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Efficacy of Internet-Delivered Computer-Tailored Multimedia Advice on Physical Activity among Healthy Individuals

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Abstract

Availability of high-speed internet and smartphones provides a relatively inexpensive and easy to use platform for promoting physical activity and a healthier lifestyle among a large portion of population. This study aimed to investigate the efficacy of internet-delivered computer-tailored multimedia advice through smartphones on physical activity and quality of life among healthy individuals. This study was a 12-week long randomized clinical trial. 155 healthy volunteers were randomly divided into intervention (n=76) and control (n=79) groups. Intervention group received weekly tailored exercise programs in multimedia format via Telegram® messenger on their smartphones. They were required to fill an online workbook every week and received suitable feedbacks based on their weekly activity. Control group had access to a general 12-week exercise program from the beginning. Intervention group showed a 168.814 (75.456-262.171) (95% CI) METs.min/week increase in total physical activity (p=0.001) and 11.2 (7.54-14.99) minutes/week increase in moderate to vigorous physical activity (p<0.001) compared to baseline. Statistically significant improvements in several domains of quality of life were observed in intervention group compared to the control group. It seems that combination of internet and smartphones is useful as a relatively inexpensive tool to increase physical activity and quality of life among healthy individuals.

Keywords: Internet, Tailored, Smartphone, Multimedia, Physical activity, Quality of life.
Trial Registration ID: IRCT20171016036805N2

Introduction

Major causes of mortality have changed from infectious and contagious diseases to chronic non-communicable diseases in past few decades. According to center for disease control (CDC), cardiovascular problems, malignant neoplasms and chronic lower respiratory diseases were the leading causes of death in US in 2014 (Kochanek et al., 2016). The most important risk factors for these diseases are sedentary lifestyle, obesity, hypertension, diabetes, smoking and alcohol consumption (Murray et al., 1997). A healthier lifestyle including regular physical activity and a healthier diet containing sufficient fruits and vegetables can plays a key role as primary, secondary and tertiary prevention of chronic non-communicable diseases, improve the quality of life of patients and reduce the mortality associated with them (Storm et al., 2016; Kanera et al., 2017; Poirier et al., 2016). American college of sport medicine (ACSM) and American heart association (AHA) recommend all 18 to 65 years old healthy adults, should have moderate-intensity aerobic physical activity for a minimum of 30 minutes over 5 days a week or 20 minutes vigorous-intensity aerobic physical activity over 3 days a week in their routine exercise to promote and maintain health. Combination of these exercises can be used to meet the recommendations (Haskell et al., 2007). Physical activity of 60% of world's population is less than the recommended amount and risk of cardiovascular diseases in people with physical activity less than what is recommended is 1.5 times greater in comparison (Murray et al., 1997). In a population-based study conducted in Iran in 2007, 37% of men and 49.2% of women were overweight and 9.1% of men and 20.2% of women were obese or morbidly obese. Distribution of physical activity outside the work showed that 42.3% of men and 49.6% of women had sedentary lives defined as less than 10 minutes of moderate to vigorous physical activity (MVPA) in a day (Kelishadi et al., 2007). Therefore, it seems sedentary lifestyle is a common and important risk factor for chronic non-communicable diseases in Iran and worldwide.

With the rise of personal computers and internet, several studies have been conducted to investigate the effect of web-based intervention on patients with different diseases and promoting a healthier lifestyle among healthy individuals (Storm et al., 2016; Kanera et al., 2017; Larsen et al., 2017; Muller et al., 2017; Nystrom et al., 2017; Schneider et al., 2015; Broekhuizen et al., 2016; Hofmann et al., 2016; Hutchesson et al., 2016; Marcus et al., 2016; Muller et al., 2016; Safran et al., 2015) .Most of these studies report a rapid decline in using the website in few first

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sessions, which may play a key role in limiting the long-term effects of the web-based interventions (Eysenbach , 2005; Leslie et al., 2005). Web-based interventions, which provide tailored and interactive feedbacks, show better results in long-term (Storm et al., 2016; Dickfos et al., 2015; Vandelanotte et al., 2015). Web-based interventions are usually presented in text format. There are studies that show the text information is not effectively transferred through the internet (Liu, 2005). An eye tracking study showed that people read websites in a different pattern than they read books, and they mainly focus on top-left corner of the web-page and don't read the entire page contents line by line (Nielsen & Pernice, 2010). Overall it seems that an internet-delivered computer-tailored advice in multimedia format (text, image and video) may be more effective than traditional text-based websites.

