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Impact of Digital Health Intervention on Promotion of Physical Activity and Psychological Well-Being among University Students: An Empirical Analysis

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Abstract:

Background:
The undeniable surge in sedentary behaviour and the concerning decline in physical activity levels among university students emphasise the urgent need to actively promote their physical activity by leveraging cost-effective and easily implementable interventions. Considering the pervasive nature of smartphones, their integration as digital health intervention targeting the promotion of physical activity emerges as an obvious choice.
Objective:
The primary objective of this study is to promote physical activity by using mobile application-based digital health intervention, taking age and gender into consideration.
Methods:
The research design used was a quasi-experimental (pre-post) design. A total of 500 university students (250 belonging to the control group, 250 belonging to the experimental group) actively engaged in the study for two weeks. The participants were randomly assigned, ensuring an equal distribution. To evaluate the impact of the intervention on subjectively measured physical activity, statistical analyses were conducted using the paired sample t-test and ANCOVA with the post hoc Bonferroni test.
Results:
The findings demonstrated a significant t-value of physical activity for the entire group, with $t(249) = 2.34$, $p < .05$. Furthermore, the F-value of 17.99 indicated a statistically significant difference in physical activity levels between the experimental and control groups. When considering female university students specifically, the t-value for physical activity was significant at $t(105) = 32.489$, $p < .05$. However, for male university students, the t-value for physical activity was found to be non-significant at $t(143) = .688$, $p > .05$.
Conclusions:
Smartphone-based health interventions targeting physical activity promotion demonstrated promising outcomes in facilitating health behaviour change and promoting psychological well-being among university students.

Keywords: physical activity, sedentary behaviour, university students, psychological well-being, digital health intervention

Introduction

Encouraging a well-balanced and health-conscious way of living plays a vital role in mitigating the impact of non-communicable diseases (NCDs), including but not limited to type 2 diabetes, cancer, osteoarthritis, depression, and cardiovascular disorders (World Health Organization, 2023). A significant proportion of fatalities resulting from NCDs can be averted through the implementation of lifestyle modifications, such as quitting smoking, adopting a healthy diet, managing obesity, engaging in physical activity, and ensuring adherence to prescribed medications (Khan et al., 2017). Gallardo et al. (2017) proposes that physical activity can be likened to a form of non-pharmacological intervention, serving as a therapeutic approach to promote health and well-being. Physical activity fosters improved self-esteem and body image, serving as a catalyst for positive self-perception and an enhanced sense of self-worth (Pateet al., 2020; Chan et al., 2018).

According to Park et al. (2020), engaging in regular physical activity has extensive and significant health benefits. Evidence suggests that regular physical activity is associated with a reduced risk of all-cause mortality, as well as lower incidences of osteoporosis, breast and colon cancer, and cardiometabolic illnesses. Stanton & Reaburn (2014) found that physical activity can be effective in managing mild to moderate mental health disorders, including depression and anxiety. Additionally, Kandola & Stubbs (2002) highlight that regular exercise can help

alleviate symptoms of anxiety and panic attacks, with its positive effects comparable to those of meditation or relaxation techniques. Although the numerous advantages linked to engaging in physical activity are widely recognized, there appears to be a decline in participation among adolescents and young adults (Nyberg et al., 2020). Work and leisure activities have become increasingly technology-oriented for both adults and minors alike; workplace physical activities have been mostly supplanted by technology and computers; present-day workplace necessitates that employees spend extended amounts of time seated in front of their computers, devoid of any occasional bout of physical activity (Seaton et al., 2020). It is rightly said that, "Sitting is considered as smoking for our generation." bring it more forward (Merchant, 2013)

Currently, there is a strong focus on prioritising the development of economical approaches that can effectively facilitate self-care, and promote lifestyle changes. digital health interventions have emerged as a promising approach, harnessing the power of technology to support individuals in adopting a healthy lifestyle. These interventions have gained attention due to their ability to offer time-efficient and cost-effective solutions (Broekhuizen et al., 2018; Vandelanotte et al., 2016). These interventions capitalise on the ubiquity and accessibility of technology, offering innovative tools and platforms that can effectively engage individuals and empower them to make positive behaviour changes. By leveraging the convenience and reach of digital platforms, digital health interventions have the potential to revolutionise health promotion efforts and contribute to the advancement of public health agendas.

Material and Methods

Study Design

Data for this quasi-experimental study, utilising a pretest/posttest design, were gathered through both online and offline modes. Participants' initial assessment of physical activity took place one day before the intervention began. The International Physical Activity Questionnaire - Short Form (IPAQ-SF) was used to measure participants' baseline physical activity. After the baseline assessment, participants were provided with instructions to download the health intervention-based mobile application, which was compatible with Android and iOS devices. The intervention was implemented for a duration of two weeks. Following the completion of the intervention, participants' physical activity was reevaluated using the IPAQ-SF.

