The Impact of Heart Rate Monitor Use on Student Intensity in Elementary Physical Education

van Klaveren

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Heart rate monitors (HRM) were used with 80 fifth grade students during an eight-day basketball unit in one elementary school located in Otsego County, Michigan to see if the implementation had any effect on increasing the intensity of the participating students. Specifically, the HRM measured the amount of time the students were engaging in moderate to vigorous physical activity (MVPA). It was hypothesized that with the use of HRM, students would increase their MVPA and maintain that time in MVPA by the eighth day. The eight days were split into four levels where students were introduced to a new feature of the HRM every level: basic HRM, HRM with lights explained, HRM with projected data and instruction, and HRM projected data maintenance. Results suggest that students show little interest in the technology when introduced to the lights in level two (p>0.05). Results also show a decrease in MVPA with the introduction of the projector on day five. However, after further use of the projector the heart rates of the students increased significantly (p=0.01), suggesting it took some time for these elementary students to gain an understanding of the technology. Once familiar, however, the technology motivated them to greater levels of physical activity. The overall influence of the data suggested a 44% positive linear trend (p=0.002). Therefore, when students are introduced to HRM technology it may increase MVPA, but it can take some time.
ACKNOWLEDGEMENTS

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Gerrit J. van Klaveren
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CHAPTER I

INTRODUCTION

Obesity and Technology

The United States is experiencing an obesity epidemic (Koplan, Kraak, & Liverman, 2005; Ogden, Carroll, Fryar, & Flegal, 2015; Strauss & Pollack, 2001). Among children, “overweight can be defined as at or above the 95th percentile of the sex-specific body mass index (BMI) for age growth charts” (Carroll, 2006, pg. 1549). From 1999 through 2014, obesity prevalence increased among adults and youth (Ogden et al., 2015). Wilfley (2017) noted that the prevalence of obesity has not decreased yet in America among children and adolescents since 2014. It is problematic that children who are obese tend to keep the weight into adulthood (Carroll et al., 2010) resulting in high medical costs of $190.2 billion annually across the United States (Cawley & Meyerhoefer, 2012). In 2011–2014, the prevalence of obesity was just over 36% in adults and 17% in youth (Ogden et al, 2015).

The rise of technology is having a negative impact on physical activity according to the American Academy of Pediatrics (2006, pg.1835); “Children and youth are more sedentary than ever with the widespread availability of television, videos, computers, and video games.” Living a sedentary life is positively associated with obesity (Mitchell et al., 2009; c). Blair (2008), argued that children who are obese are not obese because they are simply lazy, rather they are obese due to the lack of physical activity. More recently, Cawley, Fritzvold & Meyerhoefer (2013) concluded that increased time in physical education reduces the likelihood that young
children will become obese. Major health risks are associated with lack of physical education like asthma, type-2 diabetes, depression, sleep apnea and certain cancers (De Koning & Hu, 2011), but other reported causes of childhood obesity have been related to overconsumption of unhealthy food, parental responsibility, modern technology and the mass media (Crawford, Hardus, Vurren & Worsley, 2003). Carrel et al. (2005) reported that increases in physical activity has shown positive health benefits in the areas of decreasing body fat, increasing cardiovascular fitness and improvement in insulin levels.

**Moderate to Vigorous Physical Activity**

Increasing the time being active through physical activity and fitness, can lead to additional improvements in health status (Warburton, Nicole & Bredin, 2006). Sixty minutes or more of moderate to vigorous physical activity (MVPA) that is developmentally appropriate, enjoyable, and involves a variety of activities is necessary to bring about the beneficial effects of health (Ogden et al., 2015; Strong et al., 2005). Lack of MVPA is associated with obesity, according to a cohort study among 12-year-olds (Blair et al., 2007). Chen, Kim & Gao (2014), suggest that implementing physical education in schools can provide an opportunity for increasing MVPA levels, which may decrease sedentary lifestyles.

Something needs to be done to fight back against the rising levels of obesity and exploring what students are doing most days is one place to start. Students are at school seven to eight hours each day, which is approximately 1/3 of a normal weekday (Koplan, Kraak & Liverman, 2005). In the classroom, the majority of time is spent in sedentary activity, while roughly 5% is in MVPA (Brown et al., 2006). Donnelly & Lambourne (2011, pg.36) suggested that “physically active academic lessons of moderate intensity improved overall performance on
a standardized test of academic achievement by 6%.” Physical education can not only be an option for increasing physical activity and meeting the 60 minutes of MVPA, but also an option to improve academics.

Although technology has a negative connotation with decreasing physical activity, students do have a fascination and love for new technology. Therefore, since students are drawn to the use of technology, finding ways to implement it in physical education could spark interest in increasing physical activity. Researching new ways to motivate students through technological innovations like a heart rate monitor could be beneficial. Students can also be engaged in various developmentally appropriate physical activities challenging their emotional, social, mental and physical well-being necessary for living a healthy and active lifestyle. It is during physical education that students can be encouraged and motivated by HRM to strive for increased physical activity and time in MVPA.

Purpose of Study

The purpose of the study was to examine the effect that heart rate monitor use has on students’ physical activity intensity during elementary physical education. This study asked if HRM were a viable option to use in a physical education setting to help motivate students to reach MVPA. With the rise of technology leading to lack of physical activity, especially MVPA, this study created an opportunity to implement technology in the physical education setting to combat the ensuing crisis of physical inactivity. It is recommended by the Centers for Disease Control and Prevention (Ogden et al., 2015) that 60 minutes of MVPA be implemented each day. This study provides a way to gather explicit evidence of how much MVPA each student
participates in during regular physical education classes, and therefore provides an opportunity to help reach the 60-minute goal within the educational setting of school.

