study is to help in designing convenient mobile apps for skiers who use smartphones. The mobile apps designed in this study include a monitoring feature for skier's exercise logs and postures.

## 2 RESEARCH APPROACH

The mobile apps in the "Health and Fitness" sector that are currently available in the app store are in a ranking order from 'Providing instruction on how to perform behavior', 'Modeling/ demonstrating behavior' to 'Providing feedback on performance' (C onroy et al., 2014). The sector is further classified into 3 broad parts: 'Health Training Apps', 'Exercise Tracking Apps' and 'Motion Tracking Apps'. First, the key functions of 'Health Training Apps' include the followings. The users themselves exercise with their own posture as guided by a personal trainer in the video (7 Minute Workout, 2015; Daily Workout, 2015; Sworkit, 2015). First, the trainees learn about exercising for their health training. Next, the trainees determine the exercise type based upon their purpose of exercise (weight loss, muscular strength, etc.). Based on the exercise type determined by the trainees, the exercise program, recommended by their 'Health Training Apps', are then executed. Their exercise logs are then saved in their smartphones so the users can investigate their exercise logs at a glance. However, such exercise programs pose the following problems. Users exercise without measuring the individual exercise intensity. Health trainers at fitness clubs draw an exercise program considering various variables of their trainees. All items from the measurement of basic exercise unit, '1RM', intensity from exercising to muscular training should be accurately determined. However, 'Health Training Apps' require all users to enter all variables, posing the possibilities that the incorrect variables may be entered. This further poses limits of creating an accurate exercise program suitable to each individual. This problem associated with the variables that should be directly entered by users are also found in mobile apps in other sectors. 'Health Training Apps', which should suggest an exercise prescription without accurately checking the personal characteristics of users, pose a limitation to a 'General Exercise Prescription'. Despite these limitations, this program continues to grow and develop to improve user's convenience (Parikh et al., 2014). Therefore, various variables should be considered in developing 'Health Training Apps' as well as to avoid from making an incorrect exercise program.

Second, 'Exercise Tracking Apps' are considered to be nearly complete. Apps are either already embedded in the smartphones since their release or additionally sold from App Stores. The similarity of these apps are that the user's movements are measured by a GPS-based location traceability or gyroscope sensors embedded in smartphones or smartwatch (endomondo, 2015). If users perform an outdoor exercise such as running or biking, these apps enable tracking and recording of the user's route and speed very accurately. In addition, the outdoor environment such as local weather information is provided to give the users various logs. Also, users can make up their own exercise routes using the information shared by other users. People who actively use these 'Exercise Tracking Apps' can easily post and share their individual exercise logs and lifestyles on social media.

Third, 'Motion Tracking Apps' adjust users' position when they exercise using some equipment. These 'Motion Tracking Apps' are already vitalized in the golf sector and are available on the market now (Nike Golf 360° App, 2015). A device attached on a golfer's hat that serves as a guide for the distance from the hitting point to hole on the golf field is successfully commercialized these days (Voice Caddie, 2015). In addition, there are other apps that analyze the user's swing posture to instruct the correct posture while swinging via a device attached on the golf club (3baysGSA, 2015). Other apps are being developed and sold in the tennis sector. It requires a device attached on a tennis racket to analyze the user's tennis swing and proposes an accurate hitting point (Smart Tennis Sensor, 2015). These products are operated by attaching a simple device on the sporting goods that are connected to smartphones by Bluetooth to trace and record exercise motions. The major manufacturers of sporting goods, such as ‘Nike’ and ‘SONY’, are selling the mobile apps in popular sports such as golf and tennis for sports maniacs. Once the maniacs are satisfied with the mobile apps, the customer satisfaction in the existing business area is also improved (Budd and Vorley, 2013). The reason why many major global manufacturers of sporting goods are selling mobile apps and various accessories is to maintain consumer’s loyalty on their brand. Therefore, the market in sports mobile apps is expected to continuously grow.

Downhill skiing as a sport requires a basic downhill technique. Most ordinary skiers enjoy going downhill at ski resorts. Downhill skiing requires skiers’ technique to safely ski down the slope. In order to go down the hill safely, the skier should focus his or her body weight at an accurate center point. The body angle should be properly tilted toward the inner turning axis in order for skiers to stably spin at a fast speed. The body angle should be changed in proportion to speed and turning radius. The skiers learn the proper body angles through their experience with skiing. If skiers could be advised on how to control their body angle, it would be very helpful for them to acquire an advanced skill. In this study, the location of a skier collected via GPS is analyzed to check the skier’s downhill records. Therefore this study is to assist in the design of ‘Skier Training Apps’ that propose a proper body angle at a specific location. The location of a skier is collected via GPS and the skier’s posture is recorded in the smartphone via gyroscope sensors. The information recorded in the smartphone is saved on an operation server in a real-time manner. In addition, the proper body angle at a particular location is calculated and recorded by an operation server at the same time. Skiers can check their performance logs after skiing. The operation servers then advise the skiers their best body angle at each turning posture.

