Original Research

Effects of a Smart-phone Application on Psychological, Physiological, and Performance Variables in College-Aged Individuals While Running

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ABSTRACT

International Journal of Exercise Science 8(2) : 104-111, 2015. The purpose of this study was to determine the effects of auditory exergaming through the use of a smart-phone app called Zombies, Run! on psychological, physiological, and performance variables in college-aged individuals while running. Participants included both males (n = 10) and females (n = 10). Participants ran three 15 minute trials, after which they completed motivational questionnaires regarding inspiration, enjoyment, confidence, and anxiety levels. The first run got the participants accustomed to the application. The second and third were randomly counterbalanced either using the application again or running with no auditory stimulus. The analysis of the motivational questionnaire and physiological variables found that both sexes felt more inspired to run using the Zombies, Run! application than running with no auditory stimulus (P = .003), males felt more confident they could complete the trials (P = .02), females felt they exerted themselves more during the zombie run (P = .03), males were more motivated than females to run faster to avoid losing items (P = .005) and males felt more motivated than females to collect items and improve their in-game township (P = .002). These results indicated that females perceived more exertion and felt less confident, but were more inspired while running using the Zombies, Run! application. Males felt more confident, more inspired, and more intrigued by the video game itself than females. Therefore, both were more motivated to run with than without the application.

KEY WORDS: Exergaming, intrinsic, questionnaire, heart rate, speed, distance, energy expenditure, interval, pace

INTRODUCTION

Large amounts of sedentary time have been related to increased risk of cardiovascular and metabolic disease and have been linked to premature death (4). Video games require a large amount of time spent inactive and are thought to contribute to increases in obesity rates (9). It was reported by Life Project that 65% of college students play sedentary video games on a regular basis. Since 1999, video games have comprised over 30% of the United States toy market sales (11). A recent medium for video games is through the cellular phone. Since 2009, 67% of the world's population has a cellular phone, a number which continues to grow (1). This has potentially contributed to the recent dramatic reduction in the world's average physical activity level. It is thought that today's technology (including video games)

replaces time spent that has been traditionally spent on physical activity and exercise, thereby leading to this increase in sedentary lifestyle. Current statistics support this, showing that the percentage of individuals who reach adequate physical activity levels has dropped from 55% to 40% (7).

Aware of large increases in sedentary lifestyles and obesity rates being due to their products, many video game companies have begun creating physically interactive games. The Nintendo Wii, Sony PlayStation 3, and Microsoft Xbox 360 gaming consoles now have the capability to use motion sensors that allow the player to perform physical movements registered by the sensors themselves, an activity referred to as "exergaming" (5). Because of the prevalence of cellular phones in today's society, exergames have begun utilizing this new medium as well.

One in particular, known as "Zombies, Run!", plays a monologue through a runner's headphones plugged into his or her cell phone, which is then strapped to the runner's arm. Throughout this monologue, the user is told he or she is in the alternate reality of a zombie apocalypse and must collect items and perform missions in order to survive. At particular intervals, the game also beeps and tells the user he or she is being chased by a zombie and must sprint faster in order to evade it. A GPS system tracks the runner's average pace, and an increase in speed is required during these sprint intervals or the runner loses items previously collected.

According to Wack (11), the primary purpose of playing video games is to provide an outlet for socialization, relaxation, and coping with the stresses of life. These motives seem to be principally centered on intrinsic motivation, or how an individual feels emotionally before, during, and after an activity. Gallagher (3) tested whether fitness messages would be intrinsically motivational to participants based upon their individual need for cognition (NC). The study found that participants with high NC were motivated by fitness messages, while participants with low NC were motivated by non-fitness messages. These results could imply that inspirational messages in general have the potential to lead to greater motivation.

The console video game revolution may have led users to become more sedentary. These people could benefit from an active exergame that is proven to be inspirational and beneficial to their health. Alongside motivation, measuring for physiological and performance variables during the use of exergames is important because it will display the exact physical effects, which may lead to implications of long-term health benefits. Higher heart rate, speed, distance, or energy expenditure (EE) measures imply an increased calorie burn and a greater reduction in body fat percentage over an extended period in time.

As the new medium of auditory exergaming begins to rise, the effects of its use should be known in order to ensure users are benefiting from it. Intrinsic motivation could lead to a reduction in stress. An increase in heart rate, distance, speed, EE, and rate of perceived exertion (RPE) due to the effects of alternate reality audio stimulation could lead to quicker results and more satisfied users. It is hypothesized that auditory exergames will

increase intrinsic motivation through inspiration and enjoyment compared to basic running, subsequently leading to higher heart rate, speed, distance, and EE values.