Smartphones are commonly used these days. 72% of Americans and 43% worldwide owned smartphones in 2016 (Elhai et al., 2017). The combination of high-speed internet and smartphones provides a relatively inexpensive, interactive and easy to use platform for promoting physical activity and a healthier lifestyle among a large portion of population. In this study, we have investigated the efficacy of internet-delivered computer-tailored multimedia advice through smartphones on promoting physical activity and quality of life among healthy individuals.

Objectives:

To investigate the efficacy of internet-delivered computer-tailored multimedia advice through smartphone on promotion of a physical activity and elevation of quality of life among healthy individuals.

Materials and Methods:

Study design:

This study was a 10 weeks long randomized clinical trial (RCT) conducted in Tehran, Iran, from March to August 2017. Participants were healthy volunteers from Abolfazl clinic personnel and healthy patients' accompanies, Baghiatallah University of medical sciences. The study had two assessment stages, a pretest assessment at the beginning of study and a post-intervention assessment 2 weeks after the end of intervention.

Pretest and post-intervention assessments were conducted using pen & paper method. Height and weight were measured according to ACSM guidelines and physical activity and quality of life were measured using proper tools by a trained physician. Among all the volunteers (n=168), those who met the inclusion criteria (n=155) entered the study and were randomly divided into intervention (n=76) and control (n=79) groups. Participants were assigned based on their baseline physical activity and cardiovascular risk to mild, moderated and heavy exercise protocols. Both groups received the same exercises and information in multimedia format via website and Telegram® messenger application on their smartphones with the difference that participants in the intervention group received their program weekly and were required to fill a workbook online at the end of every week and received appropriate feedbacks and changes in their exercise program for the next week based on their performance on the past week's assignments. They also received weekly reminder e-mails, text messages and instant messages to remind them of their assignments and to submit their workbook at the end of the week (tailored intervention). The control group had access to all the 10-week program consisting of the same exercises and information in multimedia format from the beginning of study. They neither had to provide a weekly workbook nor received any feedbacks or reminders.

Inclusion criteria:

Inclusion criteria determines which of volunteers are eligible to enter the study. Eligible volunteers who could enter our study were 18-65 years old, with access to broadband internet connection and a smartphone, those who pass the Physical Activity Readiness Questionnaire (PARQ) - PARQ is used to assess whether an individual can increase their physical activity safely or not (Cardinal et al., 1996) - low or moderate cardiovascular risk (volunteers with high cardiovascular risk were excluded from the study), no history of cardiovascular problems (uncontrolled hypertension, valvar cardiac disease, except for mild MVP), congestive heart failure, MI or CVA in past 6 months and peripheral arterial disease), no history of cancer or significant unexplained weight loss (more than 10% of weight within 6 months), no history of advanced pulmonary disease (asthma or COPD) or a disability or condition preventing the participant from increasing his/hers physical activity like low back pain (LBP) and osteoarthritis.

Exclusion criteria:

Exclusion criteria are the conditions which if happened, the participant exits from the study. Our exclusion criteria were new onset hypertension, acute illness, pregnancy, disability due to trauma and use of sedatives, painkillers or muscle relaxants during the study period.

Outcome measures and methods of assessment:

Height, Weight and BMI - Height and Weight were measured by a trained physician according to ACSM guidelines then BMI was calculated as

$$BMI_{(\frac{kg}{m^2})} = \frac{Weight_{(kg)}}{Height^2_{(m)}}.$$

Cardiovascular risk – Cardiovascular risk for asymptomatic patients was assessed using method proposed by D'Agostino et al (Framingham Heart Study 2008) (D'Agostino et al., 2008). Cardiovascular risk was assessed based on past medical history (diabetes, hepatic, renal and thyroid diseases), age, gender, family history, history of smoking, hypertension, dyslipidemia, history of uncontrolled BS, obesity, sedentary lifestyle and signs and symptoms of pectoralis angina. The cardiovascular risk was reported as low, intermediate and high risk.

Physical activity – Physical activity (PA) was measured using WHO Global Physical Activity Questionnaire (GPAQ) version 2 which has a valid and reliable Persian version (Baghiani et al.,

2012). It measures PA in three domains; activity at work, travel to and from places and recreational activities. GPAQ reports MVPA in minutes per week and total PA in

$$\frac{METs \times min}{Week}.$$

Quality of life – Quality of life (QoL) was assessed using 36-item Short Form health survey (SF-36) version 2 which has a valid and reliable Persian version (Motamed et al., 2005). SF-36 measures QoL in eight domains; physical functioning, physical limitation, emotional limitation, energy/fatigue, emotional wellbeing, social functioning, pain and general health. It reports each domain in percent.