# 3 PROPOSED METHODOLOGY FOR DESIGN AND DEVELOP MOBILE APPS

The purpose of this study is to develop a ‘Skier Training System’ that collects and analyzes the skier’s posture information in a real time manner. These days, the hardware embedded in our smartphones have been highly developed into the same level as personal computers. However, smartphones require and use many resources in order to perform the basic functions of phone, such as calling, messaging, etc. Thus, smartphones pose difficulty in multi-tasking. ‘Skier Training Apps’ designed in this study, collect information and transfer them onto an operating server as a primary role. Instead of required calculations being done on our phones, they are rather calculated on an online operating server. In other words, the required calculations such as ‘R.A.A. (Recommend Angle Adjustment)’ are performed on an operating server.

## 3.1 Skier Training System Diagram

This study is broadly designed with two subparts: 1) ‘Skier Training Apps’ operated on smartphones; and 2) ‘Operating servers’. The information collected by smartphones is uploaded onto the operating server in a real-time manner (Figure 1).

If the information fails to upload due to poor network connections, it is temporarily saved in the smartphone and then automatically uploaded later once the network is back online. In the operating server, the database system is operated to manage the user’s information. The identification number and user ID are both used as the user’s identification information. When operating the ‘Skier Training Apps’ in the smartphone, the app continues to operate in a ‘background process’ and automatically collects information. This ‘Skier Training App’ automatically performs its function as soon as the skier arrives at the ski resort. The ski resort maps that are shared among the apps, are constantly updated with new information.

## 3.2 Development Environment

The operating server system is composed of a database system and communication system. The database system is built based on ‘Oracle Database 12c’. The communication system with ‘Skier Training Apps’ is made using an ‘XML’. The ‘Skier Training Apps’ are developed using the Android SDK 4.2 version, Java, and C-language. In the smartphones, the low priority process may be exited without prior warning in order to ensure the necessary resources to execute an application program. For this reason, the users of ‘Skier Training Apps’ have voiced-guided logs for skiers once they take a lift for skiing. The users can listen to real time log broadcasts and know the operation status of their ‘Skier Training Apps’.

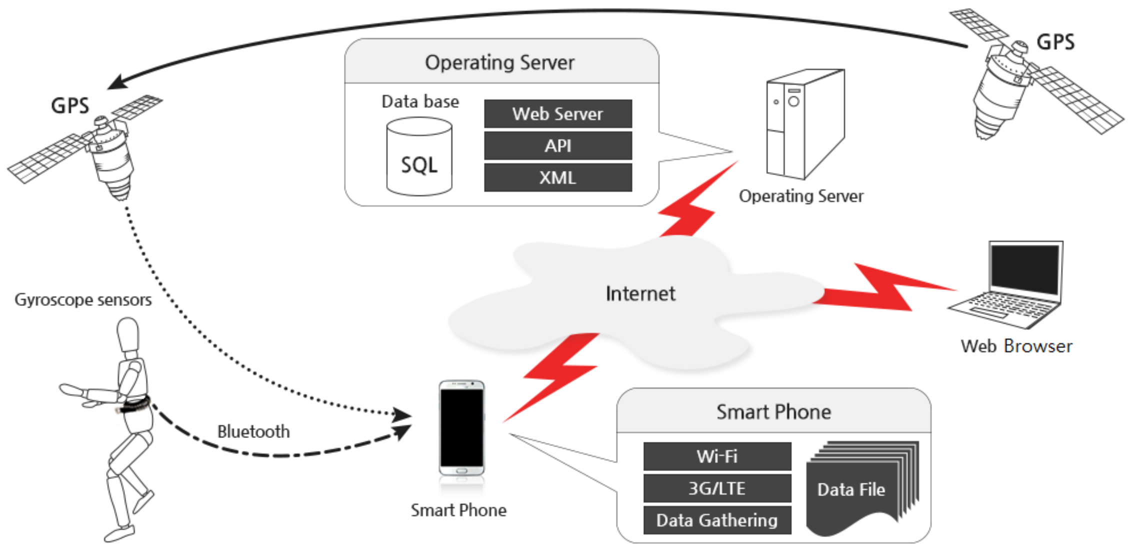


Figure 1: Skier Training System Diagram.