METHODS

Participants

Descriptive characteristics of the participants are presented in Table 1. The study was approved through the Institutional Review Board prior to its commencement. Participants were gathered using fliers posted across the Middle Tennessee State University campus and through word of mouth. No incentive was given to participate. An exact response rate was not found, though a vast majority of the population asked to participate declined, perhaps due to the busy lifestyle of the average college-aged individual. Preference in video game usage was not a participation factor or variable found. After joining, each participant was screened for cardiovascular disease risk factors and was allowed to participate if he or she was of low risk (10), exercised regularly at moderate intensity at least three days a week, and was between the ages of 18 and 35. Participants also read and signed an informed consent form.

Protocol

Participants were first instructed on how to use the Zombies, Run! application. This was accomplished through a verbal script while they were allowed to browse through the game tutorial and screen interfaces. The application was employed by the participants through a phone and arm strap but each participant was required to supply their own earbuds.

Table 1. Means (SD) of all participants' descriptive characteristics.

Characteristic	Males M (SD)	Females M (SD)
Age	21.60 (± .70)	23.50 (± 3.63)
Height (m)	1.78 (± .08)	1.63 (± .07)
Weight (kg)	79.50 (± 11.64)	62.35 (± 5.27)
BMI (kg/m2)	24.84 (± 2.69)	23.44 (± 2.24)

There were a total of three trials per participant. The first was a preliminary trial using the Zombies, Run! application, and the second and third were randomly counterbalanced with the flip of a coin to either use the application again or run with no auditory stimulus. Each trial was run on an indoor track for distance. Being indoors prevented any variables associated with weather conditions. The track was measured precisely with a measuring wheel prior to testing to ensure consistent distance data. The participants were then given a SenseWear Mini armband and a Polar RS 800 heart rate monitor to wear, which were each synchronized with the Zombies, Run! application during the application trials. The participants then performed a uniform five minute active warm-up to prevent injury, after which they were instructed to run until told to stop. This prevented any runners from skewing the data by trying to sprint harder through the end of the run, which might have occurred had they known the exact time during the runs.

The first Zombies, Run! trial was performed to set baseline measurements and to show the participants the processes of the application but was not used for data comparison. The second Zombies, Run! trial measured the effects of the application more accurately, canceling out any irregularities from the first test caused by lack of exposure to the application's processes and functions. All Zombies, Run!

trials were done performing the same mission and contained an average of two randomly timed zombie attacks per run. Each test was taken at least two days apart to ensure proper recovery. Randomly counterbalancing the order of the second trial with the application and the only trial without auditory stimulus per person was to ensure the removal of any variables associate with training order. However, the initial Zombies, Run! trial was always the first performed.

For every test, the participants were told to continue moving forward for the duration of the trial. The Polar RS 800 monitor measured heart rate and the SenseWear Mini armband, a cutting-edge and reliable form of technology (2, 6), kept track of their EE throughout the entirety of the tests. The exact location at which the fifteenth minute was reached was spotted and measured from to calculate the final partial lap completed. A tally system was also used to keep track of the number of complete laps ran.

The SenseWear Mini armband, Polar RS 800 monitor, and stopwatch were all synchronized with the start of the Zombies, Run! application, which internally recorded the exact moment when a zombie or hoard began chasing the runner, moments when new bits of monologue began, and moments when it was simulated that items were picked up in the game.

At the end of each trial, the participants filled out a motivational questionnaire that asked them what motivated them and why, as well as what their RPE was based on the Borg Scale of Perceived Exertion. See Table 2 for a list of all questions asked. The questionnaire judged each trial's effects on motivation, what aspects of the game in particular had the strongest effects, and whether the most prominent mode of motivation differed between the sexes. After the final run for each person, he or she was also debriefed.

Table 2. Questions found on motivational questionnaires used in this study.

Questions found on both zombie run and basic run questionnaires:

- Q1 = I was comfortable during the run
- Q2 = I am confident I can perform the runs in this study
- Q3 = I enjoy being a part of this study
- Q4 = This run was stressful
- Q5 = I felt anxiety during the run
- Q6 = I felt inspired during the run
- Q7 = The run exhausted me

Questions found only on zombie run questionnaires:

- Q8 = The application's zombie chase sequences were motivational
- Q9 = I ran faster to avoid losing all of the items I had collected
- Q10 = I was motivated to run faster through a fear of being caught by the zombies
- Q11 = I was motivated to continue running to collect more items to boost my township's size and population
- Q12 = I will use this application in the future to help achieve my fitness goals

Note: Answers were given on a scale from 1 (strongly disagree) to 5 (strongly agree).