Significance of the Study

The public has addressed the question, “Is physical education really benefiting the students?” Since physical education is not a core subject, and is not on standardized tests across the nation, it has lacked the evidence of its effectiveness for students in the educational system (Siedentop, 2009). The U.S. Department of Health and Human Services (2010) recommend that 50% of the physical education class be spent in MVPA. Therefore, this study examined the implementation of heart rate monitors to measure the intensity at which students were participating during class. If teachers know the intensity of students’ activity, then measurable data are available to represent students’ effort in class. If students are reaching MVPA in class, they are more likely to reap the health benefits associated with being active. Therefore, implementing new and creative ways to spark students’ interest in being physically active, like using a heart rate monitor, can help teach students to value their bodies and overall health.

Hypotheses and Variables

There are two research questions that guided this inquiry. First, did the use of HRM in 5th grade physical education classes increase the time students spent in MVPA? Second, was MVPA of the students maintained from day five through day eight? The hypotheses for this study are: 1) There will be a significant increase (P<0.05) in MVPA from students wearing the HRM in level 1 to seeing their heart rate projected on the wall in level 3. 2) There will be a significant difference (P<0.05) in MVPA when students when look for a purple light on their
HRM (level 2) compared to just wearing the HRM (level 1). 3) After the sixth day of using the HRM (level 3), students will maintain MVPA until the end of the 8\textsuperscript{th} day (P<0.05).

The intensity of the students during the physical education class was measured by the HRM in beats/min. The independent variable was the use of the HRM in the physical education classroom and had four levels. Level 1 consisted of the students wearing the HRM, with no information about the HRM other than it measures their heart rate. Level 2 consisted of students wearing the HRM, and receiving explanations of what the lights on the HRM mean: blue means below age-specific MVPA (<120 bpm), purple means in MVPA range (120-180 bpm), and red means above MVPA (>180 bpm). Level 3 consisted of wearing the HRM, knowing what the lights mean, and the heart rate being projected in class, so all students could see their heart rate and how long they were exercising at MVPA. Level 4 consists of knowing the lights and the projector, and receiving maintenance via reminders of the display throughout class. Students were encouraged to get their heart rate in the MVPA range, which would turn their box projected on the wall yellow, if reached.

The dependent variable was the amount of time spent in MVPA. The aim was to reach MVPA, which was chosen to be 60-85\% of max heart rate \([220 - \text{age}] \times 0.6\) and \([220-\text{age}] \times 0.85\) (American Heart Association, 2016). Since the ages of all the students were between 10 and 12 years old, 11 was chosen as the median, so the range of MVPA was rounded to be 120-180 beats/min.
CHAPTER II

LITERATURE REVIEW

Physical Activity and the Teacher

Physical education provides an opportunity that engages students in positive learning about their health and well-being. Teachers play an important role in educating students by encouraging physical activity. Many physical education teachers hope that by measuring the levels of the students’ physical activity during physical education classes, they will be able to monitor how much exercise students are receiving during their classes (Hardman, Horne & Rowlands, 2009). McKenzie & Lounsbery (2013) examined teacher effectiveness as being a means of promoting and administering physical education in a public health context. Through several surveys and examination of records, it was suggested that physical education is not given enough funding, and students are not in class long enough to reap the benefits and decrease their sedentary lives. Most importantly, McKenzie & Lounsbery (2013) concluded that physical education teachers need to make the most of the opportunity by developing activities within the classroom that promote physical fitness and motor skill development. Furthermore, since the U.S. Department of Health and Human Services (2010) recommend that 50% of the physical education class be spent in MVPA, teachers should try to implement more physical activity programs that allow students to be physically active in their MVPA range.

The importance of teacher interaction and lesson context as an influence on the activity levels of students was examined by Roberts & Fairclough (2011). They wanted to see if teachers
changing the sports within the class had an effect on the level of activity. Thirty different sports were analyzed using a System for Observing the Teaching of Games in Physical Education (SOTGPE). Results showed that striking and fielding games showed the least amount of activity and more importantly, that the highest recorded teacher interactions occurred when the teacher was reinforcing technical behavior of the students. It was suggested that the teacher plays an important role in the students’ behavior and the level of activity. Therefore, the teacher should provide ample opportunities to keep students moving when they are participating in less active sports & games, and when waiting for instruction or their turn to participate in motor performances.

Assor, Kaplan, Kanat-Maymon & Roth (2005) examined teacher behavior on students’ motivation by controlling teacher behaviors. Controlling the teacher behaviors was examined as frequent commands, interfering with the pace of learning and not allowing critical and independent opinions. Results showed that controlling teacher behaviors of 319 Israeli–Jewish elementary school students in 4th and 5th grade had a negative effect on their motivation, engagement and emotions. Based on Assor et al’s findings, the present study did not try to change teacher behaviors to increase motivation. Although Assor et al. (2005) examined motivation, they did not examine how the teacher impacted the intensity of the students via the influence on MVPA. For this reason, it is significant to note the importance of teacher behavior on influencing students’ motivation, but more research is needed to see the effect that has on MVPA, in the physical education setting.
Physical education classes that are poorly structured have been shown to result in significantly less physical fitness improvements (Starc & Strel, 2012). Fairclough & Stratton (2005) showed that more vigorous activity was evident with a structured physical education class with higher activity levels. Szakály et al. (2016) detected that using HRM in the physical education setting, helped show different activities’ effects on the children’s heart rates. Through various activities like gymnastics, mixed activities, ball games, athletics, and games it was evident that among 109 primary school children age 10-12 years, the lowest heart rate values were during gymnastics and the highest values were during the game activities and athletics. It was evident that the lessons with high heart rate values tended to contribute to the cardiovascular endurance, while lower heart rate tended to focus more on skill lessons. Furthermore, Clapham, Sullivan, & Chiccomascolo (2015) examined if the type of physical activity changed student intensity measured by HRM and pedometers. In a suburban community, 106 fourth and fifth grade students were examined to see if there was an increase in physical activity participation due to technological devices and/or teacher instruction. Results showed that the combination of HRM, pedometers, and meaningful feedback on how to interpret the data showed a positive effect on the amount and level of physical activity among the students. Students were found to be more motivated by the interpretation of the data and by trying to reach their target heart rate zone then by how physically active they were.