## 3.3 Information Gathering

'Skier Training Apps' that are being used in the skiers' smartphones are connected to two different sensors which are responsible for collecting downhill ski records from a skier. One of the sensors, GPS, collects the data of the skier's current location. If at least three or more GPS signals are received, an accurate location within five meters of the skier can be collected. The collected GPS information is combined with the location data from the user's 'Mobile Phone Network' to give a more accurate location of the skier. The other sensor is a gyroscope sensor that checks the posture of the skiers. Once the skier puts on the gyroscope sensor belt and connects it with his or her smartphone via Bluetooth, the gyroscopes on the belt will be activated and ready to use (Figure 2). Once a skier skis downhill, the position is recorded in a real-time manner via the gyroscope sensors in the smartphone and then uploaded to the operating server.

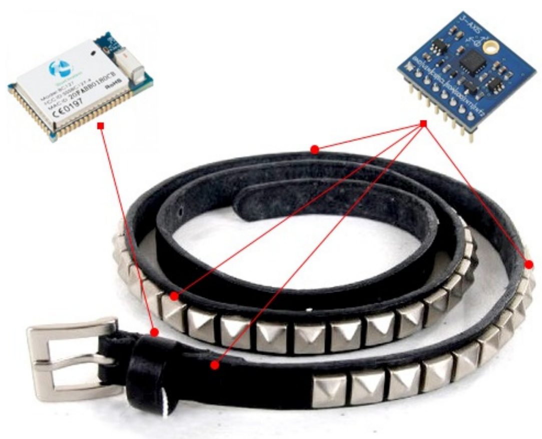

Figure 2: Gyroscope Sensors Belt.

## 3.4 Mobile Apps Design

'Skier Training Apps' are designed to be automatically executed without requiring a special operation. 'Skier Training Apps' are also designed intuitively. The skier completes all preparations by pushing the start button. A skier only needs to check the operation of the 'Skier Training App' once prior to skiing. Once the 'Skier Training App' is activated, the skier will be accurately voice-guided based on his or her travel distance and speed.

If the 'Skier Training App' is already executed while the skier is going to the ski resort, it works in the background of the smartphone's operation to see whether the skier gets on a ski-lift or not. Once it has been confirmed that the skier takes a ski-lift, the skier's activity information will be automatically saved on the operating server (Figure 3). Even though the skier forgets to turn off the app once he or she leaves the ski resort, the app will automatically turn off for the skier's sake. This function automatically operates without pressing the 'stop' button after skiing. As soon as a skier leaves the ski resort, the app stops recording by itself. Skiers can check their ski logs while resting (Figure 4). The log is recorded and listed by 'Season', 'Location', and 'Date'. Each log enables users to check their exercise routes, positions, etc.


Figure 3: Exercise Recording.

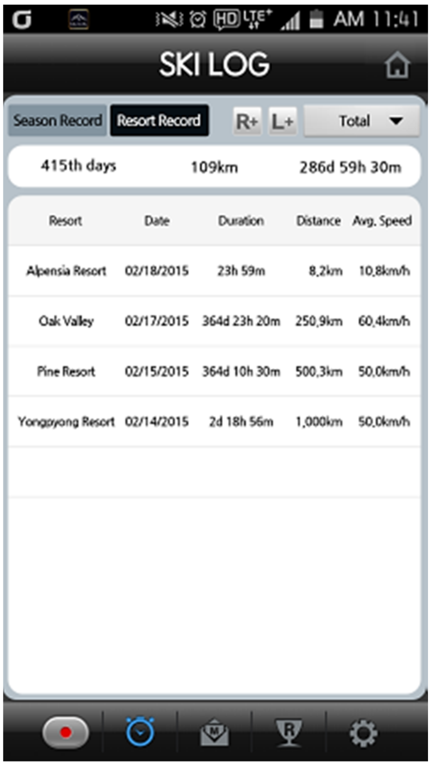


Figure 4: Skier Training Record.

# 4 FINDINGS AND ANALYSIS

The field tests of the ‘Skier Training App’ was performed at five different ski resorts in Korea and three ski resorts in Japan during the 2014 and 2015 season. Five different smartphone types including the Samsung Galaxy S5 were used in this experiment. A total of six skiers participated in the test. The level of GPS signals that were received were different in every resort. Although the signal strengths (three or more) that were received from the GPS satellites were different at every resort, there was no problem with the accuracy of the skier’s location. The disconnection points due to weak GPS signals while skiing were also observed.

