Reducing Adolescent Obesity with a Social Networking Mobile Fitness Application

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***Abstract*—We present the results of the third phase in a three part study developing an application to reduce obesity levels in adolescents with a mobile fitness application that encourages youth to engage in fitness activity by providing social networking tools to facilitate motivation. In the first phase, we studied effecting positive attitudinal changes towards fitness. The second phase studied physical improvements with the application in our target group. This third phase tests the efficacy of the socialization tools in our application for motivating both positive attitudinal changes and physical improvements towards fitness. The application contained thirteen distinct exercises that subjects could engage in using sensors on the mobile devices to unbiasedly measure progress. The socialization tools to encourage fitness engagement allowed for such activities as friending, sharing progress and collaboratively exercising with friends either in person or remotely. The study participants were adolescents age 14 to 15 with 20 subjects in an experimental group that used the fitness application and 15 control subjects that did not. The study ran for eight weeks with the results indicating both positive attitude changes towards fitness exercises and body-mass index (BMI) improvements in fitness levels correlated to socialization interests/activities for the subjects using the application, while the control group showed no such correlation of fitness level improvement.**

I. Introduction

The emergence of personal mobile devices, such as smartphones, with advanced sensor technology and processing capability, introduces convenient support for customizing health monitoring to individual needs. Along this avenue, we have developed a fitness application that targets adolescents towards combating childhood obesity which has been shown to lead to chronic diseases such as diabetes [1]. In order to motivate unfit adolescents towards physical activity, our research explores tying social networking to fitness activities in a mobile application. As can be seen with the popularity of such social networking applications as facebook, twitter and tumblr, social activity is a popular activity among adolescents. Our main experimental question asks whether social activity can be tied to physical activity in an application to effect fitness improvements both in attitude and physically.

This paper illustrates the third phase of results in a three part study. The first phase demonstrated that opinions of adolescents could be improved with a fitness application. The fitness application was used for 6 weeks in this first phase and limited to only use during school hours [2]. The second phase expanded the use to any time of day over a 6 week period where subjects could take the application anywhere they wished. The second phase demonstrated that fitness improvements could be seen in those that were classified as overweight and obese by the U.S. Centres for disease control's BMI scale [3]. This third phase introduces a control group to compare the efficacy of our social networking tools to effect fitness level improvement against subjects without the application over an eight week period, with experimental subjects using the application at any time and at any location of their choosing.

A key advantage of our approach over previous applications encouraging fitness through technology with wearable sensors is in the use of mobile devices such as smartphones and ipod touch devices. Such devices allow movement anywhere unlike console devices such as the Wii and Xbox fitness applications tying the user to a specific location. This mobility encourages cardiovasular activities such as running and biking which are well suited to adolescents as their fitness focuses more on improvement in heart and lung capacity versus anaerobic strength building.

The main challenge in any fitness application lies in both sparking a subject's interest and then sustaining it to produce sustained improvements. The advantage of using social tools to motivate versus techniques such as gaming, is that friends and social acquaintances theoretically can sustain interest over long periods through social interaction. Game motivators will often lose user interest over time unless continuous novel changes are introduced. Results of our study indicate that socialization tools such as friending, collaborative fitness play and sharing information on fitness activity can be tied to a fitness mobile application to effect improvements in subjects attitudes towards physical activity and their fitness level.

II. Background

A. Obesity and Technology

A recent American study by Jackson [4] looked for a connection between the rising rates of childhood obesity and an increase in information technology (IT) use. The study published in Computers in Human Behaviour found a direct link between IT use in youth and an increased body mass index (BMI). This link is strengthened with research linking

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sedentary technology behaviour with physical inactivity [5]. Here, researchers concluded there was a correlation between these behaviours (time spent on computers, video games, television, reading and other leisure-time activities) and increased physical inactivity. Because of the rapid increase in video game popularity with more than half of adolescents playing video games every day [6], much work has been done in the areas combining exercise and gaming, a term known as Exergaming. This area focuses on playable games that incorporate physical exercise as a main component in gameplay. The most popular example of this in the market today is the Wii Fit and the Microsoft 360 Kinect. When children play video games using these systems, they use significantly more energy when compared to traditional (sedentary) video games [7].