Heart Rate Monitors Impact

“Technology has great potential for creating a meaningful connection with students, but implementation of these tools must also be carefully and consistently applied for the maximum
benefits to be realized” (Partridge, King, Bian, 2011, pg. 40). Implementing HRM is one tool that can be used in the physical education setting. Nicols et al. (2009) found students to feel empowered when a HRM is used to assess their own performance. In a study by Lassell (2006) five of six children who used HRM were able to learn self-regulating behaviors that increased MVPA. Self-efficacy information from four sources (past performance, vicarious experience, verbal persuasion and physiological states) were gathered and contributed to positive feedback and increased motivation for the students in grades four and five. Tozer (2009) found that among second graders the use of HRM was found to be effective. Students could distinguish between high and low numbers and with little instruction, explain why they received high or low numbers in comparison to physical activity levels. If students in second grade, after only 4 days of using HRM, can learn so much, then working with fifth graders will provide an opportunity to explore more about the benefit of increasing HR and striving to reach their target heart rate zone.

Surapiboonchai, Furney, Reardon, Eldridge, & Murray (2012) examined the use of the Simple Activity Measurement (SAM) tool to asses MVPA in physical education classrooms. SAM is an observation tool that allows examiners to measure the amount of MVPA in a cost effective and convenient way. Forty-eight students from third grade to tenth grade participated in a PE setting. It was found that 88.5% of elementary students were engaged in MVPA and only 36.5% of high school students were in MVPA. The use of SAM was found to be a significant predictor ($r=0.555$, $r^2=0.308$, $p<0.05$) for HR, using linear regression. Although, Surapiboonchai and associates showed positive results for this tool, it is found to provide the basic minutes spent in MVPA and general management information. The weaknesses, however, are the data is all observed qualitatively. While using HRM may be more expensive, data are immediately
obtained and quantified relative to MVPA levels. Students can immediately see what their heart rate is via a monitor, versus the SAM tool where they never see their data displayed in class.

Physical Activity and Academic Benefits

To expand the awareness of physical activity’s benefits, much research has been done to examine the benefits of physical activity on academic achievement. Donnelly & Lambourne (2011) examined student intensity in the classroom setting and its effect on academic achievement in a three-year randomized trial of 24 elementary schools. Changes in fitness and fatness (body mass index (BMI)) were compared with changes in academic achievement in the schools that received the Physical Activity Across the Curriculum (PAAC). Among the 24 schools, 14 received PAAC and 10 control schools did not receive the PAAC treatment. The study examined the effects of implementing physical activities in math, language arts, geography, history, spelling, science, and health classes by providing 90 minutes of MVPA each week during academic lessons (Donnelly & Lambourne, 2011). The results showed that MVPA in the classroom, significantly improved academic scores and had a positive change in students’ fitness and fatness.

Similarly, Mullender-Wijnsma et al. (2015) examined the effects of physical activity in the classroom on academic performance. Second and third grade classes in six different schools were included in the study. Teachers would teach a lesson that included numerous physical movements and activities such as jumps, skips and hops. Students were observed by their on-task behavior and the level of intensity, or the extent to which they were in their MVPA range. Students were given a pre-test and post-test in math and language. During the study, children’s’ on task behavior was above 70% with 64% of the lesson spent in MVPA. Ultimately, the
conclusions were that MVPA had significant influence on academic achievement among the third graders. Mullender-Wijnsma et al. (2015) and Donnelly & Lambourne (2011) both emphasized the impacts of physical activity in the classroom, which was crucial to supporting the benefits of physical activity/MVPA on academic achievement.
CHAPTER III

METHOD OF THE STUDY

Participants

One teacher provided a three-week unit on basketball, with classes meeting three times each week for 30 minutes. There were 80 total student participants in the study from three fifth grade classes in an elementary school located in Otsego County, Michigan. Class lists were collected from the instructor of the fifth-grade physical education classes with each student being given a code to protect students’ identity. Each student was given a heart rate monitor with a code associated with their number on the class list.

HSIRB and Informed Consent

Human Subjects Institute Review Board (HSIRB) approval was obtained before research was started (see Appendix A). Written permission from the elementary school principal for the collection of heart rate data in the fifth-grade classes was obtained prior to the start of the study (see Appendix B). Written consent forms for parents and assent forms for students were sent home and were to be returned to school before the end of the study (see Appendix B for consent forms). This timing was to allow for any student or parent who did not wish to have the students’ data included to withdraw from participation at any time during the study. No parent or student declined the use of the data, therefore all students participated in class as usual, wearing the HRM and all data were included in the study.
There were no known risks associated with the use of HRM, beyond mild discomfort at the forearm if the strap was applied too tight. Students were taught to correctly put on the armbands to minimize the potential for discomfort. No known risks beyond those generally found in a regular physical education class were evident. All data, upon collection were sent to a single file on Western Michigan University’s database managed by the principal and student investigator that was password-protected. All research data obtained at the end of the study will be destroyed, including consent documents, after the 3-year mandated period at WMU.