Intervention program and goals:

Participants in intervention and control group were divided into three sub-groups based on their baseline PA; low, moderate and high physical activity using WHO GPAQ analysis guide (Table 1) (Global, 2006).

Table 1: Baseline PA levels according to WHIO GPAD analysis guide (Global, 2006).

PA level	Criteria
High	A person reaching any of the following criteria is classified in this category: - Vigorous-intensity activity on at least 3 days achieving a minimum of at least 1,500 MET-minutes/week OR - 7 or more days of any combination of walking, moderate- or vigorous-intensity activities achieving a minimum of at least 3,000 MET-minutes per week.
Moderate	A person not meeting the criteria for the "high" category, but meeting any of the following criteria is classified in this category: - 3 or more days of vigorous-intensity activity of at least 20 minutes per day OR - 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day OR - 5 or more days of any combination of walking, moderate- or vigorous-intensity activities achieving a minimum of at least 600 MET-minutes per week.
Low	A person not meeting any of the above-mentioned criteria falls in this category.

Then based on baseline PA level and cardiovascular risk, participants divided into three exercise groups; low, moderate and high intensity aerobic exercises (Table 2).

Table 2: Exercise assignments based on baseline PA and cardiovascular risk.

Baseline PA	Cardiovascular Risk Factor		
	Low	Intermediate	High
Low	Low intensity exercise	Low intensity exercise	Excluded
Moderate	Moderate intensity exercise	Low intensity exercise	Excluded
High	High intensity exercise	Moderate intensity exercise	Excluded

The goal of low, moderate and high intensity exercise groups were 70, 90 and 150 minutes per week MVPA respectively. All the sub-groups received a 10-15 minutes of flexibility, strength and core-stability exercises daily.

Sample size and statistical analysis:

Sample size was calculated with 80% power to rule out null hypothesis and acceptable type I error 0f 5% ($\alpha = 5\%$) and 25% participant dropout, to be 74 participants in each group according to the following formula:

$$N_{ss} = \frac{2 \times \left(Z_{\frac{1-\alpha}{2}} \times Z_{1-\beta} \right)^2 \times \sigma^2}{\left(\mu_1 - \mu_0 \right)^2}$$

Statical analysis was done with IBM SPSS® software version 23. The normality of distribution of data was assessed using non-parametric Kolmogorov–Smirnov test. Further analysis was done using, descriptive analysis, explore and cross-tab for measuring and visualizing central tendency and data distribution. Chi^2 test was used to investigate the relation between two qualitative variables. Independent samples T-Test and ANOVA tests were used to investigate the relation between a quantitative and a qualitative variable. Linear regression was used to model the relation between two quantitative variables and finally paired samples T-Test was used to investigate the relation between pretest and post-intervention data. A p-value <0.05 was considered as statistically significant.

Statement of Human and Animal Right:

All the participants received an informed consent form at the beginning of study. Only research team had access to participants' individual data and kept them secret in concordance with the participants' rights to keep their medical records private and individuals' data could be published only with their written permission if necessary. Results of the study will be published as a group such that nobody's data would be identifiable.

Participants could discontinue the study and drop out whenever they desired at any stage without any consequences for them. Participants were informed that any of these exercise programs and health tips cannot be considered as suitable medical advice and if they experienced any side effects because of the intervention, they should visit the assigned doctor free of charge.

Several lines of communication including, website, e-mail, instant messages using Telegram® and WhatsApp® messenger application were provided for the participants to communicate directly with the researchers and share possible problems, questions and suggestions with the researches.

All the steps of the study were confirmed and supervised by Baqiyatallah university of medical science's ethics committee (ethics committee reference number: IR.BMSU.REC.1394.176) according to standards of Iranian ministry of health and medical education for medical research and Helsinki Declaration of 1975 (revised in 2000).

Results:

Out of 168 healthy individuals who were interested in participation in the study, 155 met the inclusion criteria and were randomly divided into intervention (n=76) and control (n=79) group. 76 participants (49.0%) were female and 79 (51.0%) were male. Participants' age ranged from 19-47 years and mean age was 31.69 ± 6.52 years. Out of all eligible participants 39 (25.2%) had high school diploma, 103 (66.5%) had undergraduate and 13 (8.4%) had postgraduate education. 129 (83.2%) of participants had low cardiovascular risk and 26 (16.8%) had intermediate cardiovascular risk (volunteers with high cardiovascular risk were excluded from the study).