Researchers from California have conducted studies trying to compare the perceived enjoyment of exercising on a treadmill to playing Dance Dance Revolution (DDR). The study concluded that while the rate of perceived exertion was not significant, rate of enjoyment was significantly higher for those playing DDR when compared to exercising on a treadmill [8]. It should also be noted that the total kilocalorie expenditure was not significantly different. This research produced several interesting findings. It has shown that exergaming can be more fun than traditional exercising, which can promote participation and engagement. The research has also shown that while being a more fun experience, users are exerting just as much energy. However, one of the major limitations on this approach is that games tend to lose people's interest over time thus limiting the overall health benefits that exergames may have unless continuous novel features are added to maintain user interest.

B. Mobile Technology and Health

In regards to mobile fitness technology, there have been several studies aimed at combining exergaming, mobile hardware and software. One such example is the work completed by researchers in Dublin who created a campus-wide running game. Their collaborative exergame - LUFTEN, gave users objective destinations to which they would have to run [9]. This work was limited to the development of an application framework with some suggestions made based on work completed. Researchers recommend personalizing the gaming experience to the requirements of the players, as well as adding in social interaction to enable players to collaborate and improve their fitness levels more effectively.

Other work has involved the inclusion of physiological data combined with accelerometer data from the device. A team of researchers from the United Kingdom developed a mobile version of the popular arcade classic Asteroids [10]. Heart rate was recorded using a standard heart rate monitor, and acceleration values were recorded by a modern smartphone. Gameplay was affected by both heart rate and acceleration values. Results showed that while the game did employ both acceleration and physiological data, these input methods should have been designed into the game from it's inception to make these factors have a greater affect on gameplay. Researchers also found that the game was an effective way to encourage players to engage in physical activity. In a similar study, Italian researchers used the current heart-rate of the player to dynamically change in-game metrics with their 'Monsters and Gold' game [11]. The game motivates users to run outdoors using incentives (gold) to battle monsters during their run. A subsequent evaluation of this game confirmed that the game does have beneficial effects on motivation.

Similar to our study, a recent Italian study looked at the effect of social networks but only on running sports [12] and limited to the psychological motivation ratings without measuring for physical improvements. These researchers allowed users to run and compete with others around the world in real-time. The researchers incorporated a fun-oriented design to further enhance the theme of play, collaboration and competition. After running a preliminary study with thirty-five participants the researchers concluded that the application could motivate both those who are non-habitual athletes to begin working out and also those who are more active to continue these active behaviours. Our work expands on that notion by testing for both improved opinion on a broader range of fitness activities and for its efficacy in producing fitness level improvements.

III. Application Design

In this section we will provide a general description of the overall application construction and follow with a description of changes/improvements made from the previous phase two design to this third phase.

A. General Application Design

The application was titled *UOIFit*. The Apple iOS operating system was chosen as the platform because of it's greater adoption [13][14].

Unlike on PCs, where the screen space allows for nearly unlimited functionality, mobile devices lack screen space and for this reason need to be focused in their feature list. With this consideration in mind, the application utilized a three-tabbed interface. Each tab represents different operations within the application. These three tabs are:

- **FitFeed Tab**: The first tab of the application displays all stories posted by friends of the active user as well as a current leaderboard. Similar to other popular social media feeds, the FitFeed displays this data in chronological order, showing the newest stories at the top of the feed. An example of this window is displayed in Figure 1.
- **Exercises Tab**: The exercises tab displays each of the exercises available in the application. They are organized by the areas of the body to which they affect.
- **Friends Tab**: The Friends tab shows a list of current friends, and has an option to add more friends. Adding friends can be accomplished in this tab by tapping the '+' button, which searches the database for a specified name and shows a list of matching names. The Friends

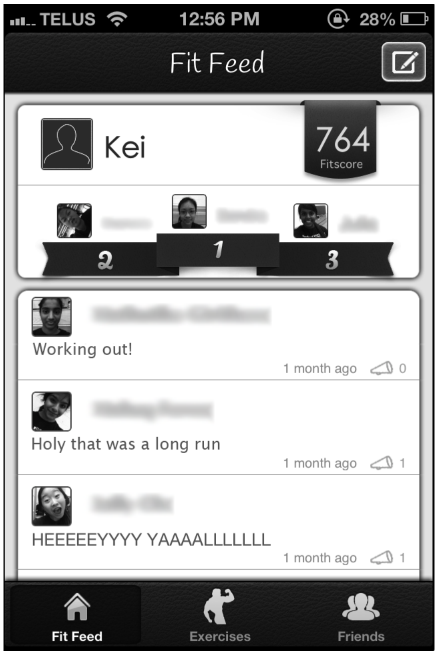

Fig. 1. Fit Feed for user to assess their progress and receive social interaction and encouragement from others

