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Comparison of College Students' Health Metrics during Stationary Cycling and Vrbased Stationary Cycling

Diana Stoltzfus, B.S., Cassady Wallace, B.S., Riley Mccalicher, B.S., Praveen Veerabhadrappa*, Ph.D.

Department of Kinesiology, Division of Science
Pennsylvania State University, Berks, Pennsylvania, USA

*Corresponding Author
Praveen Veerabhadrappa, MBBS, MS, PhD, ISHF,
Associate Professor
Department of Kinesiology, Division of Science
Pennsylvania State University, Berks, Pennsylvania, USA

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Introduction

Physical inactivity has become a global concern due to increasingly sedentary lifestyles. Individuals spend significant portions of their day performing sedentary activities, such as working at a desk, watching television, or playing video games. Alarmingly, only 23% of adults in the United States meet national physical activity guidelines (McDonough et al., 2020). College students are particularly at risk, with approximately 80% not meeting activity guidelines and 34% classified as overweight or obese (McDonough et al., 2020). Physical inactivity is associated with numerous health risks, including cardiovascular disease, obesity, and impaired cognitive function, emphasizing the need for interventions that promote physical activity.

The rapid growth of video games and virtual reality (VR) technology offers a novel approach to engaging sedentary populations. VR creates immersive environments that simulate real-world experiences, combining visual, auditory, and other perceptual stimuli (Pasco, 2013). By integrating VR into traditional exercise equipment, such as stationary bikes, it may be possible to enhance exercise engagement and adherence among college students (McDonough et al., 2020).

Previous studies have shown that VR-based exercise can positively affect perceived exertion, enjoyment, and self-efficacy, though most have not measured heart rate (HR) as an outcome (McDonough et al., 2020; Zeng et al., 2017). Heart rate, along with blood pressure (BP) and rating of perceived exertion (RPE), provides important insights into cardiovascular and perceptual responses during exercise.

The purpose of this study was to compare the effects of VR-based stationary cycling versus traditional stationary cycling on HR, BP, and RPE in college students. By including HR as an outcome measure, this study aims to fill a critical gap in the literature and determine whether VR-based exercise can elicit comparable or enhanced physiological and perceptual responses relative to traditional cycling.

Methods

Participants first met with the principal investigator in the Exercise Physiology Laboratory at the Penn State Berks Athletics and Wellness Center. During this meeting, participants were briefed on the research. Participants then completed and signed an informed consent form, which was approved by the Institutional Review Board. After obtaining consent, the participants completed the PAR-Q+ Questionnaire and the Health History Questionnaire to ensure they were physically eligible for the study. Participants who answered "no" to each question on the PAR-Q+ form were eligible to participate in the study. Next, demographic data including their gender, age, height, weight, body composition, and baseline HR and BP were measured and recorded. Resting BP was measured using the automated blood pressure cuff, and resting HR was measured using an Apple watch. Body composition, which included body mass index (BMI), body fat percentage, lean muscle mass, resting metabolic rate (RMR), visceral body fat, and body age was assessed through bioelectrical impedance analysis (BIA) using an OMRON body composition monitor. Waist and hip circumferences were also measured, and the ratio of these circumferences was then calculated for each participant. All the participant data were exported to Excel for analysis.

Before beginning the cycling sessions, participants were familiarized with the equipment. They then completed two separate 20-minute cycling sessions—one stationary cycling session and one stationary cycling session while wearing the VR oculus—in a randomly allocated order. Pedaling resistance was set to the same moderate intensity for both sessions, which was 40-59% of HR reserve (HRR). HRR was calculated as maximum HR - resting HR, and maximum HR was calculated as 220 - age for all participants. Participants rested for ten minutes between each cycling session to allow BP and HR to return to baseline levels. HR, BP, and RPE were assessed and recorded immediately before each session, at five-minute intervals during each session, and immediately after each session. The testing was terminated if the participant exhibited any absolute indications to stop, or if they were experiencing significant dizziness and nausea during the VR-based session that prohibited them from continuing the session. The data were then exported to Excel and analyzed to determine if there were any significant differences in these metrics between stationary cycling and stationary cycling while wearing the VR oculus.