Height of participants varied from 159-192 centimeters with mean of 170.94±7.55 centimeter. Participants' weight ranged from 52.0-109.0 kilograms with mean of 71.78±9.86 kilograms. Body mass index (BMI) ranged from 18.65-35.19 with mean of 24.57±2.98 $\frac{kg}{m^2}$.

Total physical activity ranged from 420 to 3420 $\frac{METs \times min}{Week}$ with mean of 1525.00±478.63$\frac{METs \times min}{Week}$.

Domains of physical activity and quality of life as well as demographic data in pretest measurement are summarized and compared between intervention and control group in Table 3.

Table 3. Comparison of baseline measurements between intervention and control groups.

Variable		Baseline Count (%) / Mean ± SD		p-value
		Control	Intervention	
Gender	Female	38 (48.1%)	38 (50.0%)	0.873 *
	Male	41 (51.9%)	38 (50.0%)	
Age (years)		32.09±6.10	31.28±6.98	0.441 +
Education	High school	21 (26.6%)	18 (23.7%)	0.310 **
	Undergraduate	54 (68.4%)	49 (64.5%)	
	Postgraduate	4 (5.1%)	9 (11.8%)	
Cardiovascular risk	Low	66 (87.3%)	63 (82.9%)	> 0.999 **
	Intermediate	13 (16.5%)	13 (17.1%)	
Height (cm)		170.14±7.35	171.78±7.71	0.178 +
Weight (kg)		72.24±8.78	71.30±10.92	0.557 +
BMI ($\frac{kg}{m^2}$)		24.94±2.41	24.18±3.45	0.110 +
Physical Activity ($\frac{METs \times min}{Week}$)	Work	833.92±319.61	856.58±354.84	0.667 +
	Transport	181.27±136.45	167.11±126.31	0.503 +
	Recreational	487.59±326.01	530.53±366.48	0.443 +
	Total	1502.78±444.03	1554.21±513.79	0.507 +
MVPA ($\frac{min}{Week}$)		123.61±37.23	126.91±37.36	0.583 +
Quality of life (Percent)	Physical Functioning	74.62±17.61	74.93±20.12	0.918 +
	Physical Limitation	21.51±27.69	21.71±29.26	0.967 +
	Emotional Limitation	30.80±35.31	32.89±36.31	0.717 +
	Energy/Fatigue	64.75±17.11	64.74±17.22	0.997 +
	Emotional Wellbeing	71.14±14.92	71.16±15.03	0.994 +
	Social functioning	71.25±17.44	72.04±17.78	0.854 +
	Pain	25.25±19.21	25.36±19.38	0.972 +
	General health	65.95±17.10	65.00±18.09	0.738 +

* Fisher's Exact Test **Pearson Chi^2 +Independent samples T-Test

Dropout analysis:

59 (77.6%) out of 76 participants in intervention group and 39 (49.4%) out of 79 participants in control group finished the study. Dropout was significantly more in control group compared to intervention group (p-value<0.001). The main reason of drop out was that participants did not see the information and instruction offered at the program, relevant to or beneficial for them. 11 (7.1%) of the participants reported muscle cramps and pain after executing the suggested program as the main cause of discontinuing to participate in the study.

Post-intervention:

Total PA was increased by 168.81 $\frac{METs \times min}{Week}$ in intervention group compared to baseline (p=0.001). Moderate to vigorous PA also increased by 11.27 minutes per week compared to baseline in intervention group (p<0.001).

There was no statistically significant change in weight and BMI compared to baseline in intervention group (p-value=0.262 and p-value=0.303 respectively).

Statistically significant improvements in physical functioning, physical limitation, emotional limitation, emotional wellbeing, social functioning and general health subsets of quality of life were observed compared to baseline in intervention group (Table 4).

Table 4. Comparison between baseline and post-intervention between control and case groups.