Statistical Analysis

Means, standard deviations, and frequencies were used to give descriptive characteristics of the sample. Two-way repeated measures analysis of variance (ANOVA) and post hoc dependent *t*-tests were utilized to compare heart rate, speed, distance, and EE during the basic run and the zombie run. Non-parametric Wilcoxon Signed Ranks tests were used to compare

Table 3. Results of outcome variables during the zombie run versus the basic run.

	Males		Females	
	ZR	BR	ZR	BR
Main Effect	M (SD)	M (SD)	M (SD)	M (SD)
HR (bpm)	168.80 (± 14.72)	166.30 (± 11.72)	171.70 (± 10.06)	171.60 (± 14.18)
Speed (kph)	11.38 (± 1.68)	11.10 (± 1.30)	8.78 (± 1.53)	8.79 (± 1.68)
Distance (m)	2846.22 (± 418.77)	2775.86 (± 324.50)	2194.10 (± 381.57)	2198.67 (± 420.13)
EE (kcals)	13.03 (± 1.95)	12.85 (± 2.37)	9.14 (± .83)	9.28 (± 1.11)
RPE (6-20)	14.60 (± 2.59)	14.00 (± 3.86)	14.20 (± 1.93)*	12.80 (± 1.48)*

* Significant differences at $P < .05$ level. Note: ZR = Zombie Run; BR = Basic Run

motivational questionnaire answers for the basic run and the zombie run. Mann-Whitney U-tests were utilized to compare differences in the answers of the questionnaire between males and females. All tests were run using SPSS statistical analysis software. The alpha level for significance in this study was $P < .05$.

RESULTS

The two-way repeated measures ANOVAs for heart rate, speed, distance, and EE found no significant difference between the zombie runs and the basic runs. The two-way repeated measures ANOVA for RPE revealed that the main effects were significant ($P = .04$) and the interaction of sex was not significant. Post hoc dependent *t*-tests showed RPE was significantly higher in the zombie run than in the basic run in females, t (9) = 2.69, $P = .03$, $\eta^2 = .45$, but was not significantly different in males. See Table 3 for a complete list of all main effect means (SD).

A Wilcoxon Signed Ranks test revealed significant agreement with the zombie run being more inspirational than the basic run, $z = -2.96$, $P < .003$, with a large effect size ($r = .66$). The median score was higher for the zombie run ($Md = 4$) than the basic run ($Md = 3$). A first Mann-Whitney U-test revealed a significant difference in having confidence to perform the zombie run between males and females. A second Mann-Whitney U-test revealed a significant difference in being motivated to run faster to avoid losing items collected during the zombie run between males and females. A third Mann-Whitney U-test revealed a significant difference in being motivated to continue running to collect more items to boost the in-game township's size and population between males and females. See Table 4 for a list of statistical results for measuring confidence and motivation comparing males and females.

DISCUSSION

This study is the first to ever test the effects of using alternate reality audio stimulation. The majority of the video game industry focuses on sedentary console usage, so this new medium of auditory exergaming is important. It gives the user the ability to exercise anywhere he or she wants while playing an exergame at the same time. As rates of obesity continue to climb worldwide, tailoring exercise programs to the desires of the individual has become more essential than ever before. Using exergames could act as a gateway for video

Table 4. Results of the Mann-Whitney U-test comparing males and females.

Questions	Male (n=10) *Md*	Female (n=10) *Md*	*U*	*z*	*P*	*r*
Basic Run						
Q1	5.0	4.0	41.00	-0.74	.460	.165
Q2	5.0	5.0	45.50	-0.40	.687	.090
Q3	5.0	5.0	43.50	-0.59	.557	.131
Q4	2.0	2.0	34.50	-1.34	.182	.299
Q5	2.0	2.0	39.00	-0.94	.350	.209
Q6	3.5	3.0	48.50	-0.12	.906	.026
Q7	3.0	3.0	42.00	-0.62	.533	.140
Zombie Run						
Q1	4.0	4.0	45.00	-0.41	.684	.091
Q2	5.0	4.0	24.50	-2.30	.021*	.515
Q3	5.0	5.0	34.00	-1.60	.111	.357
Q4	2.0	2.0	46.00	-0.33	.738	.075
Q5	2.0	2.0	46.00	-0.34	.738	.075
Q6	4.5	4.0	38.50	-0.95	.344	.212
Q7	3.5	3.0	39.00	-0.86	.392	.191
Q8	5.0	4.5	42.50	-0.66	.511	.147
Q9	5.0	4.0	15.00	-2.83	.005*	.632
Q10	5.0	5.0	43.50	-0.58	.562	.130
Q11	4.0	3.0	12.00	-3.09	.002*	.690
Q12	4.0	4.0	44.00	-0.49	.622	.110

* Significant differences at $P < .05$ level

game players to develop healthier lifestyles. The purpose of this study was to verify that this new medium of auditory exergames actually has a significant physical or motivational effect on the user to give an understanding as to the benefits of the medium.