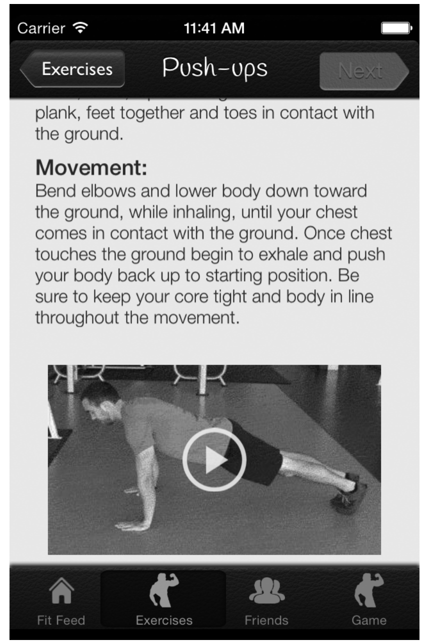

Fig. 2. Sample screen of exercise instructions with video demo.

tab allows for viewing profile pages to show all exercise and social news for a selected profile.

This navigation structure was chosen to eliminate any navigational learning curve for subjects as it is used extensively within both the iOS and Android platform and thus should be very familiar to the users of these devices already. There is a database server to handle communications between user friends and maintain user account information and fitness activity.

B. Social Networking Capabilities

As we described in the general application design, in order to allow for social interaction the first tab of the application displays all stories posted by friends of the active user as well as the current leaderboard. If a user taps on a friend's name within the news feed, that user's profile is then pushed on the navigation controller stack. The content is loaded on first run, and each subsequent update will be performed in one of two ways. First, each time the tab is presented, if the content is older than fifteen minutes it is automatically updated. Second, the FitFeed can be manually updated by the user. This is accomplished with the traditional 'pull down to refresh' concept prevalent in most mobile applications wherein the user simply scrolls to the top of the list and scrolls beyond the bounds of the list. An arrow appears instructing the user to continue pulling to refresh. There are also several features of the applications such as a 'Fitscore' which is an aggregate score from all the exercises performed by the user. It is a feedback mechanism for the user to gauge their fitness progress. Further details on the Fitscore may be found in our phase 1 and 2 studies [2][3].

C. Exercises

The exercises tab displays each of the exercises available in the application. They are organized by the areas of the body to which they affect. The body areas listed in the application are Back/Biceps, Chest/Triceps, Shoulders/Traps, Full Body/Core and Cardio. When a user chooses an exercise from this view, then a detailed view of the selected exercise is presented. This view includes both textual instructions as to how to complete the exercise, as well as a short informative instructional video. All exercises and movement form were chosen and developed in consultation with kinesiology and health professionals. See figure 2 for a sample screen of the 'Push-ups' exercise.

D. Friending Features

The Friends tab shows a list of current friends, and has an option to add more friends. Similar to the FitFeed tab, the content in this view is static and can be updated by the user using the 'pull down to refresh' concept. Each time a friend request is accepted, this view is updated for both parties. Adding friends can be accomplished in this tab by tapping the '+' button, which presents the add friends view. Adding friends is accomplished by searching for a name and then sending a friend request to the selected party. These requests also include a small editable message. The Friends tab is used to quickly view profile pages. By clicking a friend's name, the friend's profile pages shows all their exercise and social news (see figure 3 for a sample screen shot).

E. Exercise Customization

One of the major modifications made from the second to third phase version of our application is the enhanced customization capability for fitness measuring. This feature

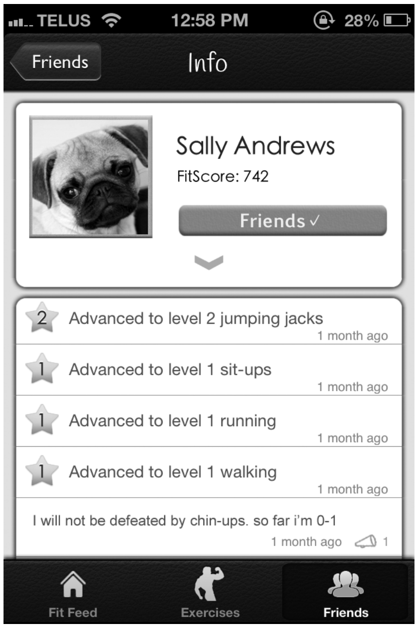

Fig. 3. News feed of a friend showing their fitness progress to facilitate social networking.