Data Analysis

Mean HR, BP, and RPE were calculated for each condition. Paired t-tests were used to compare physiological and perceptual responses between the VR and traditional cycling sessions. Statistical significance was set at $p < 0.05$. Data were analyzed using SPSS version 28.

Results

The results in Table 1 show the mean and standard deviation of subject demographic variables. Twenty-two participants (7M/15F) were recruited for this study. The mean age was 21 years. The mean BMI was 26.25 kg/m2, which puts the cohort in the overweight category. Mean resting heart rate was 77 beats per minute (bpm), within the normal heart rate range of 60-100 bpm. Mean systolic blood pressure was 114 mmHg, and mean diastolic blood pressure was 68 mmHg, both of which fall within the normal blood pressure range. Mean body fat percent was 32.2%, which is within the normal range for females, who comprised the majority of the participants for this study. Mean waist to hip ratio was 0.88, which is healthy for men, but slightly over the recommended ratio for women.

Table 1: Demographics

Variable	Mean/SD
Gender	7M/15F
Age (yrs)	21/2.246
BMI (kg/m^2)	26.25/5.008
RHR (bpm)	77.045/14.772
SBP (mmHg)	114.818/14.083
DBP (mmHg)	68.909/8.585
Body fat %	32.2/9.599
WHR	0.887/0.041

BMI: body mass index; RHR: resting heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; WHR: waist to hip ratio.

Using SPSS version 29.0.0, a paired samples t-test was run for each of the outcome variables of blood pressure (BP), heart rate (HR), and rating of perceived exertion (RPE) to determine whether there was a significant ($p<0.05$) difference between BP, HR, or RPE during the non-VR (traditional) session and the VR session.

The results indicated that there was no significant difference between the pre-SBP/pre-DBP during the traditional session (M=114/69 mmHg, SD=12/9) and during the VR session (M=118/71 mmHg, SD=13/7). The results also showed that there was no significant difference between the 5-minute SBP/5-minute DBP during the traditional session (M=143/77 mmHg, SD=15/8) and during the VR session (M=144/77 mmHg, SD=13/7); between the 10-minute SBP/10-minute DBP during the traditional session (M=151/78 mmHg, SD=13/8) and during the VR session (M=153/79 mmHg, SD=12/6); between the 15-minute SBP/15-minute DBP during the traditional session (M=154/79 mmHg, SD=13/7) and during the VR session (M=155/81 mmHg, SD=11/6); and between the post-SBP/post DBP during the traditional session (M=143/76 mmHg, SD=17/9) and during the VR session (M=145/79 mmHg, SD=16/11). (See Table 2.)

Table 2: Blood Pressure During Traditional and VR Session

Variable: BP (mmHg)	Mean/SD	Significance
Traditional Pre SBP	114/12	0.120
VR Pre SBP	118/13	
Traditional Pre DBP	69/9	0.311
VR Pre DBP	71/7	
Traditional 5-Min SBP	143/15	0.713
VR 5-Min SBP	144/13	
Traditional 5-Min DBP	77/8	0.958
VR 5-Min DBP	77/7	
Traditional 10-Min SBP	151/13	0.465
VR 10-Min SBP	153/12	
Traditional 10-Min DBP	78/8	0.662
VR 10-Min DBP	79/6	
Traditional 15-Min SBP	154/13	0.672
VR 15-Min SBP	155/11	
Traditional 15-Min DBP	79/7	0.238
VR 15-Mine DBP	81/6	
Traditional Post SBP	143/17	0.322
VR Post SBP	145/16	
Traditional Post DBP	76/9	0.112
VR Post DBP	79/11	

The results of the paired samples t-test for HR indicated that there was no significant difference between the pre-HR during the traditional session (M=78 bpm, SD=16) and during the VR session (M=81 bpm, SD=15); between the 5-minute HR during the traditional session (M=128 bpm, SD=11) and during the VR session (M=126 bpm, SD=12); between the 10-minute HR during the traditional session (M=133 bpm, SD=14) and during the VR session (M=131 bpm, SD=14); between the 15-minute HR during the traditional session (M=137 bpm, SD=13) and during the VR session (M=137 bpm, SD=14); and between the post-HR during the traditional session (M=135 bpm, SD=17) and during the VR session (M=136 bpm, SD=12). (See Table 3.)