Inclusion & Exclusion Criteria

Participants within the age range of 18 to 27 were eligible for inclusion in the study. Individuals with any medical condition that limited their ability to engage in physical activity were excluded from the study. Only students from the targeted population were recruited as participants.

Sample

The study aimed to include a sample size of 500 participants, requiring the researcher to approach a total of 1000 students. Among them, 697 students expressed their consent to participate in the study. However, due to personal commitments, 197 participants were unable to complete the study within the designated two-week timeframe. Nevertheless, the researcher successfully attained the desired sample size of 500 participants, with an equal distribution of 250 participants in the control group and 250 participants in the experimental group. The majority of participants, comprising 85.3% of the sample, fell within the age range of 18-22 years, while 14.7% belonged to the age group of 23-27. The participants consisted of 45.2% males and 54.8% females.

Intervention

In this study, a readily available health intervention-based application was utilised. The application delivered personalised prompts to users, encouraging them to take regular breaks and engage in periodic physical activity throughout the day. It offered a diverse range of guided exercise breaks that were tailored specifically for university students who typically spend prolonged periods of time sitting. The development of the application was informed by established behaviour change techniques (BCTs) supported by previous research conducted by Bohlen et al. (2020) and Orji & Moffatt (2018). The application incorporated elements of social cognitive theory and the transtheoretical model to deliver personalised reminders, facilitate goal setting, and provide user feedback, as outlined by Bohlen et al. (2020). Additionally, the application included a self-monitoring feature, allowing users to track and receive feedback on their behaviours, as described by Orji & Moffatt (2018). The application encompassed various movement breaks focusing on body mobilisation, stretching, strength training, mood enhancement, and muscle relaxation. Users were also able to track and monitor the duration of their break times.

Analysis

The study hypothesis was examined through the use of several statistical analyses. Firstly, descriptive statistics including the mean and standard deviation (SD) were employed to provide a summary of the data. Secondly, the paired sample t-test was utilised to assess the significant difference between the means of the pretest and post-test measurements. Lastly, the one-way analysis of covariance (ANCOVA) was conducted to investigate potential differences between the groups being studied.

Results

a) Relation between digital health intervention and physical activity (t-test comparison)

Table 1 Effect of digital health intervention on Physical Activity

Variable	Groups	Sub-groups	n	Mean	SD	t-value	Sig.
Physical Activity	Control group	Pre - Test	250	1612	1236	**2.34**	**<.05***
		Post - Test	250	1427	1075		
	Experimental group	Pre - Test	250	1496	1095		
		Post - Test	250	1653	1276		

**Significant at the .01 level; *Significant at the .05 level

The mean and SD scores for the pre-test and post-test of the control group for physical activity of university students were as follows: M_ pre = 1612, SD_ pre = 1236, M_ post = 1427, SD_ post = 1075. The mean and SD scores for the pre-test and post-test of the experimental group for physical activity of university students were as follows: M_ pre = 1496, SD_ pre = 1095, M_ post = 1653, SD_ post = 1276. The t-value was found to be significant, at $t(249)= 2.34$, $p<.05$. The mean score for the experimental group's pretest physical activity was M = 1496, which increased to M = 1653 in the post-test, indicating a significant increase in physical activity due to participation in the digital health intervention.

Therefore, there is a significant relationship between digital health intervention and physical activity of college students.

b) One-way ANCOVA: Physical Activity

The F-value of 17.99 indicated a statistically significant difference in physical activity of the experimental group (M=1653, SD=1276) compared to the control group (M=1427, SD=1075), with 1/497 df. The between-subjects effects analysis results show that pretest ($F = 537.941$, $p < .001$, $\eta p^2 = 0.52$) and group ($F = 17.99$, $p < .001$, $\eta p^2 = 0.035$) were both significant predictors of post-test physical activity. The overall model was significant ($F = 273.73$, $p < .001$, $\eta p^2 = 0.524$), accounting for 52.4% of the variance in post-test physical activity in university students, adjusted $R^2 = 0.522$. The intercept was also a significant predictor ($F = 44.57$, $p < .001$, $\eta p^2 = 0.082$). The error term was estimated to be 670030.433, with a total of 500 observations.

c) Relation between digital health intervention and physical activity of male & female university students (t-test comparison)

Table 2 Effects of digital health intervention on Physical Activity: Males & Females