At times when the skier skis in an area that is not found by the GPS satellites, the operating server will predict and come up with the missing location info by calculating the last known position with the current one. Additionally, the location information via GPS data and ‘Mobile Phone Network’ will be adjusted and updated on the operating server (Figure 5).

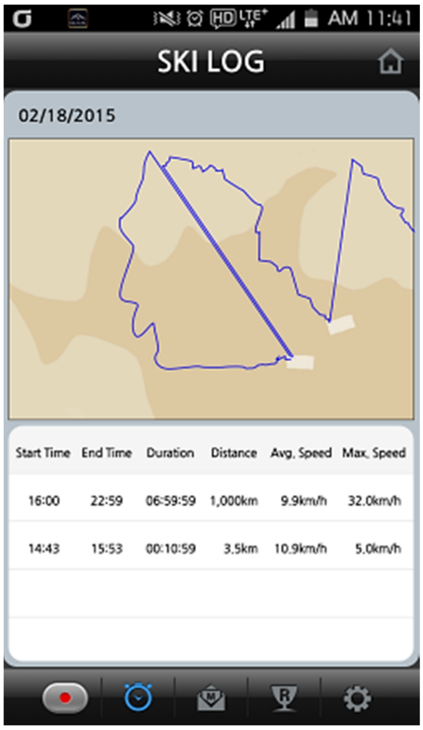


Figure 5: Track Route.

The standard time used in calculations were not based on GPS time but the operating server’s time regardless of different time zones. The time that is shown in the ski log in the same as the user’s smartphone time. The speed of a skier was calculated by 3-D coordinates through the skier's latitude, longitude, and altitude (Figure 6). The irregularity of travel route was not considered.

$$\text{Distance} = \sqrt{((X_1\text{-}X_2)^2 + (Y_1\text{-}Y_2)^2 + (Z_1\text{-}Z_2)^2)}$$

Figure 6: Three-Dimensional Calculation Formula.

However, more than a ten meter deviation was found in the attitude information received by the GPS; so a 'Google Elevation API' was used to adjust the GPS altitude. A skier's speed was calculated considering a 10-second long skier's distance as the basic unit. The skier's speed was recorded every 0.5 seconds and the recorded speed 60 different linearized measurements. Incorrect speed records on the linear graph were adjusted and removed.

Posture information collected via the gyroscope sensors were measured and calculated more precisely than speed. Once changes in the skier's posture were detected by the gyroscope sensors, the sensor information collected at every 0.1 second. The information collected 50 linearized postures so the skier's posture change data was more accurately calculated and recorded (Figure 7).

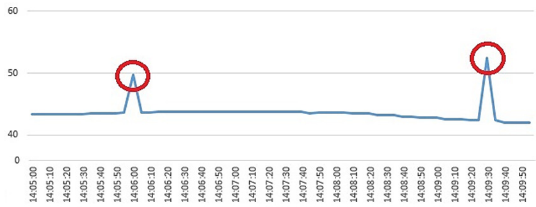


Figure 7: Linear Graph of Speed.

Skiers rarely check their smartphones while going downhill so real-time R.A.A. (Recommended Angle Adjustments) were not calculated. The R.A.A. is calculated as soon as the skier uploads his or her location and posture data onto the operating server. The users can receive their feedback when they check their records while resting after skiing (Figure 8). The R.A.A. was calculated based on the body angle proposed in the 'Downhill Posture Research of Alpine Skiers' (Lee et al., 2013; Scheiber et al., 2012). Other than the recommended body angle of the 'Downhill Posture Research of Alpine Skiers', our test skier's body angle was also calculated considering the skier's speed and directional turning track data.

## 5 CONCLUSION

Even though skiers are eager to develop their ski skills, not many of them improve their skills in the master level training course. By using 'Skier Training Apps' developed in this study, among other things, skiers will be able to check their downhill trajectory. The skiers are also able to check their downhill position at a particular location. The body angle of a skier changes based upon the skier's speed and turning radius when turning while skiing downhill. Then the information collected is analyzed to recommend a skier the best body angle for improvement. Therefore, the skier makes an effort to improve his or her downhill skiing position compared to the recommended body angle. This is a mobile app that enables skiers to check and adjust their posture, definitely helps skiers to improve their skiing techniques. In addition, the skiers can check their ski log data such as duration, distance, burnt calories, etc. This information helps skiers to establish their own exercise plan during the winter season. Therefore, 'Skier Training Apps' developed through this study produced the following results.

