

# Effect of efitbuddy on promoting physical activity and motivation in college students

PENG ZHANG<sup>1</sup> ✉, YOU FU<sup>2</sup>, RYAN BURNS<sup>3</sup>, STEVEN GODIN<sup>4</sup>

<sup>1</sup>College of Health Sciences, East Stroudsburg University, Pennsylvania, United States of America

<sup>2</sup>School of Community Health Sciences, University of Nevada Reno, Reno, United States of America

<sup>3</sup>Department of Health, Kinesiology & Recreation, University of Utah, Salt Lake City, United States of America

<sup>4</sup>Department of Family & Preventive Medicine, University of Utah, Salt Lake City, United States of America

## ABSTRACT

The purpose of this study was to examine the effect of a theory-based smartphone application, *efitbuddy*, on college students' physical activity and motivation. A convenience sample of 106 college students (mean age = 20.4 ± 2.8 years; 77 females) were recruited from a university located in the Northeastern U.S. Participants installed the *efitbuddy* application on their smartphone, and used it every day over a 2-week time period. Physical activity was measured using a self-recall questionnaire and motivational variables were collected using established surveys. All measures were collected at baseline and at a 2-week post-test time-point. A 2 × 2 Doubly Multivariate Analysis of Covariance (MANCOVA) test was employed to test time main effect and the sex × time interaction effect on each outcome measure, using age as covariate. Results of the study indicated that there was a statistically significant multivariate model (Wilks'  $\lambda = 0.87$ ,  $F(12, 542.7) = 2.49$ ,  $p = 0.003$ ). Statistically significant effects included a sex main effect ( $F(1, 205) = 4.98$ ,  $p = 0.002$ ) and the statistical significance of the age covariate ( $F(3, 205) = 3.73$ ,  $p = 0.012$ ). There were no significant time main effects ( $p = 0.594$ ). To conclude, *efitbuddy* has limited effect on young adults' physical activity and motivation over a 2-week intervention. Additional research with longer intervention periods should be conducted to explore potential effectiveness. **Keywords:** Smartphone application; Physical activity; Enjoyment; Self-Efficacy; College student.

### Cite this article as:

Zhang, P., Fu, Y., Burns, R., & Godin, S. (2018). Effect of efitbuddy on promoting physical activity and motivation in college students. *Journal of Human Sport and Exercise*, 13(4), 799-. doi:<https://doi.org/10.14198/jhse.2018.134.08>

✉ **Corresponding author.** College of Health Sciences, East Stroudsburg University of Pennsylvania. Koehler Fieldhouse #81, 200 Prospect St., East Stroudsburg, PA, 18301. USA

E-mail: [pzhang@esu.edu](mailto:pzhang@esu.edu)

Submitted for publication January 2018

Accepted for publication April 2018

Published *in press* July 2018

JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

© Faculty of Education. University of Alicante

doi:10.14198/jhse.2018.134.08

## INTRODUCTION

Mobile technology (i.e., smartphone applications or “apps”) is emerging as an innovative platform for promoting physical activity among smartphone users (Hebden, Cook, van der Ploeg, & Allman-Farinelli, 2012; Lewis, Lyons, Jarvis, & Baillargeon, 2015). Increasingly, smartphone applications are designed and developed with various methods that attempt to engage the user into being more physically active. These methods include, but are not limited to, the ability to collect on-going personal data, provide tailored feedback to each user, as well as generate motivational messages in effort to incite behaviour changes in the users (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Coughlin, Whitehead, Sheats, Mastrotonico, & Smith, 2016; Middelweerd, Mollee, van der Wal, Brug, & te Velde, 2014). The extensive growth of cell phone ownership by adolescents and youths in recent years, (e.g., 80% smart phone adoption by 12 to 17 year olds in 2013) coupled with the cost effectiveness and ease of disseminating information through smartphones has increased interest in utilizing mobile technology to promote healthy lifestyles among young adults (Stephens & Allen, 2013).