Instruments

The Heart Zones PE app from Upbeat Workouts (2016) was used to track the heart rates of each student, each day. Thirty Heart Zones Blink Armbands were used for each class, with each student being given one of the HRM, which they strapped to their arm at the beginning of each class. Students wore the armbands on the upper part of their forearm, so it was out of the way. These monitors were all activated by pressing and holding the middle button until lights started flashing. Each monitor was connected to the data collector, known as the bridge, which saved the data and sent it to an iPAD for display. Once class was finished, data were saved on the iPAD, and students would press their HRM button down again until a solid red light was on, let go, and the HRM would turn off. The students had no data collection responsibilities other than pressing the button to turn the HRM on and off. Starting the fifth day of class, a projector was used to display the students’ heart rates on a wall, with only the HRM number visible, no names. Students partook in an individually prescribed instructional (IPI) basketball unit, which created a structure of stations within the classroom to keep students as active as possible.
Research Design

Eight 30-minute class sessions were observed for each fifth-grade class over a three-week period. The first two days consisted of the students wearing the HRM. No information about the HRM other than it measured their heart rate was given, which provided baseline heart rate data. Days three and four consisted of students wearing the HRM, and getting an explanation of what the HRM lights meant: blue means lower than moderate intensity (<120 bpm), purple means in MVPA (120-180 bpm), and red means above MVPA (>180 bpm). Days five and six consisted of students wearing the HRM, knowing what the lights mean, and having all students’ heart rates projected on the wall in class. All students could see their heart rate and how long they were exercising in MVPA. Days seven and eight consisted of knowing the lights and the projector, and receiving maintenance via reminders of the display throughout class.

The experimental design was focused on a group time sample design. The experimental groups were those receiving the Heart Rate Monitors (Class 1, 2, 3). The time refers to the eight days over the three weeks. Heart rate was retrieved from students each day, and compared among the four different levels over the three-week period (see Table 1 below).

Table 1

\[ \begin{array}{|c|c|c|c|c|c|c|c|c|}
\hline
& \text{Week 1} & & \text{Week 2} & & \text{Week 3} \\
& \text{Day1} & \text{Day2} & \text{Day3} & \text{Day4} & \text{Day5} & \text{Day6} & \text{Day7} & \text{Day8} \\
\hline
\text{Class} & \text{Level 1} & \text{Level 2} & \text{Level 3} & \text{Level 4} \\
1 & \text{HRM Only} & \text{HRM} & \text{HRM} & \text{HRM} \\
& \text{Lights explained} & \text{Projected in class, with instruction} & \text{Projected in class Maintenance} \\
\hline
\text{Class} & \text{Level 1} \\
2 \\
\hline
\text{Class} & \text{Level 1} \\
3 \\
\hline
\end{array} \]
Data Analysis

Excel (v16.0) was used to organize all the data from each class. IBM SPSS (v23) was used to test for significance of the variables. The hypotheses were tested using One-way ANOVA with repeated measures on time (ANOVA-RM). The total time students were in MVPA was averaged for each day then added to the other day in each subsequent level to give a total time in MVPA for each level. The students’ total time in MVPA (min) was compared using pairwise comparisons from each level to each other level. For example, days one and two total average time in MVPA (TAT) was compared to days three and four TAT, five and six TAT, and seven and eight’s TAT to see if a significant difference was evident. Graphs were then examined of the comparison of the four levels and separate days, to determine if there was a trend among the data whether linear (straight line), quadratic (curved) and/or cubic (wavy curve). Due to a snow day on day four, data for one of the classes was lost, resulting in a total of only 54 students in the data analysis. The results expand on how this unexpected situation was further analyzed.
CHAPTER IV

RESULTS

The results of this study were broken down into two scenarios. First, the results were analyzed for the 80 subjects, but SPSS(v23) excluded 26 subjects’ data resulting in 54 subjects, due to the missing day four data for class one. This scenario kept the original experimental design, but decreased the originally intended number of subjects. Second, the results were analyzed ignoring day four for all three classes and simply analyzing the results with only seven days instead of eight days. Furthermore, since day four was ignored, day five also was ignored when comparing the levels, to maintain the consistent two days for each level. This kept the originally intended number of subjects (n=80), but changed the experimental design by eliminating the second level of instruction (light function of HRM).

Scenario One

Time Spent in MVPA

The TAT for each level, was compared using ANOVA-RM on time. When analyzing the results, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated (variance differences of the levels are not equal), $\chi^2(5) = 32.357$, $p < .0005$, and therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\epsilon = 0.724$). The results show there was a significant effect of the use of HRM on time, $F(2.173, 115.18) = 4.90$, $p = .007$ (see Appendix C, Table C1 and C2 for full results). These results suggested the use of HRM was significant ($p<0.5$) in influencing the students’ heart rate and thus the amount of
time spent in MVPA. Since there was a significant difference between the use of HRM in a fifth-grade class and the impact of time spent in MVPA, it was important to examine the pairwise comparison of the data (see Table 2 below), to see where the differences occurred.

Table 2

*Pairwise Comparisons of Time MVPA for Four HRM Levels*

<table>
<thead>
<tr>
<th>(I) TotalTime</th>
<th>(J) TotalTime</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
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</tbody>
</table>

* The mean difference is significant at the .05 level. Level 1: HRM only; Level 2: HRM and lights; Level 3: HRM, lights and projector; Level 4: HRM projector maintenance
An examination of Table 2 reveals significant differences occurred between levels one and four (p=0.01) as well as between levels three and four (p<0.001). It was important then to examine the graph of the means for the four levels (see Figure 1 below).

Figure 1. Total Time in MVPA for the Four levels
Figure 1 shows the change in heart rate over the span of the four levels. Increases in time spent in MVPA are evident between level one (M=22.17, SD=9.03 min) and level 2 (M=23.46, SD=8.94 min), as well as an increase from level three (M=21.60, SD=6.84 min) to level four (M=26.61, SD=9.79 min). It is important to note the drop in MVPA from level two to level three. The overall trends of Figure 1 show a positive increase among the levels of time spent in MVPA as the use of the HRM was increased and more fully explained (see Table 3 below).

Table three breaks down the influence of each trend, which shows a 44% positive linear trend. However, when examining the cubic trend (wavy curve) even with a smaller influence of 33%, a power of 0.899 is evident with a significance of p = .002. This suggests that the cubic trend may have a more significant influence on the data.