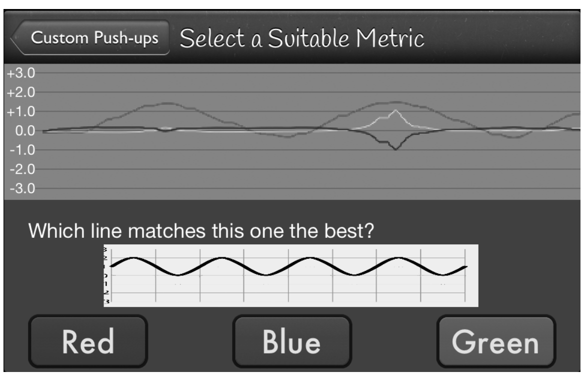

Fig. 4. Customization screen to allow for modification of exercise techniques.

arose from frustration among adolescent subjects at what they perceived as a too restrictive form of movement for some of the exercises. Thus the customization of exercises was incorporated to allow for a wide variety of movement and physical body type. Our customization feature allows for the user to modify the thresholds for counting an exercise to accommodate for varying ability and body type. We accomplished this with an editable pre-defined exercise measurement threshold. Using a step-by-step process, the user completes a few repetitions of the customized version of the selected exercise. From here all the user must do is enter some simple data based on the chart, and their exercise is customized. Visibly customized from the main exercises tab, this altered exercise will then be the only version of that exercise. The user can also revert back to the default form if desired through a settings change. Figure 4 displays a sample screen shot of the customization window selection process.

IV. Study Design

This third phase study involves a total of 35 participants aged 14 to 15 drawn from grade 9 physical eduction classes. Grade 9 students were chosen because in the school board for these subjects, physical education class are still mandatory, producing a range of subjects of varying fitness interest and ability. 20 of the participants were in the experimental group and 15 were in the control group. The subjects were measured on their height and weight to assess their Body-Mass Index (BMI) both before and after an eight week study period during which the experimental group used the social fitness application on iPod touches that were lent to the experimental subject group. Both groups also received a survey that measured their interest levels in fitness, games and socialization activity. After the eight week study period, the experimental group was then given a post-study survey to measure any changes in attitude on the exercises the application allowed them to engage in, provide their opinion on the application and offer any suggestions on improvement.

BMI was used as an approach to assess fitness level as one of the least invasive methods to assess fitness level and also as it corresponds to the United State's Centers for Disease Control's method for classifying subjects as overweight or obese using the technique of those in the upper 5th percentile classified as obese while those between the upper 15th to 5th percentile being classified as overweight.

Participants in the experimental group were provided with a demonstration on the use of the fitness application, proper movements for each of the exercises available on the device and how to customize the exercises to their body type and movement range. The exercises included in this study were: chin-ups, pull-ups, bench press, dips, shoulder press, sit-ups, jumping jacks, jogging, walking, running, swimming strokes and skipping.

V. Experimental Results

In our first test, we measured changes in subject's perception on the difficulty of performing each of the exercises available in our application. Figure 5 plots the 13 exercises along the horizontal axis with changes in the difficulty level on the vertical axis with grey bars indicating that the change was statistically significant at 95%. A scale of 1 to 5 was used with 1 indicating very easy and 5 very difficult. Reported values are the average of

$$prestudy\ opinion - poststudy\ opinion.$$

Thus a positive value indicates the subjects felt the exercise was easier to perform after the study. As can be seen in figure 5, all the exercises except pushups showed subjects felt were easier to perform after the study with six of the exercise improvements reaching statistical significance.

Figure 6 illustrates the changes in the subject's self-perceived fitness capacity on four fitness scales of measure: strength, flexibility, cardiovascular level and overall general fitness. The reported values are the differences of