Although smartphone applications are thought to have the potential to influence young adults’ health and health choices, relatively few have been the focal point of an extensive research study. Due to this, there is currently a lack of scientific support behind the theory that promoting physical activity through smart phone applications is an effective way to promote physical activity (Coughlin et al., 2016; Middelweerd et al., 2014). A study by Huang and colleagues (2009) reported users experienced statistically significant increase in physical activity performance (steps) from pre-test and post-test over using a smartphone application intervention. A different study by Fukuoka et al. (2010) utilized sedentary women as participants and discovered that over the course of the three-week study participants had a daily increase of approximately 800 steps in combination with application use. A third study by Stuckey et al. (2011) revealed an increase in physical activity, training heart rate, aerobic capacity and a reduced BMI among older adults when by a coupled with a smartphone application which provided graphical feedback based on step counts and heart rate. Despite the encouragingly positive results these studies showed regarding a smartphones’ applications ability to encourage physical activity promotion, the small sample sizes (<42) present issues of the generalizability of results. Another impacting factor is a lack of theoretical support the applications feature as many applications currently were designed by technology-savvy entrepreneurs. While innovative, these designers often lack professional training and education in health behaviour change methodologies. Many apps are based on theories of health behaviour change but often fail to include established evidence-based features such as reinforcement and recommendations for physical activity are rarely included (BortRoig et al., 2014; Conroy, Yan, & Maher, 2014; Middelweerd et al., 2015).

Self-regulatory behaviours, particularly self-monitoring physical activity levels, has proved to be an important contributing factor in maintaining a person’s active lifestyle (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). Self-monitoring one’s behaviour, as proposed in self-regulation theory (Bandura, 1991) is important since it permits individuals to stay aware of their current behaviours and give the ability to track their performance towards specific goals (Wing & Phelan, 2005) and/or physical activity guidelines (Department of Health and Ageing, 1999). Numerous studies demonstrated there is a correlation between self-monitoring health behaviours and improved health results, such as increased physical activity levels (Conroy et al., 2010) and weight loss (Neve, Morgan, & Collins, 2011; Wing & Phelan, 2005).

The *efitbuddy* application is anchored to the Self-regulation theory (SRT) by utilizing four behaviour-changing techniques; self-monitoring, setting goals, provision of encouragement, and general health information regarding a user’s physical activity. The application comes with a simple, structured layout without any

unnecessary features. *Efitbuddy* allows users to tailor it to their personal preferences by including the capacity to hide features which may hold less interest to users. Moreover, Users appear to be highly motivated by the individualized feedback, ability to set personalized goals, and ability to share their physical activity accomplishments to various social media platforms via the application. *Efitbuddy* underwent multiple phases during its inception and development: 1) paper-based design-layout sketches, 2) discussions with colleagues to determine the app functions and navigation, 3) development of a PDF document to highlight the navigation, 4) development of a prototype, 5) testing and revision. As this is a newly developed smartphone application, no research has been conducted regarding its ability to effectively alter an individual's physical behaviour, its core purpose is to promote an increase in the user's physical activity level. Therefore, the purpose of this study has been to explore the efficacy of a grounded theory-based, smartphone app, *efitbudddy*, and its ability to promote increased physical activity among college students. It was hypothesized that the use of the *efitbudddy* application would lead to increased physical activity levels and motivation over a 2-week intervention period.

## METHODS

### ***Participants***

A convenience sample of 141 undergraduate students were recruited for the study from a public state university in the northeastern United States. A total of 106 individuals (29 males, and 77 females, mean age = 20.38 ± 2.84 years) met the inclusion criteria and completed the study. Inclusion criteria was defined as 1) age between 18 to 35 years, 2) no medical conditions or other physical problems requiring special attention in an exercise program, 3) ownership and ability to use a smartphone that either featured an IOS or Android operating system. Consent forms were obtained from each participant during recruitment and the study was approved by the University Institutional Review Board.

### ***The efitbuddy application***

This *efitbuddy* application uses the build-in accelerometer found in many smartphones to count and record the user's daily steps and provide estimated caloric expenditures. It's design and creation was a collaborative effort by a group of faculty members from Computer Science, Exercise Science, and Public Health at the University of study. *efitbuddy* aims to increase user's physical activity levels by providing 10,000 steps as a measurable goal of physical activity behaviour. This application is an advocate to the public health guidelines of weekly PA participation for adults (Hagloch, 2011; Haskell et al., 2007). The application was designed with both IOS and Android versions which was a free to download available to the public from both the Apple Store and Google Play. The application contained four unique features designed to motivate users to strive for specific goals while encouraging the participant's to increase their physical activity through interactive features.