Table 3

*Trends Among Heart Rate Levels*

<table>
<thead>
<tr>
<th>Source</th>
<th>Trend</th>
<th>Type III Sum of Squares</th>
<th>Percentage</th>
<th>F</th>
<th>Sig.</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time MVPA</td>
<td>Linear</td>
<td>353.881</td>
<td>44%</td>
<td>3.957</td>
<td>.052</td>
<td>.497</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>187.135</td>
<td>23%</td>
<td>3.635</td>
<td>.062</td>
<td>.465</td>
</tr>
<tr>
<td></td>
<td>Cubic</td>
<td>271.853</td>
<td>33%</td>
<td>10.878</td>
<td>.002</td>
<td>.899</td>
</tr>
</tbody>
</table>

Percentage of Time in MVPA

The percentage of time spent in MVPA for the two days at each level was averaged to give a total percentage of time spent in MVPA for each subsequent level. Table 4 (see next page) shows the descriptive statistics for the percentage of time spent in MVPA at each level. Note the drop in the number of subjects due to averaging the days. Levels one through three showed
percentage of time in MVPA quite close, while level four showed a greater percentage of time spent in MVPA.

Table 4

*Percentage of Time in MVPA*

<table>
<thead>
<tr>
<th>Level</th>
<th>Mean %</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lev1</td>
<td>.5931</td>
<td>.12437</td>
<td>33</td>
</tr>
<tr>
<td>Lev2</td>
<td>.5956</td>
<td>.14612</td>
<td>33</td>
</tr>
<tr>
<td>Lev3</td>
<td>.5915</td>
<td>.13842</td>
<td>33</td>
</tr>
<tr>
<td>Lev4</td>
<td>.6772</td>
<td>.11736</td>
<td>33</td>
</tr>
</tbody>
</table>

After analyzing the differences among the percentage of time in MVPA, there was a significant difference after Mauchly's Test, which indicated that the assumption of sphericity had been violated, $\chi^2(5) = 11.139$, $p = .049$, and therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\epsilon = 0.800$). The results show there was a significant effect of the use of HRM on the percentage of time spent in MVPA, $F(2.40, 76.80) = 6.28$, $p = .002$ (see Appendix C, Table C3 and C4 for full results). Figure 2 shows the percentage of time in MVPA among the four levels.
The only significant differences among the four levels were between levels one and four (p = .015) and levels three and four (p = .012) (see Appendix Table C5 for full results), which was similar in results to that obtained when examining the total time spent in MVPA (see Table 2, page 17). A positive linear influence, p = .006, with an observed power of 0.817 was evident (see Appendix C, Table C6).

MVPA for Each Day

Analyzing the time spent in MVPA for each day (see Figure 3 on next page), we can see there is a drop around days four, five and six after day three, followed by a substantial spike to
days seven and eight.

Figure 3. *Total Time in MVPA for Each Day*

The descriptive statistics for the total time in MVPA for each day are provided (see Table 5 on next page). Note the jump from day one (M=10.85, SD=4.65 min) to day eight (M=13.61, SD=6.10 min), a difference of about 2.76 minutes. In other words, there was approximately two minutes and forty-five seconds of an increase in time spent in MVPA.
Table 5

*Descriptive Statistics for MVPA for Each Day*

<table>
<thead>
<tr>
<th>Day</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day1Z2</td>
<td>10.8466</td>
<td>4.64992</td>
<td>54</td>
</tr>
<tr>
<td>Day2Z2</td>
<td>11.3281</td>
<td>5.63106</td>
<td>54</td>
</tr>
<tr>
<td>Day3Z2</td>
<td>12.5377</td>
<td>6.01039</td>
<td>54</td>
</tr>
<tr>
<td>Day4Z2</td>
<td>10.9272</td>
<td>5.07647</td>
<td>54</td>
</tr>
<tr>
<td>Day5Z2</td>
<td>11.1296</td>
<td>4.92026</td>
<td>54</td>
</tr>
<tr>
<td>Day6Z2</td>
<td>10.4698</td>
<td>4.95890</td>
<td>54</td>
</tr>
<tr>
<td>Day7Z2</td>
<td>13.0037</td>
<td>5.14137</td>
<td>54</td>
</tr>
<tr>
<td>Day8Z2</td>
<td>13.6090</td>
<td>6.10407</td>
<td>54</td>
</tr>
</tbody>
</table>

*Z= Zone 2, which is MVPA zone*
Scenario Two

Time Spent in MVPA

Scenario two was an alternate approach to the analyses where day four was eliminated for all classes resulting in a N=80, instead of N=54. This slightly changed the outcome of the results. Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, meaning the F-statistic is valid, $\chi^2(2) = 0.723$, $p=697$, and therefore degrees of freedom were not corrected (see Appendix D, Table D1). When the assumption of sphericity has not been violated, the results show there was a significant effect of the use of HRM on time in MVPA, F (2, 158) =5.38, $p = .006$ (see Appendix D, Table D2, for full results). The differences, when analyzing the pairwise comparisons (see Table 6 below) occurred between the same levels of Scenario one: Levels one and four ($p = .007$), and levels three and four ($p = .006$).

Table 6

*Pairwise Comparisons of Time MVPA Between Three Levels*

<table>
<thead>
<tr>
<th>(I) Time</th>
<th>(J) Time</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>-.133</td>
<td>1.249</td>
<td>.916</td>
<td>-2.619</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>-3.747*</td>
<td>1.354</td>
<td>.007</td>
<td>-6.443</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>.133</td>
<td>1.249</td>
<td>.916</td>
<td>-2.353</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>-3.614*</td>
<td>1.285</td>
<td>.006</td>
<td>-6.172</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3.747*</td>
<td>1.354</td>
<td>.007</td>
<td>1.051</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3.614*</td>
<td>1.285</td>
<td>.006</td>
<td>1.056</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.
When looking at the graph of the three levels (see Figure 4 below) a much different result is seen than that obtained in scenario one. A small increase is shown in time spent in MVPA between levels one (M=23.52, SD=8.93 min) and three (M=23.66, SD=8.94 min), as well as a much larger and significant (p=.007) increase from level three (M=23.52, SD=8.93 min) to level four (M=27.27, SD=10.11 min). The overall trends shown in Figure 4 reveal a positive increase across treatment levels (see Table 7 below). Table 7 breaks down the influence of each trend, which shows that the graph in Figure 4 depicts a 77% influence for a linear trend, power of 0.780 is evident with a significance of p = .007. This suggests that there is a significant positive linear influence on the data.