$$poststudy\ perception - prestudy\ perception$$

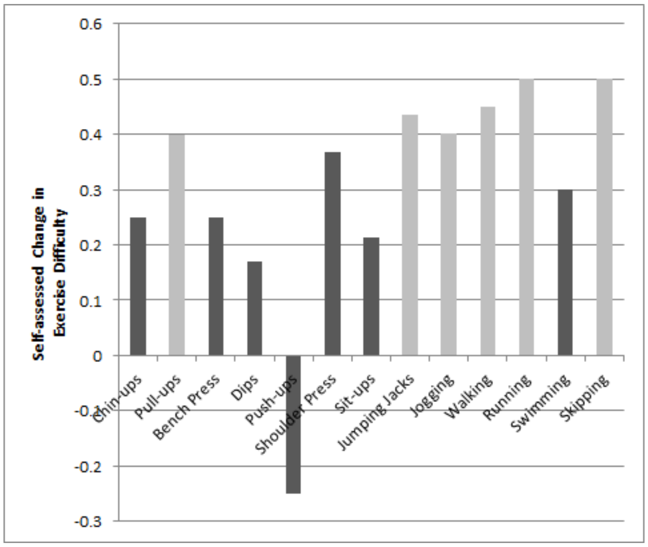

Fig. 5. Changes in opinion on exercise difficulty with values in grey being statistically significant. Above zero indicates positive change in opinion while below zero indicates a negative change.

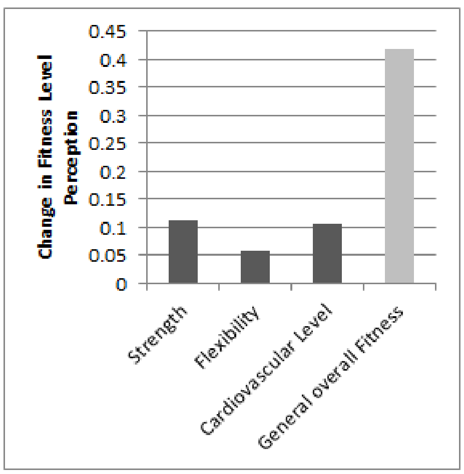

Fig. 6. Changes in self perception of fitness level improvement with value in grey being statistically signficant and values above zero indicating an improvement in fitness ability for various fitness categories (strength, flexibility, cardiovasular level and overall fitness level).

so that a postive value indicates that their preception of their fitness level improved after the study versus before the study. Figure 6 shows that all the fitness measures displayed an improvement in self-perceived ability, but only the overall fitness level reached 95% statistical significance.

We also categorized the subjects into healthy and overweight or obese categories in order to assess unbiasedly any improvements in the fitness levels of subjects. Subjects categorized at a healthy BMI range (according to the CDC) should theoretically stay in that range and have little change in BMI over the study period. Our results for healthy subjects are shown in figure 7. These subjects averaged a BMI change of only 0.04 with the distribution being relatively symmetric with a range of -1.47 to 1.19. Figure 8 shows the distribution

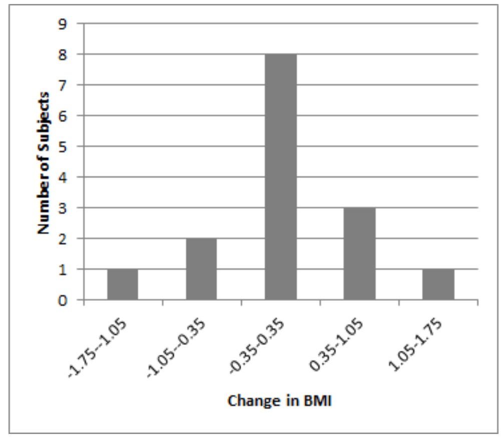

Fig. 7. Changes in BMI level of subjects on horizontal axis vs. number of subjects on vertical axis for healthy BMI level subjects.

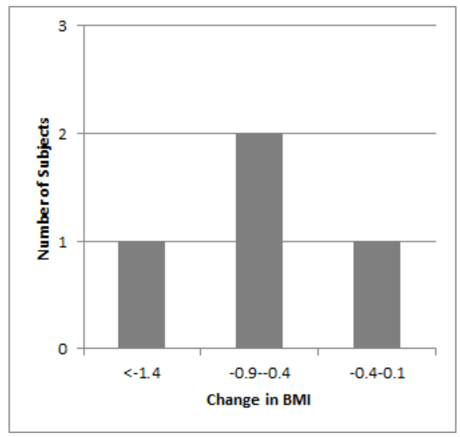

Fig. 8. Changes in BMI level of subjects on horizontal axis vs. number of subjects on vertical axis for BMI categorized overweight and obese subjects.

of BMI change for subjects classified as either overweight or obese (according to the CDC). The average change for this overweight/obese group was -0.73 with a range of -1.47 to -0.24. Thus all the overweight/obese subjects improved in reducing their BMI levels to a healthier range.

