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A Pilot Randomized Controlled Trial to Promote Physical Activity and Change Fitness Scores in Rural College Students: The Northern eHealth / mHealth Trial (N-EMT)

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Abstract The aim of this study was to examine the feasibility and efficacy of two different technology-based health education interventions on physical activity (PA) and physical fitness (PF) outcomes in college students. A total of N=15 college students attending a small rural university were equally randomized to one of three groups: eHealth, mHealth, or wait-list control. Intervention components lasted four weeks. The eHealth group received four 1-week long health education modules via a campus-based website. The mHealth group also received four 1-week long modules with similar content as eHealth but with use of instant messaging and Facebook alerts. The control group was asked to behave in their usual manner. Outcome measures included scores from PF assessments, self-reported PA, theory of planned behavior (TPB) scales, and health-related quality of life (HRQOL) measures. Analyses indicated that mHealth made improvement on all PF measures. As well, mHealth made more improvement on PA measures than either eHealth or control. Results from this pilot study indicate that technology-based health education interventions are a feasible and efficacious strategy for promoting PA on rural college campuses.

Keywords: *health promotion, physical activity, physical fitness, eHealth, mHealth, rural health*

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1. Introduction

Physical activity (PA) is defined as any bodily movement produced by skeletal muscle contraction resulting in energy expenditure [1]. Current guidelines for adults recommend the accumulation of at least 150 minutes a week of moderate intensity PA, or 75 minutes a week of vigorous-intensity aerobic activity, or an equivalent combination of the two [2]. Despite this recommendation, only approximately 44% of U.S. adults meet these amounts, with a national goal set of 48% for year 2020 [3]. Health-related physical fitness (PF) is a set of attributes related to an ability to carry out specific tasks with high performance and that are also related to good health [4]. Exercise, which is a more planned and structured form of PA, usually has the purpose of improving PF. There are five (5) known components of health-related PF [5]. These components consist of 1) cardiorespiratory endurance, 2) muscular strength, 3) muscular endurance, 4) flexibility, and 5) body composition.

eHealth is a broad term referring to health education methods communicated using technology, especially the internet [6]. mHealth is a more specific form of eHealth that more so focuses on the use of mobile technology and handheld devices [7]. Health promotion interventions have been implemented using eHealth and mHealth strategies to increase physical activity [8], however, no studies to date have examined the effects of such interventions with the inclusion of PF assessments or among rural college students.

Given this background, PA is an important health behavior that should be promoted on rural college campuses [9]. Additionally, increasing PA in college students can have many benefits such as the improvement of one or more components of health-related PF [10]. Furthermore, due to growing usage of technology among college students, opportunity exists to use such technology, in novel ways, to promote PA. Therefore, the purpose of this study was to examine the feasibility and effect of two different technology-based health education interventions on PA and PF outcomes in rural college students. A secondary purpose was to determine whether the intervention affected health-related quality of life (HRQOL).

2. Methods

2.1. Participants

Participants were recruited via campus flyers and word-of-mouth. Inclusion criteria included being an enrolled college student with self-rated PA assessed as inactive to moderately active. Highly active students and/or athletes were not included in this study primarily because the intervention strategies were targeting less active individuals by design. Also, eligible participants needed to have had ownership of a mobile phone and needed to have been motivated to improve their fitness levels. After reading a study flyer, participants signed an IRB approved consent form and awaited further details.

2.2. Research Design

A total of N=15 participants agreed to participate and were equally randomized to one of three intervention groups: eHealth, mHealth, or wait-list control [11]. Each participant was asked to participate in their assigned intervention for exactly four weeks, in parallel. All outcome measures were collected twice: 1) on the first day of the intervention start date (pretest) and 2) on the last day of the intervention (posttest). Figure 1 displays the intervention design.

2.3. Planning Model

To increase the likelihood of success, the intervention was designed using a planning model. The generalized model (GM) was selected because its stages were in-line with the overall goals of this study [12]. Stages of the GM include: 1) needs assessment, 2) writing objectives, 3) intervention development, 4) implementation, and 5) evaluation.