Figure 4. Total Time in MVPA for Three Levels
Table 7

*Trends Among HR Levels Scenario Two*

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>Sum of Squares</th>
<th>Percentage</th>
<th>F</th>
<th>Sig.</th>
<th>Observed Power&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMVPA</td>
<td>Linear</td>
<td>561.625</td>
<td>78%</td>
<td>7.654</td>
<td>.007</td>
<td>.780</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>161.588</td>
<td>22%</td>
<td>2.642</td>
<td>.108</td>
<td>.362</td>
</tr>
</tbody>
</table>

Percentage of Time in MVPA

When analyzing the percentage of time in MVPA Mauchly's Test indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 5.627$, $p = .060$, and therefore degrees of freedom were not corrected. Sphericity is assumed, and the results show a significant effect of the use of HRM on the percentage of time spent in MVPA, $F(2, 98) = 5.46$, $p=.006$ (see Appendix D, Table D3 and D4 for full results). Figure 5 (on next page) shows the percentage of time in MVPA among the three levels.

Table 8

*Mean % MVPA Three Levels*

<table>
<thead>
<tr>
<th>Level</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lev1</td>
<td>.6157</td>
<td>.12723</td>
<td>50</td>
</tr>
<tr>
<td>Lev3</td>
<td>.6238</td>
<td>.14458</td>
<td>50</td>
</tr>
<tr>
<td>Lev4</td>
<td>.6767</td>
<td>.12671</td>
<td>50</td>
</tr>
</tbody>
</table>
Significant differences were found between levels one and four ($p = .008$) and levels three and four ($p = .015$) (see Appendix Table D5 for full results), which was similar to the results obtained when examining the total time spent in MVPA for scenario two and for scenario one in both the Total time and percent of time spent in MVPA. A positive linear influence is noticeable again, $p = .008$, with an observed power of 0.767 (see Appendix D, Table D6). Note the graph is more linear due to level two missing; however, it is important to note an overall positive increasing influence over the span of the levels.
MVPA for the Seven Days

Analyzing the time spent in MVPA for the seven days (see Figure 6 below), there is still a significant drop around days five and six, leading to some questions. However, there is still a spike to days seven and eight that was similar to the eight-day graph of Total Time MVPA (see Figure 3 on page 21). From day seven to eight there is a short dip in total time in MVPA, which differs from scenario one, where the MVPA continued to increase until the end.

Figure 6. Total Time in MVPA for Seven Days
When looking at the descriptive statistics of the MVPA over the seven days (see Table 9 below) there are some important findings. There is an increase from day one to day three, as well as decreases from day three to days five and six. A quick increase in MVPA is evident from day six to seven, and then a slight drop from day seven to eight. Day one to day eight shows an increase of 2.2 minutes in MVPA. Day seven was slightly higher than eight, showing an increase of 2.92 minutes, which is a similar finding to that found in scenario one (see Table 5 on page 23).

Table 9

*Descriptive Statistics for MVPA for Seven Days*

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day1Z2</td>
<td>11.0702</td>
<td>4.68921</td>
<td>80</td>
</tr>
<tr>
<td>Day2Z2</td>
<td>12.4525</td>
<td>5.95441</td>
<td>80</td>
</tr>
<tr>
<td>Day3Z2</td>
<td>12.8431</td>
<td>5.83309</td>
<td>80</td>
</tr>
<tr>
<td>Day5Z2</td>
<td>11.8825</td>
<td>5.36801</td>
<td>80</td>
</tr>
<tr>
<td>Day6Z2</td>
<td>11.7731</td>
<td>5.97164</td>
<td>80</td>
</tr>
<tr>
<td>Day7Z2</td>
<td>13.9983</td>
<td>5.15800</td>
<td>80</td>
</tr>
<tr>
<td>Day8Z2</td>
<td>13.2715</td>
<td>7.13003</td>
<td>80</td>
</tr>
</tbody>
</table>

*Z=Zone 2, which is time in MVPA zone*
Hypothesis One

The hypothesis that there would be a significant increase (p<0.05) in MVPA from students wearing the HRM in level one to seeing their heart rate projected on the wall in level three was not supported by the data, in either scenario (p = 0.68, p=0.92). In fact, the actual time in MVPA of the students dropped slightly from levels one (M=22.17, SD=9.03 min) to three (M=21.60, SD= 6.84 min). Scenario two showed a minimal increase in the average time spent in MVPA between levels one (M=23.52, SD=8.93 min) and three (M=23.66, SD=8.94 min). It appears that when the students were first introduced to the projector and HRM on day five of level three, their HR decreased for scenario one by ≈34s, and increased slightly by ≈8s in scenario two. Reasons for this could be that the technology itself can be slightly overwhelming at first. The projected material portrays quite a bit of information and numbers that can be confusing to the students, which seems to have resulted in no significant impact on MVPA.

Another possible explanation for the drop-in HR may be that the lesson content choice may not have been the best for the day. Since mentioned in the literature review that the structure and lesson content play an important part in increasing MVPA, the lessons for days five and six were not the greatest for optimal MVPA. The lesson for day five was the skill of performing the foul shot and day six was learning the games lightning and PIG, neither of which are very physically active games. When observing the students, it was evident that a lot of teacher
explanation and demonstrations were provided, with students standing and even laying down at times (see Appendix E for lesson details). Therefore, the results provide evidence there was not a significant increase in HR immediately following the display of HR on the wall. However, this could, in part, be due to the lesson content or lack of simple explanation for the display details. Furthermore, level four also used the projector for displaying the HR and time participating in MVPA. Therefore, the use of displaying HR for the students on the wall should not be totally rejected due to the jump that occurs between level three and four. This is explained further in Hypothesis three.