Variable	Groups	Sub-groups	n	Mean	SD	t-value	Sig.
Physical activity level in males	Control group	Pre - Test	131	1660	1150	.688	>.05
		Post - Test	131	1493	1051		
	Experimental group	Pre - Test	144	1549	1135		
		Post - Test	144	1600	1138		
Physical activity level in females	Control group	Pre - Test	119	1560	1329	**2.489**	**<.05***
		Post - Test	119	1353	1099		
	Experimental group	Pre - Test	106	1424	1039		
		Post - Test	106	1724	1446		

**Significant at the .01 level; *Significant at the .05 level

The mean and SD scores for the pre-test and post-test of the control group for physical activity of males were M_ pre = 1660, SD_ pre = 1150, M_ post = 1493, SD_ post = 1051. The mean and SD scores for the pre-test and post-test of the experimental group for physical activity of males were M_ pre = 1549, SD_ pre = 1135, M_ post = 1600, SD_ post = 1138. The t-value was found to be not significant at, $t(143)=.688$, $p>.05$. The mean increase in physical activity for males in the experimental group was not statistically significant.

Therefore, there is no significant relationship between digital health intervention and physical activity of male college students.

The mean and SD scores for the pre-test and post-test of the control group for physical activity of females were as follows: M_ pre = 1560, SD_ pre = 1329, M_ post = 1353, SD_ post = 1099. The mean and SD scores for the pre-test and post-test of the experimental group for physical activity of females were as follows: M_ pre = 1424, SD_ pre = 1039, M_ post = 1724, SD_ post = 1446. The t-value was found to be significant at, $t(105)= 32.489$, $p<.05$. The mean score for pre-test physical activity in females of the experimental group was M = 1424. After participating in digital health intervention, the mean score increased to M = 1724, indicating a significant increase in physical activity among the experimental group's female participants.

Therefore, there is a significant relationship between digital health intervention and physical activity of female college students.

d) One-way ANCOVA: Physical Activity (Male & Female)

The F-value of 4.63 indicated a statistically significant difference in physical activity of males, with 1/272 df. The between-subjects effects analysis results show that, pretest ($F = 363.331$, $p < .001$, $\eta p^2 = 0.572$) and group ($F = 4.63$, $p = 0.032$, $\eta p^2 = 0.017$) were both significant predictors of post-test physical activity in males. The overall model was significant ($F = 182.416$, $p < .001$, $\eta p^2 = 0.573$), accounting for 57.3% of the variance in post-test physical activity in male university students, adjusted $R^2 = 0.570$. The intercept was also a significant predictor ($F = 25.586$, $p < .001$, $\eta p^2 = 0.086$). The error term was estimated to be 517982.108, with a total of 275 observations.

The F-value of 14.578 indicated a statistically significant difference in physical activity of females, with 1/222 df. The between-subjects effects analysis results show that pretest ($F = 203.468$, $p < .001$, $\eta p^2 = 0.478$) and group ($F = 14.578$, $p < .001$, $\eta p^2 = 0.062$) were both significant predictors of post-test physical activity. The overall model was significant ($F = 106.266$, $p < .001$, $\eta p^2 = 0.489$), accounting for 48.9% of the variance in post-test physical activity in females, adjusted $R^2 = 0.485$. The intercept was also a significant predictor ($F = 20.355$, $p < .001$, $\eta p^2 = 0.084$). The error term was estimated to be 851260.358, with a total of 225 observations.

e) Relation between digital health intervention and physical activity of university students aged 18-22 & 23-27 (t-test comparison)

Table 3 Effect of digital health intervention on Physical Activity: Age Range 18-22 and 23-27

Variable	Groups	Sub-groups	n	Mean	SD	t-value	Sig.
Physical activity level in age range 18-22	Control group	Pre - Test	216	1620	1251	**2.179**	**<.05***
		Post - Test	216	1452	1105		
	Experimental group	Pre - Test	219	1524	1096		
		Post - Test	219	1687	1301		
Physical activity level in age range 23-27	Control group	Pre - Test	34	1566	1155	.990	>.05
		Post - Test	34	1261	848		
	Experimental group	Pre - Test	31	1293	1076		
		Post - Test	31	1409	1069		

**Significant at the .01 level; *Significant at the .05 level

The mean and SD scores for the pre-test and post-test of the control group for physical activity of students aged 18-22 were M_ pre = 1620, SD_ pre = 1251, M_ post = 1452, SD_ post = 1105. The mean and SD scores for the

pre-test and post-test of the experimental group for physical activity of students aged 18-22 were M_ pre = 1524, SD_ pre = 1096, M_ post = 1687, SD_ post = 1301. The t-value was found to be significant at, $t(218)= 2.179$, $p<.05$. The mean score for pre-test physical activity (M = 1524) of the experimental group increased significantly (M = 1687) in the post-test after participating in the digital health intervention, indicating an increase in physical activity.

Therefore, there is a significant relationship between digital health intervention and physical activity of college students within the age range 18 - 22.