2.4. Intervention Components

Intervention components lasted four weeks. The eHealth group received four 1-week long health education modules via a campus-based website [13]. Each weekly module consisted of lecture slides and a short multiple-choice quiz. The health education-based lectures were specifically designed with two main objectives. First, lecture material was strategically planned to target constructs within the behavior change model (see below). Second, lecture material was also specifically tailored to participants using the behavioral scales collected during pretest. For example, if the mHealth group self-reported less control over PA than eHealth, then lecture material would add extra emphasis on improving such behavioral control. The mHealth group also received four 1-week long modules with similar content as eHealth but with use of instant messaging and Facebook alerts. Both eHealth and mHealth weekly components were framed using a catch phrase that captured that week's overall goal. The control group was asked to behave in their usual manner. Table 1 displays the intervention components for each of the three study groups.

2.5. Behavior Change Model

The Theory of Planned Behavior (TPB) was used to drive improvement in PA and PF [14]. TPB constructs were measured at pretest and used to tailor intervention messaging. As well, TPB construct changes during the intervention were hypothesized to mediate changes in PA. Figure 2 displays the TPB model, modified to change PA and PF.

	N = 15 Total subjects signing	**Inclusion Criteria**: Inactive to moderately active Motivated to change fitness Has own mobile phone
Randomization		
mHealth N =5	eHealth N =5	Control N =5
Pretesting		
Fitness Testing PA Assessment Mediator Assessment HRQOL Assessment	Fitness Testing PA Assessment Mediator Assessment HRQOL Assessment	Fitness Testing PA Assessment Mediator Assessment HRQOL Assessment
Intervention		
4 week mHealth (Text Message / Facebook)	4 week eHealth (Weekly Lecture & Quiz)	4 week Control (Normal Activity)
Posttesting		
Fitness Testing PA Assessment Mediator Assessment HRQOL Assessment	Fitness Testing PA Assessment Mediator Assessment HRQOL Assessment	Fitness Testing PA Assessment Mediator Assessment HRQOL Assessment

Figure 1. Schematic layout of the N-EMT intervention design (*Note*. All subjects were post-tested)

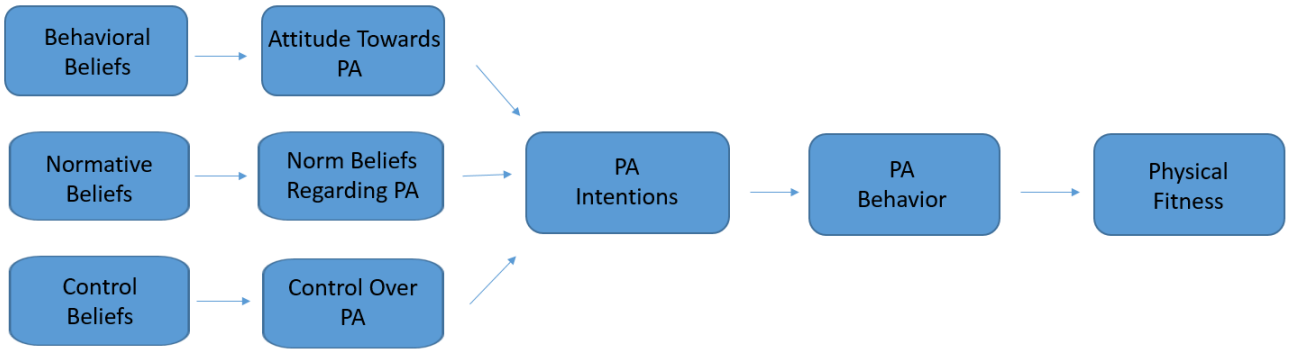

Figure 2. Theory of planned behavior (TPB) as applied to the Northern eHealth/mHealth trial (N-EMT) (*Note*. All scales were created specifically for the N-EMT trial)