Hypothesis Two

The hypothesis that there would be a significant difference (P<0.05) in MVPA when students looked for a purple light on their HRM (level 2) compared to just wearing the HRM (level 1) is not supported by the data. Although the results show a slight increase in the time spent in MVPA, it is not significant (p=0.213). The data suggest that explaining to the students about the light color on the HRM may only slightly increase the time students spent in MVPA, but does not suggest a significant influence on the intensity at which the students participated.

Examining the fourth day of the study, which was the second day of level 2, a sudden drop from day three (M=12.54, SD=6.01) to day four (M=10.93, SD=5.07) was observed and may suggest the influence of the HRM light mechanism was not very motivating for students after a brief time. When observing the day four lesson, it was not evident that the students were too thrilled about the light mechanism. It appeared students did not look at the HRM often, and therefore, were not that motivated by it possibly because they were not yet able to see their HR
projected on the wall. Therefore, encouraging students to look at the light on the HRM may not be the best influence to increase students’ intensity during physical education class.

**Hypothesis Three**

The hypothesis, that an increase in MVPA after the sixth day through the end of day eight would be observed was supported by the analyses conducted for scenario one, but not scenario two. Interestingly, when comparing level one (M=22.17, SD=9.03 min) to level four (M=26.61, SD=9.79 min) in scenario one, there was a significant increase in time spent in MVPA (p=0.001). The large spike in MVPA on the seventh day leads to the acceptance of the third hypothesis because after the sixth day of using the HRM, students did maintain an increased level of MVPA until the end of 8th day in scenario one only.

The difference between levels three and four is significantly different for both scenarios (p=0.001, p=0.006), but due to the low HR levels achieved in level three a huge spike is evident leading to an increase in MVPA. Upon the displaying of HR and time in MVPA in level three, students may not have understood the display details and may have been minimally influenced to increase physical activity intensity. However, after two days the students started to catch on and seemed to understand the details presented on the projected material in class. When observing the classes, it was evident the students were not looking at the teacher as much due to looking at the display. The students were constantly moving arms and jogging on the spot compared to standing still on previous days. The data suggests that the students possibly understood much more about the new technology and were beginning to increase their intensity by spending about 6-8% more time in MVPA (on average from both scenarios). In the span of a 30minute lesson that reflects an average increased time of 2-2 ½ minutes longer in MVPA.
Research Question 1

Did the use of HRM in 5th grade physical education classes increase the time students spent in MVPA? The results suggest that after using the HRM for a total of eight days, the students in this study did show an increase in HR, total time and percentage of time in MVPA. In both scenarios, the overall trend was a positive increase (p=.002) from just using the HRM to seeing the HR displayed on the wall. This suggests that the use of the HRM and projector to display HR and time in MVPA provided a positive influence on students’ physical activity intensity. It is not suggested by the results that teachers rely on the data from the lights on each individual’s HRM (during level two) to motivate students. Rather, the recommendation is that teachers get right to using the projector, so students can visually see their HR and how they are doing in regard to time spent in MVPA. Emphasizing the importance of getting yellow to show on the display and staying in his/her own MVPA range is more important than explaining the benefit of getting points or trying to get the highest HR you can. Overall, students may take time to adjust to the visual display, but in time students may be motivated and HR of the students can increase.

Research Question 2

Is students’ MVPA maintained from day five through day eight? The results suggest that MVPA was not maintained from day five through eight, rather a maintained increase of MVPA was evident after the sixth day in scenario one, not scenario two. The introduction of the projected data may be confusing or a hindrance at first, but students do get used to it and benefit greatly from the ability to see their individual HR and time spent in MVPA.
Limitations and Assumptions

There were 30 heart rate monitors programmed for use in three different fifth grade classes totaling 80 students, which created a smaller sample size. Due to a snow day, data were lost with one whole class, resulting in not only losing the data, but reducing the sample size to 54. For measuring the percent of MVPA to obtain the average over each level, students had to be there both days. Students who missed classes reduced the sample sizes to 33, and 50, respectively for those studies. Results were taken from the fifth grade only, reducing the transferability to the greater educational community. Participants were students, who missed class/es, which created missing data for those individuals and thus resulted in varying sample sizes depending on the test used. The heart rate monitors were not perfect, as some cut in and out, fell off or turned off suddenly and had to be turned on again. An assumption made was that the results from the sample are representative of the greater population of those in fifth grade because the study can be replicated and all students are roughly the same age—10 to 12 years old.

Recommendations for Further Research

Further research using HRM is needed to grasp exactly what is occurring in the physical education classroom, specifically related to students’ physical activity intensity. Teachers could be encouraged to use HRM to evaluate and gain valuable data of the students’ intensity during the class. Also, finding new and innovative ways to motivate students to be physically active is always needed. Using new technology in the physical education setting can be helpful to increase HR, but it can take time for students to get used to and understand it. After analyzing the students heart rate in this study, it would be interesting to know what exactly the students were doing while participating in the physical education class. We understand that the structure, choice of
sport, and teacher interactions can impact instruction and learning in a multitude of ways. However, if we use HRM and measure the behavior of the student and the teacher during the class, it would be interesting to see what the students are doing that is potentially increasing or decreasing their HR. Further research around using HRM and analyzing student and teacher behavior would be valuable to enhancing student performance within the classroom. Lastly, more research can be done to analyze the HR of students beyond the fifth-grade class. Simply strapping the HRM on the students can give valuable information for all teachers to see exactly how their students are performing in class.