First, the developers of the application created used a fictional heart avatar, named *efitbuddy*, to represent the user and demonstrate the step accumulation status. This avatar had five versions which indicated various levels of physical activity based on the user's physical activity: Sedentary (0-4999 steps), Low Active (5000-7499 steps), Somewhat Active, (7500-9999 steps), Active (10000-12500 steps), Very Active (above 12500 steps) as shown in Figure 1. As user's increase their step numbers and ascend the levels, the heart avatar becomes stronger and healthier. Second, the displayed version/level of *efitbuddy* is determined by calculating the average number of steps achieved over the previous three days. This function informs users of their average steps from the last three days of use and aims to motivate users to remain active on a regular basis. The research team wanted the users to keep moving everyday so they would remain at high performance level on the application. Third, *efitbuddy* allowed users to specify their intensity or pace of walking as casual

or brisk which helps provide a precise estimate of caloric expenditure. The calculation used to determine this caloric expenditure for each is as follows; casual walking:  $0.57 \times \text{weight (lb)} / 2200 \times \text{total steps}$  and brisk walking:  $0.5 \times \text{weight (lb)} / 1400 \times \text{total steps}$  (Banas, 2017). Finally, the application presented seven health messages about the benefits of physical activity taken from the Centers for Disease Control and Prevention (CDC) website for user motivation. These messages were randomly selected and were presented to the users throughout the day. An example of said messages provided would be “*Physical Activity could prevent 1 in 12 cases of diabetes.*” Beyond these unique features, *efitbuddy* stored daily steps allowing users access to their personal records and enable users to link their physical activity data to various forms of social media. It is anticipated that this interface will enhance user satisfaction while potentially providing additional benefits to user’s who may gain encouragement and social support from friends on social media. The *efitbuddy* app that provides the messages is intended as an entertaining novelty, with the user receiving tailored messages, along with visually identifiable changes to the physical physique as the user progresses towards improved health.

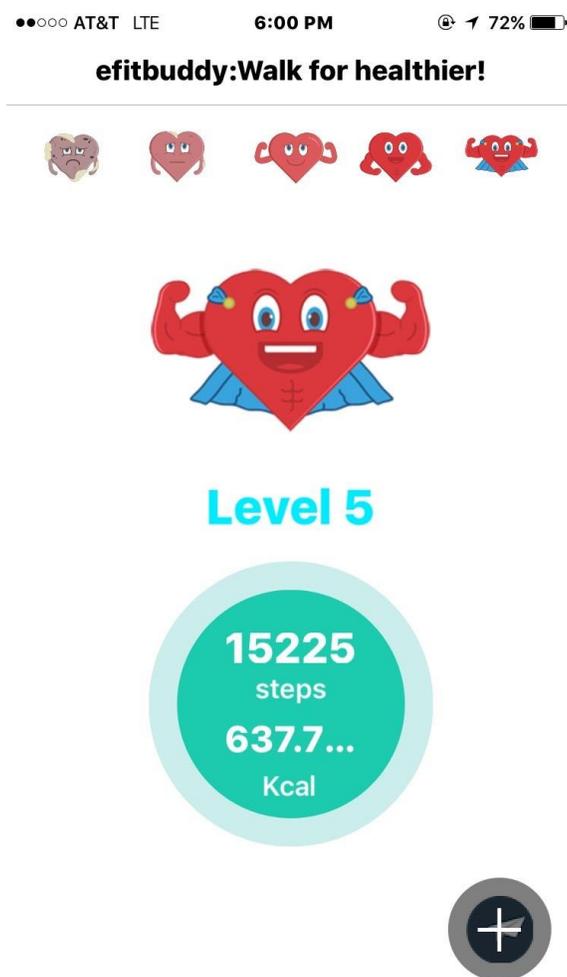


Figure 1. Steps and calories screen of efitbuddy app

### Procedures

This study utilized a repeated measure design in which participants were instructed to download the app and use it a minimum of three times daily for two weeks. During the intervention, participants were trained on how

to download the app, check their daily steps, calorie estimates, and health education messages. Before and after the two week intervention, participants were expected to complete a 7-day Physical Activity Recall which was used to assess their self-reported physical activities during the week. Additionally, a Self-Efficacy of Physical Activity was used to measure participant's confidence when engaging in physical activity and a different scale was used to assess their Enjoyment for Physical activity.