Proving the first half of this study's original hypothesis, it was found that both males and females felt more inspired to run using the auditory exergame called Zombies, Run! than they did while running with no auditory stimulation whatsoever. In terms of sex differences, males felt more confident they could complete the trials. It was also found that females perceived that they ran significantly harder during the zombie run than the basic run. Males were found to be more motivated than females to collect items and improve their in-game township's population and base structures. Disproving the second half of the hypothesis, the rest of the main effects, which included heart rate, speed, distance, and EE, were found to be insignificantly different between the sexes and between the zombie run and basic run.

While this study is unique in concept, there have been recent studies on other forms of exergaming that relate to the healthful and motivational effects thereof. One study found that console exergames, those played

indoors using a motion sensitive camera, actually led to improvements in health-related outcomes (8). This study on auditory exergames measured no significant increase in EE using the application than without any stimuli. If this had been found, prolonged use of auditory exergames may lead to improved health-outcomes such as a reduction in body fat percentage. Because this study focused on acute physical effects, the potential for improved health-outcomes in an extended study cannot be ruled out.

A recent study focusing on the motivational factors found that playing video games gave participants a way to socialize, relax, and cope with stress, all of which are intrinsically motivational factors (11). The results from this study on the motivational effects of using the auditory exergame Zombies, Run! lean toward similar factors. Both male and female participants felt more inspired to run while using the application rather than while running with no stimulation at all. The Zombies, Run! game, though not leading to any higher physical results, made the participants feel more motivated to run. Females even felt like they were running harder with the application than without it based on RPE measures, which may have led to the increased motivation because they felt like they were putting forth more effort during the run.

The reasoning behind the results of this study lies primary within the practicality and the physiological factors involved in the outcome. The result that males were more motivated to collect items and improve their in-game township may have been due to the male participants being more competitive with the theme of the application than females. Lastly, another point of evidence that shows that females lacked interest in the subject matter of the exergame was demonstrated by an increased difficulty in recruiting female participants.

Females perceived that they worked harder and were less confident during the zombie run than the basic run. This may be due to the very nature of the zombie run. Randomly being told that they were getting chased by a zombie caused them to sprint at random intervals. These random sprints followed by prolonged jogging intervals may have caused the female runners to perceive a higher exertion than simply running at a consistent pace for the entire run, as evidenced by the significantly higher RPE values.

The primary strength of this study was the success of the motivational questionnaire to determine the main reasons behind why individuals preferred one type of run over the other. Finding that both males and females were more inspired using the application implies that the participants may be more likely to adhere to an extended exercise program. While adherence was not measured during this acute study, the results imply greater long-term usage of auditory exergames.

The primary limitation of this study was its sample size. Having only 10 males and 10 females led to higher standard deviations within the statistical analysis than was originally anticipated. Because of this, measures that began to lean toward significant differences between the sexes or the runs, such as EE, had too high a standard deviation to reach significance. For this reason, a higher sample size might

help future researchers find significance in both physiological and performance variables using auditory exergames.

Testing the effects of this new medium could lead to betterment in the health of one of the world's most sedentary populations. Measuring the motivation, heart rate, speed, distance, EE, and RPE in both male and female college-aged individuals while using the Zombies, Run! application helped define what affected them the most and how auditory exergames can be more beneficial than running simply to run. It was found that both sexes were more inspired to run with the app, males felt more confident they could complete the trials, females felt like they ran harder with than without it, and males were motivated to collect items and increase their in-game base more than females.

There were no significant differences in heart rate, speed, distance, or EE between the sexes or types of runs, but that may have been due to an averaging out effect of the sprints and subsequently slower jog intervals of the zombie runs. The strength of the study was the motivational questionnaire while the weakness was the sample size. Future research should be conducted to increase the sample size which may lead to significant findings in terms of physiological and performance measures and to test for participant adherence when on a program implementing the use of auditory exergames.

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