Figure 9 is a scatterplot of experimental subjects' rating for using social networking on the horizontal axis against their change in BMI on the vertical axis. Figure 10 shows the same plot of variables for the control group. We measured social networking interest on a scale from 1 to 5 where 1 indicates low interest/use and 5 high interest/use for two types of applications: facebook use and twitter use. The socialization rating in figures 9 and 10 are the sum of the rating for the two social networking applications (twitter and facebook) for each subject producing a lowest possible socialization rating score of 2 to a highest of 10.

The best fit linear regression line is shown in both figure 9 & 10 with the experimental group producing a correlation of $r = -0.48$ (d.f. = 18), which is statistically significant at 95%, while the control group produces a correlation of $r = 0.29$ (d.f. = 13) which does not reach the 95% statistical significance

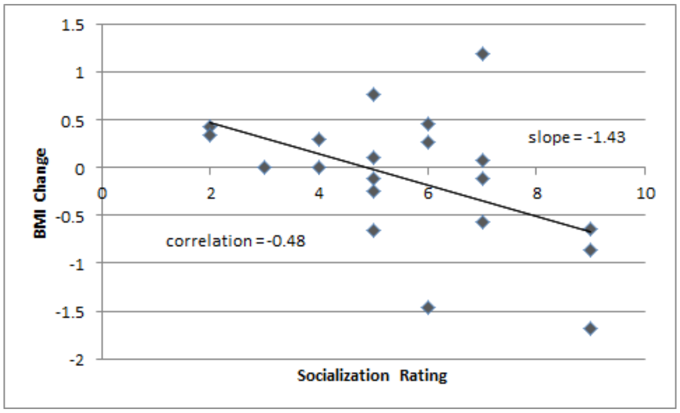

Fig. 9. Experimental group social networking interest on horizontal axis vs. change in BMI level of subjects on vertical axis.

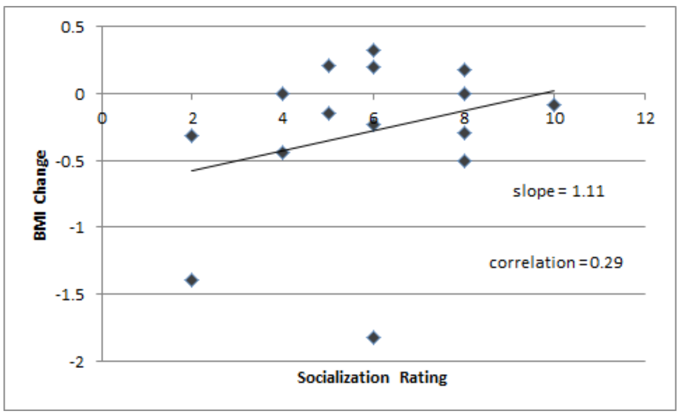

Fig. 10. Control group social networking interest on horizontal axis vs. change in BMI level of subjects on vertical axis.

level. Thus our socialization tools which are meant to help motivate subjects to engage in the exercise activities of our application show a corresponding strong correlation between social activity and reduction in BMI with the experimental group. While no such relationship is shown in our control group. In fact, our control group shows a weak increase in BMI with increasing social networking interest.

VI. Conclusion

Utilizing social networking techniques such as friending, texting, sharing fitness news and allowing for collaboration on fitness goals is a technique that builds on the concept that humans in general and adolescents in particular are social animals. The concept of our study is to test an approach of tying socialization tools to fitness activity in order to inspire interest in fitness activity and produce improvements in fitness levels among adolescents. Our study uses mobile devices with sensor and accelerometer technology to detect and measure progress in fitness activity with social networking facilities allowing both collaborative and competitive engagement with friends in these activities. We studied 14 to 15 year olds drawn from grade 9 high school gym classes which are mandatory for all adolescents in grade 9. Results of our study show that not only did attitudes towards fitness activities improve in our experimental group, but also that against a control group, our experimental group showed a significant correlation in reduction in BMI levels as their interest in social networking activity increased. Thus we have an indication that our socialization tools are aiding in motivating subjects to engage and improve in fitness levels.

Our approach to motivating adolescents differs from numerous other applications which tend to motivate by developing games around the fitness activities. The challenge in using a game venue for motivation is the loss of interest over time in the game unless novel new features are added steadily. The potential advantage of using social networking tools to motivate fitness activity is that social friendship activity has the potential for life-long sustained activity and thus support for life-long fitness activity if the two are successfully related. Thus for future work, we plan to conduct longer term studies to measure the efficacy of our application approach to maintaining fitness interest and activity improvements.

Acknowledgment

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