## **Measures**

### *Physical Activity*

A self-administered Physical Activity Questionnaire (PAQ) was used to assess participants' physical activity. PAQ is a 7-day recall instrument developed to assess general levels of physical activity in healthy youth and adults between the ages of 14 to 20. This instrument included a series of questionnaire items about sport participation, activity during and after school, as well as during the evenings and weekends. The validity correlation coefficients between PAQ and the activity monitor were moderate ( $r=0.56$ ) which was among the highest reported associations between any 7-day physical activity recall and objective measures of concurrent physical activity. The internal consistency of PAQ was reliable with Cronbach's coefficient alpha  $> 0.7$  (Welk, 2002).

### *Enjoyment*

The enjoyment of physical activity (PA) was assessed by the revised PACES, which was originally designed to measure positive affect associated with involvement in physical activities in college students (Kendzierski & DeCarlo, 1991). It has since demonstrated an acceptable internal consistency with coefficient  $\alpha = 0.90$ , and item-total correlations = 0.38–0.76 (Crocker et al., 1995). The original PACES consisted of 18 bipolar statements on a 7-point continuum (I enjoy it—I hate it) which were summed to produce a total enjoyment score. The revised PACES consists of 16 statements that begin with the stem "When I am physically active . . ." a 5-point Likert-type scale (1 = "Disagree a lot" to 5 = "Agree a lot"), which was considered more comprehensible to younger children, replaced the 7-item bipolar continuum (Motl et al., 2001). A final score is computed by calculating the average of the 16 items.

### *Self-Efficacy*

Self-Efficacy for Exercise Scale (SEES) were used for the motivation results data collection. A 9-item questionnaire that focuses on the self-efficacy expectations for exercise for adults. Participants were asked about their confidence level, on a scale from 0 (not confident) to 10 (very confident), if they would exercise 3 times per week for 20 minutes during each of the nine situations. Sufficient construct & criterion-related validity. SEES scores significantly predicted exercise activity ( $F = 78.8$ ;  $p < 0.05$ ), accounting for 30% of the variance in exercise activity. The SEES' internal consistency is evident by an alpha coefficient of 0.92 (Moore et al., 2009).

## **Statistical Analysis**

Data were screened for outliers using box-plots and z-scores and data were checked for Gaussian distributions using k-density plots. Differences between the sexes on age and all outcome variables at the pre-test time-point were explored using independent t-tests, assuming unequal variances because of the discordance in the relative group distributions. Pearson product-moment correlations were run to examine the linear relationships among age and all outcome variables at the pre-test time-point. Correlations were determined to be weak if  $r < 0.30$ , moderate if  $r = 0.30 - 0.60$ , and large if  $r > 0.60$  (Pagano & Gauvreau, 2000). To examine the effect of the smart-phone app intervention on PAQ scores, self-efficacy, and enjoyment, a  $2 \times 2$  Doubly Multivariate Analysis of Covariance (MANCOVA) test was employed using sex (female, male) and time (pre-test, post-test) factors and an age covariate. Statistical significance of the

multivariate model was determined using Wilks' lambda. Follow-up univariate Analysis of Covariance (ANCOVA) tests with repeated measures were employed, depending on the statistical significance of the multivariate model. The effect of interest was the time main effect and the sex  $\times$  time interaction. Pair-wise comparison effect sizes were calculated using Cohen's delta ( $d$ ), where  $d < 0.20$  indicating a small effect,  $d = 0.50$  indicating a medium effect, and  $d > 0.80$  indicating a large effect (Cohen, 1988). Alpha level was set a priori at  $p \leq 0.05$  and all analyses were carried out using STATA v14.0 statistical software package (College Station, TX, USA).

## RESULTS

Table 1. Descriptive statistics at the pre-test time-point (means and standard deviations)

|               | Total Sample<br>(N = 106) | Females<br>(n = 77) | Males<br>(n = 29)  |
|---------------|---------------------------|---------------------|--------------------|
| Age (years)   | 20.37 (2.87)              | 20.13 (2.80)        | 21.03 (2.88)       |
| PAQ score     | 2.47 (0.61)               | 2.39 (0.58)         | <b>2.68 (0.67)</b> |
| Self-Efficacy | 5.15 (1.82)               | 4.78 (1.72)         | <b>6.15 (1.73)</b> |
| Enjoyment     | 5.54 (0.99)               | 5.47 (1.01)         | 5.75 (0.90)        |

Note: PAQ stands for Physical Activity Questionnaire; bold denotes statistical differences between sexes,  $p < 0.05$ .