Table 1. Explanation of N-EMT intervention components with examples

Week (Module)	eHealth	mHealth	Wait List Control	Objectives
1: Are you ready?!	Definitions by lecture slides. ACSM fitness scores norm tables. End of week quiz.	Facebook links showing 5 components of fitness. Personal text message explaining pretest fitness scores.	Continuation of normal activity.	-Define PA and fitness. -Explain fitness scores. -Evaluate their scores.
2: Let's do this!	Lecture slides with local fitness center pictures. Videos of exercises. End of week quiz.	Text message with link to pedometer app. Facebook page of exercise database.	Continuation of normal activity.	-Introduce local fitness facilities. -Show example exercises. -PA guidelines.
3: Give me one more!	Lecture slides showing FITT principle. Target heart rate formulas. End of week quiz.	Facebook page of FITT principle. Text message with weight and time management apps.	Continuation of normal activity.	-Explain FITT principle. -Time management. -Weight control strategies.
4: Don't stop!	Summary slides with main points. Links to resources. End of week quiz.	Test message with a link to mapometer.com. Summary points on Facebook.	Continuation of normal activity.	-Tie material together. -Create long-term PA plan. -Give helpful resources.

Note. Material for each week was tailored to participant pretest scores and designed to improve PA attitudes, control, norms, and intentions.

2.6. TPB Measures

Four TPB construct scales were developed specifically for rural college students regarding PA: 1) Attitudes toward PA (6 items), 2) Norm beliefs regarding PA (5 items), 3) Perceived control over PA (5 items), and 4) Intention to participate in PA (6 items). All scales were rating scale type with the same seven category options ranging from strongly disagree to strongly agree. A reliability study prior to the intervention showed acceptable internal consistency for all scales (alphas: .71 to .91). All TPB scales were scored to have larger values indicate more construct trait except for perceived control over PA.

2.7. PA Measures

A modified PA scale was used and combined items from the International Physical Activity Questionnaire (IPAQ) [15] and National Health and Nutrition Examination Survey (NHANES) [16] assessments. Particular attention was paid during scale development to ensure participants would not include muscle strengthening activity in with their recall of aerobic PA. A total of six PA measures were obtained: 1) Transportation PA (min/week), 2) Vigorous PA (min/week), 3) Moderate PA (min/week), 4) Moderate to vigorous PA (min/week), 5) Muscle strengthening activity (min/week), and 6) Sitting time (hours/day). A reliability study prior to the intervention showed acceptable internal consistency for the newly developed PA scale (alpha: .85).

2.8. PF Measures

Trained research assistants administered all PF tests. Body composition was assessed via body mass index (BMI) and percent body fat (PBF) using sum of three skinfold site equations [17]. Muscular strength was assessed via hand grip dynamometer [18]. Muscular endurance was assessed via standardized push-up and curl-up tests [17]. Flexibility was assessed via the Canadian sit-and-reach box [17]. And cardiorespiratory fitness was assessed by measuring VO2max via the Queen's College step test [19].

2.9. HRQOL Measures

The SF-12 was administered to assess HRQOL [20]. Four measures were derived from this assessment: 1) single item general health, 2) raw summed score, 3) SF-12 physical component score (PCS), and SF-12 mental component score (MCS).

2.10. Statistical Analyses

Analysis of variance (ANOVA) models and Kruskal-Wallace tests were used to determine statistical differences across groups. When differences were found, follow-up post-hoc t-tests and Mann-Whitney tests were performed. Pretest to posttest differences were evaluated by creating change scores and followed the same statistical procedure stated above. Since both parametric and nonparametric tests showed the same significant differences, results are only reported for the parametric methods. Due to small sample sizes, effect sizes were reported for ANOVA models [21,22]. SPSS and SAS were used for all analyses [23,24].

3. Results

Table 2 shows baseline characteristics of study variables across intervention groups. All measures were balanced across groups with exception of perceived control over PA, where eHealth showed significantly more ($p<.05$) control than mHealth. All N=15 participants followed through with their respective intervention component and took part in post-testing assessments. Participants in the technology-based intervention groups were engaged in the health education strategies as evaluated by usage analytics. i.e., all eHealth participants took and passed all weekly quizzes and all mHealth participants responded to text messaging and Facebook alerts.