The mean and SD for the pre-test and post-test of the control group for physical activity of students within the age range 23-27 were as follows: M_ pre = 1566, SD_ pre = 1155, M_ post = 1261, SD_ post = 848. The mean and SD for the pre-test and post-test of the experimental group for physical activity of students within the age range 23-27 were as follows: M_ pre = 1293, SD_ pre = 1076, M_ post = 1409, SD_ post = 1069. The t-value was found to be not significant at, $t(30)= .990$, $p>.05$.

Therefore, there is no significant relationship between digital health intervention and physical activity of college students within the age range 23 - 27.

f) One-way ANCOVA: Physical Activity (Age-range: 18-22 & 23- 27)
The F-value of 13.933 indicated a statistically significant difference in physical activity of the experimental group (M=1687.13, SD=1301) compared to the control group (M=1452, SD=1105), with 1/432 df. The between-subjects effects analysis results show that pretest ($F = 445.343$, $p < .001$, $\eta p^2 = 0.508$) and group ($F = 13.933$, $p < .001$, $\eta p^2 = 0.031$) were both significant predictors of post-test physical activity for age range 18-22. The overall model was significant ($F = 226.815$, $p < .001$, $\eta p^2 = 0.512$), accounting for 51.2% of the variance in post-test physical activity, adjusted $R^2 = 0.510$. The intercept was also a significant predictor ($F = 37.877$, $p < .001$, $\eta p^2 = 0.081$). The error term was estimated to be 720610.106, with a total of 435 observations.

The F-value of 5.437 indicated a statistically significant difference in physical activity of the experimental group (M=1409, SD=1069) compared to the control group (M=1261, SD=848), with 1/62 df. The between-subjects effects analysis results show that pretest ($F = 112.961$, $p < .001$, $\eta p^2 = 0.646$) and group ($F = 5.437$, $p = 0.023$, $\eta p^2 = 0.081$) were both significant predictors of post-test physical activity. The overall model was significant ($F = 57.013$, $p < .001$, $\eta p^2 = 0.648$), accounting for 64% of the variance in post-test physical activity, adjusted $R^2 = 0.636$. The intercept was also a significant predictor ($F = 8.906$, $p = 0.004$, $\eta p^2 = 0.126$). The error term was estimated to be 331803.483, with a total of 65 observation

Discussion

The present study investigated the impact of a health intervention-based mobile application in promoting physical activity among university students, taking into account the potential moderating effects of age and gender. The results reveal the significant efficacy of such applications in promoting positive health behaviours, particularly in targeting physical activity. Participants assigned to the experimental group exhibited a substantial increase in their physical activity levels, as indicated by a notable rise in average METs from a pre-test mean of 1496 METs to a post-test mean of 1653 METs. These findings suggest that the implemented intervention successfully facilitated an increase in physical activity levels among the participants.

Behavioural electronic-health (eHealth) interventions have been the subject of numerous reviews and meta-analyses, presenting opportunities to extend the reach of mobile health interventions targeting diet and physical activity behaviours. Utilising mobile phones and body sensing systems, these interventions have been successful in assessing physical activity levels, sedentary behaviour, and dietary patterns, while also providing participants with valuable feedback, information, and support. In the realm of eHealth and mobile health interventions, engagement plays a crucial role, as interventions need to captivate users and encourage active involvement with the intervention platform. Typically, engagement is evaluated based on intervention usage metrics, such as the number of logins, completion of modules, and pages viewed. It is widely acknowledged among researchers that incorporating theoretical frameworks into the development and evaluation of health behaviour change interventions significantly enhances behavioural outcomes. Multiple studies have consistently shown that interactive interventions that promote high usage and engagement ultimately lead to greater and more enduring effects of the intervention.

Conclusion

The present study aimed to assess the efficacy of a mobile application-based digital health intervention in enhancing physical activity levels among university students. The findings revealed the existence of distinct subgroups within Indian universities that exhibited varying degrees of engagement in unhealthy behaviours. Specifically, females demonstrated lower levels of physical activity compared to males, while students between the ages of 18 and 22 showed higher levels of physical activity. However, further investigation is required to examine the sustainability of physical activity promotion through the utilisation of digital health interventions over the long term. The use of e-health interventions and digital health intervention has gained prominence in college settings, indicating the need for educators and health practitioners to embrace this trend and delve into the psychological determinants of health behaviour change among college students. By integrating smartphone apps, online resources, monitoring tools, and social media platforms, tailored e-health interventions with personalised components can be developed to effectively support individuals in adopting and maintaining healthy behaviours, thereby promoting both physical activity and psychological well-being among university students.

Ethical Statement

Written informed consent was obtained from each participant before being included in the study.

Conflict of Interest

The authors declare no conflict of interest.

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