Table 3: Heart Rate During Traditional and VR Sessions

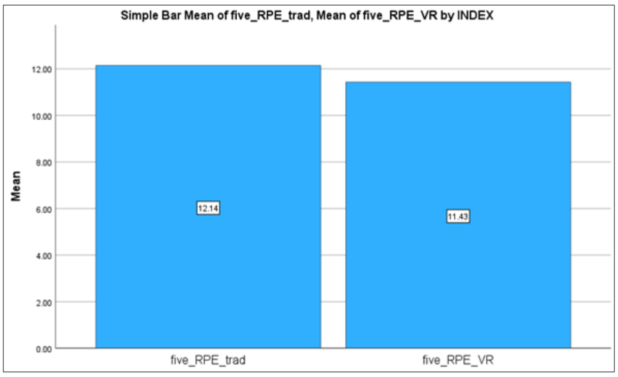
Variable: HR (bpm)	Mean/SD	Significance
Traditional Pre HR	78/16	0.230
VR Pre HR	81/15	
Traditional 5-Min HR	128/11	0.291
VR 5-Min HR	126/12	
Traditional 10-Min HR	133/14	0.519
VR 10-Min HR	131/14	
Traditional 15-Min HR	137/13	0.985
VR 15-Min HR	137/14	
Traditional Post HR	135/17	0.880
VR Post HR	136/12	

The results indicated that the 5-minute RPE during the traditional session (M=12, SD=1.9) was significantly higher than during the VR session (M=11, SD=1.9), t (20) =2.306, p=0.032, as shown in Figure 1. This significance may be attributed to the fact that participants were focused on the VR environment rather than the exercise, potentially lowering their RPE. However, the results also indicated that there was no significant difference between the 10-minute RPE during the traditional session (M=12, SD=1.6) and during the VR session (M=12, SD=2.0); and between the 15-minute RPE during the traditional session (M=13, SD=1.4) and during the VR session (M=13, SD=1.6). (See Table 4.) The fact that there were no significant differences at these times may be attributed to the changing VR environment (i.e., hills) or as a result of participants becoming desensitized to the VR stimulus.

Table 4: RPE During Traditional and VR Sessions

Variable: RPE	Mean/SD	Significance
Traditional 5-Min RPE	12/1.9	0.032
VR 5-Min RPE	11/1.9	
Traditional 10-Min RPE	12/1.8	0.197
VR 10-Min RPE	12/2.0	
Traditional 15-Min RPE	13/1.4	0.109
VR 15-Min RPE	13/1.6	

Figure 1: Comparison of RPE at Five Minutes During Traditional and VR Sessions



Discussion

This study investigated the effects of VR-based stationary cycling on heart rate, blood pressure, and perceived exertion in college students. The main findings suggest that VR cycling produces similar cardiovascular responses to traditional cycling while potentially reducing perceived exertion.

Although mean HR and BP were slightly higher during VR cycling, the differences were not statistically significant. This aligns with prior research indicating that immersive VR environments can enhance exercise engagement without imposing additional cardiovascular stress (Zeng et al., 2017; Pasco, 2013). The trend toward lower RPE during VR cycling may indicate that participants perceived exercise as less strenuous, potentially enhancing adherence to regular physical activity.

Limitations

- Small sample size limits generalizability.
- Short exercise duration (20 minutes) may not capture long-term physiological adaptations.
- The study did not measure other relevant outcomes, such as enjoyment or cognitive engagement.

Future Directions

Future studies should include larger, more diverse samples and longer exercise interventions. Additional metrics, such as exercise adherence and enjoyment, could provide a more comprehensive understanding of VR cycling benefits.

Conclusion

VR-based stationary cycling appears to be a feasible and engaging alternative to traditional cycling, eliciting comparable cardiovascular responses while potentially reducing perceived exertion. This technology may serve as an effective tool to promote physical activity among college students.

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