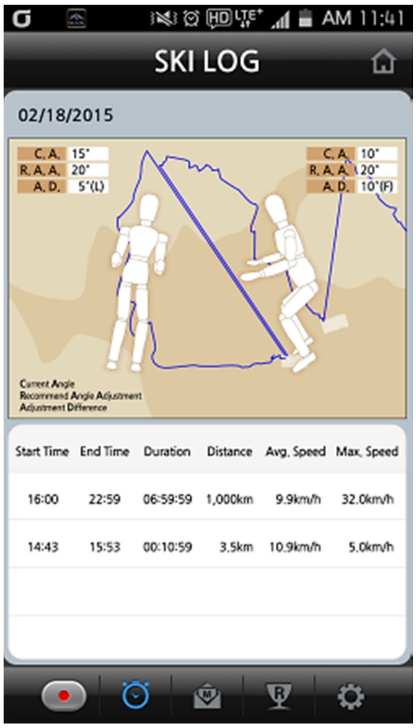


Figure 8: Recommend Angle Adjustment.

First, skiers can check their own ski log. The location collected via GPS is analyzed to record skier's travel route. Next, detailed information such as longitude, latitude, and altitude are calculated for a skier's particular location to give a recommended 'Average Speed', 'Maximum Speed', 'Turning Radius', etc. The personal information previously entered, such as skier's weight, height, age, etc., can estimate the calorie consumption. The above information is gathered so the skiers can set up their own exercise plan.

Second, skiers can adjust and improve their posture. The most important things for downhill skiing postures are 'Joint Angles' and 'Body Angles'. The 'Body Angle' is measured in this study. The information recorded from 'Mogul Ski' and 'Slalom' sports that require instant quick movements of pros, is not consistent with this study. This study has analyzed the 'Middle Turn' and 'Long Turn' done by ordinary skiers while predicting their downhill postures. The body angle is served as a very crucial factor for downhill postures. 'Skier Training Apps' developed in this study analyzed the skier's ski information (speed, turning radius) to recommend the proper body angle. However, the R.A.A proposed in this study is resulted from a simple mechanical calculation without considering the skier's height, weight, and age. The R.A.A. is provided as reference information for the skier, which is not an essential thing that the skier must follow.

Third, the 'Exercise Management Program' was first used by elite athletes and then ordinary skiers. All people who enjoy sports desire to improve their sports technique. Elite athletes are systematically and scientifically managed by a training system of a professional coach for their athletic abilities and performance. This kind of management and coaching helps to improve their athletic abilities. Ordinary skiers can also use 'Exercise Management Program' mobile apps to manage their skill.

Smartphone app technology information has been developed from the user's view, analyzed, and applied. For example, mobile apps that enable dieters to check their food consumption and calories via voice instruction has already been developed (Sun et al., 2015). In addition, smart mini-screens attached inside of skier's goggles to provide skier's information such as their skiing time, distance, altitude, etc. is already available on the market (Zeal Optics, 2015). Applying this technology proposes additional studies shown in the following.

A combination of a camera that can be installed on a skier's goggles to analyze the downhill route and a sensor attached to the skier's legs to measure and record joint angle information can produce data that can give audio suggestions for the skier while skiing. In addition, if there are foot pressure sensors that are attached in the skier's boots, the most precise and stable posture can be proposed to the skier. It can be integrated with wearable devices, such as chest sensor belts, which are already available on the market, that can measure heart rates (Banos et al., 2014). As mentioned above, various types of physical information of skier's can be collected. Therefore, the best exercise program can be recommended using data collected for comprehensive calculation.

More studies are required on the development of various sensors to collect skier's exercise data, as well as how to process the collected information. All studies should be conducted by user interface from user's view for easy and simple uses and they also should be designed based on the strategy applicable to the sales market (Boudreaux et al., 2014). Most of the current available mobile apps enable the users to record their own exercise and give self-feedback to themselves (Middelweerd et al., 2014). If the users check their training contents and make an effort to improve their skill, the mobile app definitely helps them to improve it (Cranwell et al., 2014; Glynn and Liam, 2013; Direito et al., 2015). If skiers properly use the information proposed in this study, their techniques and exercise skills are sure to improve.

# ACKNOWLEDGEMENTS

We would like to thank the anonymous reviewers for their helpful comments on an earlier version of this paper.

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