The descriptive statistics at the pre-test time-point are reported in Table 1. Males displayed higher PAQ scores compared to females (Mean difference = 0.30,  $p = 0.025$ ,  $d = 0.49$ ) and displayed higher levels of self-efficacy compared to females (Mean difference = 1.37,  $p < 0.001$ ,  $d = 0.80$ ). There were no differences between the sexes in enjoyment at the pre-test time-point ( $p = 0.178$ ). The results from the correlational analysis are reported in Table 2. There were statistically significant moderate and positive correlations among all outcome variables at the pre-test time-point ( $p < 0.001$ ). However, age only weakly correlated with self-efficacy ( $p = 0.006$ ).

Table 2. Correlation matrix for age and outcome variables at pre-test time-point

|               | Age         | PAQ Score   | Self-Efficacy | Enjoyment |
|---------------|-------------|-------------|---------------|-----------|
| Age           | 1           |             |               |           |
| PAQ Score     | -0.09       | 1           |               |           |
| Self-Efficacy | <b>0.26</b> | <b>0.38</b> | 1             |           |
| Enjoyment     | 0.06        | <b>0.40</b> | <b>0.32</b>   | 1         |

Note: PAQ stands for Physical Activity Questionnaire; bold denotes a significant correlation,  $p < 0.05$ .

Mean raw change scores for all outcome variables are displayed in Figure 2. The results from the MANCOVA test yielded a statistically significant multivariate model (Wilks'  $\lambda = 0.87$ ,  $F(12, 542.7) = 2.49$ ,  $p = 0.003$ ). Statistically significant effects included a sex main effect ( $F(1, 205) = 4.98$ ,  $p = 0.002$ ) and the statistical significance of the age covariate ( $F(3, 205) = 3.73$ ,  $p = 0.012$ ). The time main effect ( $p = 0.594$ ) and the sex  $\times$  time interactions ( $p = 0.710$ ) were not statistically significant. For exploratory purposes, using follow-up univariate testing, it was found the change score in enjoyment was trending toward statistical significance (Mean difference = 0.11,  $p = 0.060$ ,  $d = 0.18$ ).



Figure 2. Outcome variable change scores (Post-test – Pre-test)

## DISCUSSION

The purpose of the study was to examine the effectiveness of *efitbuddy*, a smart phone app on increasing PA participation, enjoyment, and SE in young adults. Even though the effectiveness of smartphone applications to improve health behaviours is only an emerging field of research (Middelweerd, Mollee, Wal, Brug, & Velde, 2014; Abroms, Padmanabhan, Thsweethai, & Phillips, 2011), available research has demonstrated inconsistent outcomes of using smart phone apps to promote individuals' health behaviours such as increasing PA, reducing weight, and consuming a nutritious diet (Caughlin, Whitehead, Sheats, Mastromonico, & Smith, 2016; Haapala et al., 2009; Turner-McGrievay & Tate, 2013; Duncan a Vandelanotte, 2014; Dantzig, Geleijnse, & Halteren, 2013; Fukuoka, Vittinghoff, Jong, & Kaskell, 2010; McKay, King, Eakin, Seeley, & Glasgow, 2001; Wontland, Portillo, Holzemer, Slaughter, & McGhee, 2004). Because *efitbuddy* is a newly designed smart phone app, there is no research on measuring its effectiveness on the user's behaviours. The results of the study were only compared to similar research, which applied different smart phone apps or methods to intervene the targeted behaviours.

The main results of the present study showed that the *efitbuddy* app did not significantly increase participants' PA participation or psychosocial associates through a two-week usage. The time main effect ( $p = 0.594$ ) and the sex  $\times$  time interaction ( $p = 0.710$ ) were not statistically significant. These results echo the previous studies,