Table 2. Descriptive statistics of pretest measures across intervention groups (N=15)

	eHealth (N=5)		mHealth (N=5)		Control (N=5)	
Measure	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Physical Fitness Scores						
BMI (kg/m^2)	28.6	6.3	22.7	3.4	24.9	3.2
PBF (%)	18.2	6.9	22.9	8.5	17.1	6.3
VO2max (ml/kg/min)	52.8	6.5	43.4	4.8	48.6	10.5
Grip Strength (kg)	49.9	6.7	37.3	13.4	41.7	13.9
Sit-n-reach (cm)	30.5	9.4	31.0	8.5	29.5	10.5
Push-ups (#)	25.8	6.3	20.6	6.3	30.4	11.9
Curl-ups (#)	44.0	28.4	36.8	36	37.0	13.7
Theory of Planned Behavior (TPB) Scales						
Attitude toward PA (6-42)[a]	37.2	4.1	36.4	2.9	34.8	2.6
Norm beliefs regarding PA (5-35)[a]	23.2	7.2	20.8	4.7	22.0	2.2
Perceived control concerning PA (5-35)[b]	**7.6**	2.4	**16.8**	6.6	11.2	3.3
Intention to participate in PA (6-42)[a]	30.4	11.3	27.8	9.1	30.0	7.3
Physical Activity (PA)						
Transportation (min/week)	162.0	184.4	76.0	99.6	121.0	116.5
Vigorous (min/week)	324.0	371.3	68.0	89.3	134.0	261.7
Moderate (min/week)	660.0	832.5	74.0	69.9	117.0	117.3
Moderate to vigorous (min/week)[c]	1308.0	1548.1	210.0	244.1	385.0	606.5
Muscle strengthening activity (min/week)	234.0	309.2	53.0	75.1	90.0	103.9
Sitting (hours/day)	6.2.0	3.6	8.0	3.1	9.0	2.2
Health-Related Quality of Life (HRQOL)						
General (1-5)[d]	3.6	1.1	3.8	0.8	2.8	0.4
Overall[e]	39.2	3.3	41.4	1.7	38.8	4.1
PCS[f]	52.1	5.7	53.8	2.2	48.2	5.5
MCS[f]	51.6	9.4	54.5	1.7	55.3	4.3

Note. [a]Larger scale scores indicate high positive trait. [b]Smaller scale scores indicate high positive trait. [c]Computed as moderate PA plus two times vigorous PA. [d]Larger score represents better HRQOL. [e]Raw SF-12 summed scores after reverse coding. [f]True HRQOL T-scores from SF-12 algorithms. Bolded values indicate means are significantly different from each other. SD represents standard deviation.

Table 3. Change (posttest - pretest) in outcome measures across intervention groups, Northern eHealth/mHealth trial (N=15)

	eHealth (N=5)		mHealth (N=5)		Control (N=5)		ANOVA	
Measures	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p*	*eta*^{2}
Physical Fitness Scores								
BMI (kg/m^2)	0.28	0.50	-0.11	1.23	-0.32	0.40	.506	.11**
PBF (%)	-0.02	3.65	-1.75	2.87	0.52	2.73	.505	.11**
VO2max (ml/kg/min)	-0.65	4.62	0.57	6.80	-4.37	11.77	.630	.07**
Grip Strength (kg)	0.06	5.13	3.44	3.93	-1.60	3.25	.193	.24***
Sit-n-reach (cm)	2.90	4.70	**6.30**	4.66	**-1.90**	4.35	.045	.40***
Push-ups (#)	2.20	6.91	1.60	9.29	-7.60	4.67	.094	.33***
Curl-ups (#)	8.40	13.43	9.00	14.39	3.40	13.83	.787	.04*
Theory of Planned Behavior (TPB) Scales								
Attitude toward PA (6-42)[a]	0.00	2.12	-5.60	12.14	-0.80	3.70	.459	.12**
Norm beliefs regarding PA (5-35)[a]	3.20	1.92	3.20	5.97	1.60	3.05	.773	.04*
Perceived control over PA (5-35)[b]	-1.60	2.70	2.20	12.13	-0.40	1.52	.704	.06**
Intention to participate in PA (6-42)[a]	1.60	6.35	-2.40	7.80	1.80	5.26	.538	.10**
Physical Activity (PA)								
Transportation (min/week)	-76.4	224.1	59.0	96.1	-11.0	111.6	.412	.14***
Vigorous (min/week)	-60.0	258.1	19.0	139.9	-94.0	239.1	.711	.06**
Moderate (min/week)	60.0	570.8	-13.0	103.2	9.0	203.4	.946	.01*
Moderate to vigorous (min/week)[c]	-60.0	1064.1	25.0	263.2	-179.0	620.6	.906	.02*
Muscle strengthening activity (min/week)	-144.0	322.0	-45.0	80.8	18.0	78.2	.448	.13**
Sitting (hours/day)	-0.6	2.5	-2.4	3.1	-1.0	1.7	.506	.11**
Health-Related Quality of Life (HRQOL)								
General (1-5)[d]	0.20	0.45	-0.20	0.84	0.00	0.00	.531	.10**
Overall[d,e]	0.00	3.16	-1.60	3.78	1.20	2.28	.395	.14***
PCS[d,f]	1.60	6.98	1.86	3.66	2.80	4.88	.934	.01*
MCS[d,f]	-0.52	6.41	-6.98	5.71	-0.40	2.59	.112	.31***