Variable		Control – Mean (SD)			Intervention – Mean (SD)			p case-control
		Post intervention	Change	p Baseline comparison	Post intervention	Change	p-value Baseline comparison	
Weight		70.30 (10.22)	-0.70 (3.75)	0.262	72.85 (11.41)	-0.44 (3.69)	0.362	0.738
BMI		24.19 (3.38)	-0.23 (1.32)	0.303	24.80 (-0.17)	-0.17 (1.27)	0.298	0.847
PA	Work	889.73 (405.78)	40.00 (240.74)	0.319	817.97 (370.57)	-23.05 (226.06)	0.437	0.205
	Transport	258.92 (172.24)	37.84 (189.02)	0.231	327.46 (234.62)	155.25 (215.93)	<0.001*	0.006*
	Recreational	509.73 (365.62)	8.65 (164.15)	0.750	560.34 (406.66)	36.61 (156.21)	0.077	0.411
	Total	1658.38 (504.98)	86.49 (277.05)	0.066	1705.76 (608.65)	168.81 (358.24)	0.001*	0.048*
MVPA		120.00 (41.08)	0.81 (8.94)	0.584	143.05 (40.19)	11.27 (14.00)	<0.001*	<0.001*
QoL	Physical Functioning	71.76 (17.45)	-0.81 (5.83)	0.404	79.41 (16.61)	6.02 (10.90)	<0.001*	0.001*
	Physical Limitation	28.23 (32.36)	2.03 (13.67)	0.373	17.37 (27.56)	-5.08 (15.24)	0.013*	0.020*
	Emotional Limitation	26.13 (34.37)	-0.90 (5.48)	0.324	33.90 (40.35)	-4.52 (14.46)	0.020*	0.049*
	Energy Fatigue	63.65 (15.40)	0.00	> 0.999	63.98 (16.50)	1.1 (4.46)	0.063	0.137
	Emotional Wellbeing	71.78 (15.69)	1.08 (4.28)	0.134	72.61 (16.41)	3.05 (6.57)	0.001*	0.109
	Social functioning	70.95 (15.88)	0.00	> 0.999	72.88 (19.44)	2.12 (6.63)	0.017*	0.047*
	Pain	26.55 (18.13)	0.00	> 0.999	24.62 (21.11)	-0.51 (2.89)	0.182	0.288
	General health	68.24 (16.27)	0.14 (3.43)	0.812	67.88 (16.27)	4.83 (10.71)	0.001*	0.011*

* Statistically significant

Discussion:

Principal results:

The objective of this study is evaluation of effectiveness of internet-delivered computer-tailored multimedia advice through smartphone on promotion of a physical activity and elevation of quality of life among healthy individuals in short-term. This intervention led to statistically significant increase in amount and duration of physical activity and statistically significant elevation of physical functioning, social functioning and general health and lowering physical and emotional limitations among participants in intervention group compared to the control. These results fall in line with previous studies that have studied the efficacy of web-based self-training programs (Broekhuizen et al., 2016; Boyne et al., 2017; Marques et al., 2016). Our study showed a lower base-line physical activity compared to the literature, which was in consistency with previous studies done in Iran (Farid et al., 2012). This study showed 168.81 $\frac{METs \times min}{Week}$ increase in total physical activity and 11.27 minutes per week increase in moderate to vigorous physical activity in intervention group compared to the control, which was statistically significant. However, this change in physical activity is smaller than previous studies with similar design (Muller et al., 2016; Catenacci et al., 2014; Irvine et al., 2013). This difference can be explained by lower baseline physical activity in Iran according to our results and other studies conducted in Iran (Farid & Dabiran, 2012).

Although these results are statistically significant, whether they are clinically significant or not requires further investigation.

Study limitations:

Selection bias: subjects were selected form pool of healthy individuals who were interested to precipitate in the study in order to increase their physical activity or improve their quality of life. This fact may have contributed to better and more significant result (increased PA and elevated QoL in both intervention and control groups). In other words, that sample may have not been a perfect representative of the intended population.

Recall bias: since the data was measured subjectively and was collected using questionnaires, it is possible that participants' self-report was influenced by their experience and emotions they were experiencing. For instance, they may have over/under reported the time they spent and the intensity of their workout while traveling from place to place or while playing recreational sports with friends and family.

Sample size: sample size was calculated with consideration of 25% dropout based on similar studies (Storm et al., 2016; Larsen etal., 2017; Muller et al., 2017). However, our study results showed 22.4% dropout in the intervention group and 50.6% dropout in control group (36.8% in total). Therefore, our post-intervention sample size decreased significantly more than our estimation in control group, and that may have weakened the significance of the relations we were investigating.

Conclusion:

Results of this study suggests that smartphones and internet-delivered computer-tailored multimedia programs are suitable means of delivery for self-training programs to increase physical activity and elevate quality of life in short-term in healthy individuals, although these results should be interpreted with caution due to high dropout rates. Authors suggest further studies with a larger sample size should be conducted to better evaluate the long-term effect of similar strategies.

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