in which the smart phone apps displayed a maintenance of the physical activity behaviours but did not increase observed physical activity (Kirwan, Duncan, Vandelanotte, & Mummery, 2014). In addition, other literature has also revealed no significant increases in PA participation from pre- to the post-assessment by using electronic monitors to 18-35-year-old adults (Tabak, DAH, & Hermens, 2014; Thompson, Kuhle, Koepp, McCrady-Spitzer, & Levine, 2014). They attributed that no change in PA may take place when the intervention group was considered to be active prior to the study period. Coughlin et al. (2016) concluded that smart phone apps can still be effective in promoting physical activity even though the magnitude of the intervention effect is modest. The maintenance of PA participation may result from the specifically designed features of *efitbuddy*. For instance, *efitbuddy* incorporated four behaviour-change tools including self-monitoring, setting goals, provision of encouragement, and health information provision. *efitbuddy* had the capabilities to track daily calorie consumption and step counts, as well as to show status of daily goals automatically. *efitbuddy* stored the PA data and provided a tracking history function to the users, allowing them to share the data on social media. The *efitbuddy* app had the capability to provide a heart image that was altered according to the step count changes of the participants. That was similar to the previous study (Lee, Chae, Kim, Ho, & Choi, 2010), in which an app was used to modify participants' weight control behaviours by using an avatar-like exercise game. Many of the behaviour change tools have been reported for their effectiveness in motivating individuals' PA (Bort-Rog, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Middelweerd, Mollee, Wal, Brug, & Velde, 2014; Stephens & Allen, 2013). Multiple researchers have summarized that multiple functions should be applied and combined for effectiveness.

By comparing the studies that showed the significant differences on PA, three plausible reasons may explain why the current study did not produce a similar outcome. The first factor may come from the length of the study. Behaviour change may need a long period of time, depending on the where the stage of the behaviour would be. Duncan and colleagues (2013) conducted a randomized trial to examine the efficacy of a 9-month mobile phone based intervention. They reported that there was a significant increase in the number of minutes and sessions of physical activity at 3 months and 9 months measures. The authors concluded that the intervention was effective and with longer periods, for instance three months, more efficacious results may be produced. Nguyen and colleagues (2016) compared two groups using different apps within a six-month pre-post study. The study findings showed small but significant increases in the step counts in the control group, while there was a step count decrease in the intervention group. The research attributed these results to differences in baseline characteristics and the small sample size.

The second factor explaining why physical activity did not increase may relate to the engagement level of the app. Having apps on your smartphone and using apps are not synonymous. Of the 50% of adult mobile phone owners who have apps on their phone, it has been reported that only about two-thirds (68%) are actually using them (Purcell, 2011). Therefore, it is necessary to ensure that the participants use the app regularly. Literature showed that lack of engagement may attribute to the lack of efficacious results of smart phone apps (Coughlin et al., 2016). The engagement level may also contribute to the results, since the more frequently individuals engage with an online health intervention, the more likely they are to improve or maintain health related behaviour (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). A recent survey conducted by the Consumer Health Information Corporation found that smartphone applications have a high rate of dropouts, with 26% being used only once and 74% being discontinued by the 10<sup>th</sup> use. It has been demonstrated that less exposure to the intervention results in a lower overall effectiveness of the program (Draper, Jennings, Baron, Erdur, & Shankar, 2000). Hence there is consensus that more research is needed to examine avenues that may enhance program engagement.

Lastly, the study took place at the end of a spring semester while the data were collected in the last week of the academic semester. Most students were busy preparing for the final exams and course projects. The pressure from dealing with end-of-semester work might have impacted their participation of physical activity and the enjoyment and self-efficacy of using the application. Future research shall be applied in the beginning of the school semester so there would be no final exam pressure on the participants.

It was hypothesized that the motivation would also increase over the 2-week intervention; however, no positive change was reported. No effect in motivation might be due to the length of the intervention: college students may need more time and longer experience period to have their motivation changed or responded. Previous study has reported that the changes on adults' exercise motivation, including self-efficacy and enjoyment, were found within a 3-month time frame (Kuroda, Sato, Ishizaka, Yamakado, & Yamaguchi, 2012). Accordingly, the 2-week intervention time span was not long enough to make any changes in participants' enjoyment and self-efficacy in this study. Additionally, no motivation effect may be a product of the psychometric properties of the questionnaires (Fan et al., 2006). Despite established reliability and validity of the questionnaires employed in this study, in this specific sample there may be potential for response bias. Despite the lack of increase in motivation, the positive trend of the enjoyment score is promising.