Note. All positive (+) changes represent improvement from pretest except BMI, PBF, TPB perceived control over PA, and sitting time. [a]Larger scale scores indicate high positive trait. [b]Smaller scale scores indicate high positive trait. [c]Computed as moderate-intensity PA plus two times vigorous-intensity PA. [d]Larger scores represents better HRQOL. [e]Raw SF-12 summed scores after reverse coding. [f]True HRQOL T-scores from SF-12 algorithms. Bolded values indicate means are significantly different from each other. SD represents standard deviation. Cohen's eta^2 effect size criteria: * is small, ** is medium, and *** is large.

Table 3 displays changes (posttest-pretest) in outcome measures across intervention groups. Positive values indicate improvement with exception of BMI, PBF, perceived control over PA, and sitting time. Most noteworthy, mHealth made improvement on all PF measures. As well, mHealth made more improvement on PA measures than either eHealth or control.

4. Discussion

The aim of this study was to examine both the feasibility and efficacy of two different technology-based health education interventions (eHealth and mHealth) on PA and PF outcomes in rural college students. Results clearly showed that both eHealth and mHealth interventions are feasible means of providing rural college students with PA-related health education. This was primarily demonstrated through the 100% participant adherence to all intervention components as well as the 100% compliance with all posttest measurements.

Results of this study also demonstrated intervention efficacy, albeit with few statistically significant effects due to low statistical power. When merely counting the number of PA measures that improved at intervention end, the control group, eHealth, and mHealth saw three, two, and four improved measures, respectively. These differences were also accompanied by significant effect sizes. When counting PF improvements, the control group, eHealth, and mHealth saw two, five, and all seven improved measures, respectively. These PA and PF effects when considered together indicate that the mHealth group saw the most improvement in PA and PF. This may suggest that mHealth intervention components were responsible for improving college student PA which in turn improved their PF.

The results of this pilot study should be interpreted while considering other factors. For example, the N-EMT occurred across four weeks in April, after a winter season typical of a northern U.S. state. This fact may have influenced the participants to be more compliant with intervention components as compared to other semester months. Nonetheless, the intervention groups were randomized, and mHealth saw more improvements than either eHealth or control groups. Another factor to consider, is the small samples of the N-EMT. Given these small samples, most of the statistical analyses suffered from low power. Even so, the reported effect sizes supported mostly medium to large effects for all outcome measures.

A final factor to consider is the instructional method that was used in the eHealth group. Students in this group were enrolled in a campus-based Desire-to-Learn (D2L) course. The format of this course was already familiar to eHealth participants since this was the same format provided to them for all their regular college courses. Therefore, motivation to learn in the eHealth group may have been lower than that provided to the mHealth group. In other words, there was no innovative technology being offered to the eHealth participants. This fact may in part explain why the mHealth group made more improvements that their counterparts.

5. Conclusions

Results from this pilot study indicate that a short-term four-week technology-based (eHealth and mHealth) health education intervention may be a feasible strategy in promoting PA on rural college campuses. The use of mHealth, in particular, was shown to offer more flexibility in tailoring intervention components to participants. As well, mHealth may provide a more efficacious means to improving PA behavior and in turn improving PF in rural college students.

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