Several limitations of the study should be noted before the results can be generalized. This study design was pre-test/post-test without a control group with a small sample size, and this limits the generalizability of the findings. In addition, the length of the study was only two weeks. More research is needed to determine the long-term outcomes of adopting *efitbuddy* as a tool in health promotion. Despite these limitations, this research contributes to a paucity of work concerning smartphone applications and their use as a health promotion tool.

## CONCLUSION

This study provides unique insights on the effectiveness of the *efitbuddy* application on PA levels and motivational beliefs in college students. Results suggest that PA levels and SE scores did not change significantly, though the enjoyment level shows a slight increase across the two-week intervention period. The results displayed that *efitbuddy* has no influence on young adults' PA through a short period of time usage. These results are consistent with previous studies investigating the relationship between smartphone apps of health and fitness and PA behaviours; however, more research is needed for longer periods of intervention, which may combine mobile technology with specific behaviour change strategies potentially more effective in changing PA.

## REFERENCES

- Banas, T. (2017). How to Convert Pedometer Steps to Calories. Retrieved from <https://www.livestrong.com/article/238020-how-to-convert-pedometer-steps-to-calories/>
- Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, 50, 248-287. [https://doi.org/10.1016/0749-5978\(91\)90022-L](https://doi.org/10.1016/0749-5978(91)90022-L)
- Bort-Roig, J., Gilson, N., Puig-Ribera, A., Contreras, R., & Trost, S. (2014). Measuring and Influencing Physical Activity with Smartphone Technology: A Systematic Review. *Sports Medicine*, 44(5), 671-686. <https://doi.org/10.1007/s40279-014-0142-5>
- Conroy, D. E., Yang, C., & Maher, J. P. (2014). Behavior Change Techniques in Top-Ranked Mobile Apps for Physical Activity. *American Journal Of Preventive Medicine*, 46(6), 649-652. <https://doi.org/10.1016/j.amepre.2014.01.010>

- Conroy, M. B., Yang, K., Elci, O. U., Gabriel, K. P., Styn, M. A., Wang, J., & Burke, L. E. (2010). Physical activity self-monitoring and weight loss: 6-month results of the SMART trial. *Medicine & Science in Sports & Exercise*, 43, 1568-1574. <https://doi.org/10.1249/MSS.0b013e31820b9395>
- Coughlin, S. S., Whitehead, M., Sheats, J. Q., Mastromonico, J., & Smith, S. (2016). A Review of Smartphone Applications for Promoting Physical Activity. *Jacobs Journal Of Community Medicine*, 2(1).
- Crocker, P. E., Bouffard, M., & Gessaroli, M. E. (1995). Measuring enjoyment in youth sport settings: a confirmatory factor analysis of the Physical activity enjoyment scale. *Journal Of Sport & Exercise Psychology*, 17, 200-205. <https://doi.org/10.1123/jsep.17.2.200>
- Department of Health and Ageing. (1999). National physical activity guidelines for Australians. Canberra, ACT, Australia: Author.
- Fan, X., Miller, B. C., Park, K., Winward, B. W., Christensen, M., Grotevant, H. D., & Tai, R. H. (2006). An Exploratory Study about Inaccuracy and Invalidity in Adolescent Self-Report Surveys. *Field Methods*, 18(3), 223-244. <https://doi.org/10.1177/152822X06289161>
- Fukuoka, Y., Kamitani, E., Dracup, K., & So Son, J. (2011). New Insights Into Compliance With a Mobile Phone Diary and Pedometer Use in Sedentary Women. *Journal Of Physical Activity & Health*, 8(3), 398-403. <https://doi.org/10.1123/jpah.8.3.398>
- Fukuoka, Y., Vittinghoff, E., Jong, S. S., & Haskell, W. (2010). Innovation to motivation—pilot study of a mobile phone intervention to increase physical activity among sedentary women. *Preventive Medicine: An International Journal Devoted To Practice And Theory*, 51(3-4), 287-289. <https://doi.org/10.1016/j.ypmed.2010.06.006>
- Hebden, L., Cook, A., van der Ploeg, H. P., & Allman-Farinelli, M. (2012). Development of smartphone applications for nutrition and physical activity behavior change. *JMIR Research Protocols*, 1(2), e9. <https://doi.org/10.2196/resprot.2205>
- Huong Q, N., Dawn P, G., Seth, W., & et, a. (2009). Pilot study of a cell phone-based exercise persistence intervention post-rehabilitation for COPD. *International Journal Of COPD*, Vol 2009, Iss Default, Pp 301-313.
- Kendzierski, D., & DeCarlo, K. J. (1991). Physical activity enjoyment scale: two validation studies. *Journal Of Sport & Exercise Psychology*, 13, 50-64. <https://doi.org/10.1123/jsep.13.1.50>
- Kuroda Y, Sato Y, Ishizaka Y, Yamakado M, Yamaguchi N. Exercise motivation, self-efficacy, and enjoyment as indicators of adult exercise behavior among the transtheoretical model stages. *Glob Health Promot*, 2012; 19:14-22. <https://doi.org/10.1177/1757975911423073>
- Lewis, Z. H., Lyons, E. J., Jarvis, J. M., & Baillargeon, J. (2015). Using an electronic activity monitor system as an intervention modality: A systematic review. *BMC Public Health*, 15, 585. <https://doi.org/10.1186/s12889-015-1947-3>
- Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology*, 28, 690-701. <https://doi.org/10.1037/a0016136>
- Middelweerd, A., Mollee, J. S., van der Wal, C. N., Brug, J., & te Velde, S. J. (2014). Apps to promote physical activity among adults: A review and content analysis. *The International Journal Of Behavioral Nutrition And Physical Activity*, 11. <https://doi.org/10.1186/s12966-014-0097-9>
- Middelweerd, A., van der Laan, D. M., van Stralen, M. M., Mollee, J. S., Stuij, M., te Velde, S. J., & Brug, J. (2015). What features do Dutch university students prefer in a smartphone application for promotion of physical activity? A qualitative approach. *International Journal Of Behavioral Nutrition & Physical Activity*, 12, 1-11. <https://doi.org/10.1186/s12966-015-0189-1>

- Moore, J. B., Yin, Z., Hanes, J., Duda, J., Gutin, B., & Barbeau, P. (2009). Measuring Enjoyment of Physical Activity in Children: Validation of the Physical Activity Enjoyment Scale. *Journal Of Applied Sport Psychology*, 21(1), 116-129. <https://doi.org/10.1080/10413200802593612>
- Motl, R. W., Dishman, R. K., Saunders, R., Dowda, M., Felton, G., & Pate, R. R. (2001). Measuring enjoyment of physical activity in adolescent girls. *American Journal Of Preventive Medicine*, 21(2), 110-117. [https://doi.org/10.1016/S0749-3797\(01\)00326-9](https://doi.org/10.1016/S0749-3797(01)00326-9)
- Neve, M., Morgan, J. P., & Collins, E. C. (2011). Weight change in a commercial web-based weight loss program and its association with website use: Cohort study. *Journal of Medical Internet Research*, 13(4), e83. <https://doi.org/10.2196/jmir.1756>
- Nguyen, E., Bugno, L., Kandah, C., Plevinsky, J., Pouloupoulos, N., Wojtowicz, A., & Greenley, R. N. (2016). Is there a good app for that? Evaluating m-health apps for strategies that promote pediatric medication adherence. *Telemedicine And E-Health*, 22(11), 929-937. <https://doi.org/10.1089/tmj.2015.0211>
- Pagano, M., Gauvreau, K. (2000). *Principles of Biostatistics* (2nd Ed.). Belmont, CA: Brooks/Cole, Cengage Learning.
- Stephens, J., & Allen, J. (2013). Mobile phone interventions to increase physical activity and reduce weight: A systematic review. *Journal Of Cardiovascular Nursing*, 28(4), 320-329. <https://doi.org/10.1097/JCN.0b013e318250a3e7>
- Stuckey, M., Russell-Minda, E., Read, E., Munoz, C., Shoemaker, K., Kleinstiver, P., & Petrella, R. (2011). Diabetes and Technology for Increased Activity (DaTA) study: results of a remote monitoring intervention for prevention of metabolic syndrome. *Journal Of Diabetes Science And Technology*, 5(4), 928-935. <https://doi.org/10.1177/193229681100500416>
- Welk, G. (2002). *Physical activity assessments for health-related research*. Champaign, IL.; Human Kinetics.
- Wing, R. R., & Phelan, S. (2005). Long-term weight loss maintenance. *American Journal of Clinical Nutrition*, 82(1), 222S-225S. <https://doi.org/10.1093/ajcn/82.1.222S>