Another measurement obtained from the HRM data, but not examined was individual Peak Heart Rate (PHR). The graph (Appendix F) presents a similar trend in data as the other graphs in the study, showing that on average students had high PHR at the beginning, but then when introduced to the lights during level 2 PHR dropped, then steadily increased toward the end of level four. For this study’s purpose, PHR was not explained further, but is more for informational purposes or for future research.
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cpubs


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APPENDIX A

HSIRB Approval Form

Date: January 26, 2017

To: Debra Berkey, Principal Investigator
   Gerrit Van Klaveren, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 17-01-21

This letter will serve as confirmation that your research project titled “The Use of Heart Rate Monitors on Student Intensity in Elementary Physical Education” requested in your memo received January 26, 2017 (to correct spelling of Amy Nieuwenhuis’ name on the consent and assent documents) has been approved by the Human Subjects Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: January 24, 2018
APPENDIX B

Consent Forms

Principal Approval Letter

Gerrit van Klaveren:

I support the IRB-approved research project, *The Use of Heart Rate Monitors on Student Intensity in Elementary Physical Education* you will conduct with our Physical Education teacher, Amy Nieuwenhuis. I understand this project will be limited to the collection of data available during a normal physical education class, specifically heart rate values. No student names will be associated with any personally identifiable data. Parents and students who do not wish to have data collected will sign a form to be removed from the study, but will participate in the normal class routine. Since the data is part of a normal physical education class, I approve the use of this information as data for research.

Sincerely,

Heather Badders
Dear Parent/Guardian:

Your child is currently enrolled in Physical Education at Washington Street Elementary School, taught by Amy Nieuwenhuis. Amy Nieuwenhuis has agreed to participate in a research study with a graduate student from Western Michigan University named Gerrit van Klaveren. The study will examine the use of heart rate monitors in the physical education classroom and how this impacts the intensity to which students are participating.

The study will occur during the regular 3-week basketball unit. If you allow your child to participate in this research, they will not be asked to do anything outside of their normal classroom activities, except to allow their heart rate data to be collected for research purposes. There will be no grade associated with the data obtained, nor will any name be linked to the data, as identification numbers will be given for each student. If students wish to drop at any time during the study, there will be no penalty beyond that normally levied for non-participation in class activities. As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or additional treatment will be made available to the subject except as otherwise stated in this consent form.

If you do not wish for your student’s anonymous data to be included in this project, please sign below and have your child return this form to Amy Nieuwenhuis by 2/10/2017. If you have any additional questions about this research project, you may contact Gerrit van Klaveren (gerritjohn.vanklaveren@wmich.edu, 505-399-8172). You may also contact the Chair, Human Subjects Institutional Review Board (269-387-8293) or the Vice President for Research (269-387-8298) if questions or problems arise during the course of the study. The stamped date and signature of the board chair in the upper right corner means this consent document is approved for use for one year by the Human Subjects Institutional Review Board. Do not participate if the stamped date is more than one year old.

Thank you for your support of our Physical Education program.

Amy Nieuwenhuis, Physical Educator

-------------------------------------------------------------------------------------------------------------------
Parent/Guardian signature if UNWILLING to allow your student’s participation in the described research project
Student Form

Student Assent Form
Assent Form Western Michigan University
Department of Human Performance and Health Education
Principal Investigator: Dr. Debra Berkey
Student Investigator: Gerrit van Klaveren

The Use of Heart Rate Monitors on Student Intensity in Elementary Physical Education

We are doing a research study. A research study is a special way to find out about something. We want to find out if using a heart rate monitor in physical education class increases your heart rate.

You can be in this study if you want to. If you want to be in this study, you will not be asked to do anything extra, except to allow your heart rate data to be used for research. When we are done with the study, we will write a report about what we found out. We will not use your name in the report. You do not have to be in this study. You can say “no” and nothing bad will happen. If you say “yes” now, but you want to stop later, that’s okay too. No one will be mad at you, or punish you if you want to stop. All you have to do is tell us you want to stop.

If you do not wish for us to see the heart rate data on your heart rate monitor, then please sign below and return this form to your teacher Mrs. Nieuwenhuis by 2/10/2017. If you have any questions about this research project, you may contact Gerrit van Klaveren (gerritjohn.vanklaveren@wmich.edu, 505-399-8172). The stamped date and signature of the board chair in the upper right corner means this consent document is approved for use for one year by the Human Subjects Institutional Review Board. Do not participate if the stamped date is more than one year old.

If you DO NOT want to be in this study, please sign your name.

I, ___________________________, DO NOT want to be in this research study.
APPENDIX C

Scenario One Tables

Mauchly's Test for the Time Spent in MVPA

Table C1

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly's W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon Lower-bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>TimeMVPA</td>
<td>.535</td>
<td>32.357</td>
<td>5</td>
<td>.000</td>
<td>.724</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>.756</td>
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<td></td>
<td>.333</td>
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</tbody>
</table>

Greenhouse-Geisser Correction of Time in MVPA

Table C2

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>TimeMVPA Sphericity Assumed</td>
<td>812.869</td>
<td>3</td>
<td>270.956</td>
<td>4.900</td>
<td>.003</td>
<td>.085</td>
<td>.904</td>
</tr>
<tr>
<td>TimeMVPA Greenhouse-Geisser</td>
<td>812.869</td>
<td>2.173</td>
<td>374.055</td>
<td>4.900</td>
<td>.007</td>
<td>.085</td>
<td>.820</td>
</tr>
<tr>
<td>Error(TimeMVPA) Sphericity Assumed</td>
<td>8792.90</td>
<td>2</td>
<td>159</td>
<td>55.301</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error(TimeMVPA) Greenhouse-Geisser</td>
<td>8792.90</td>
<td>2</td>
<td>115.1</td>
<td>76.343</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Mauchly's Test of Sphericity for % MVPA

Table C3

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly's W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon Greenhouse-Geisser</th>
<th>Epsilon Huynh-Feldt</th>
<th>Epsilon Lower-bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>%MVPA</td>
<td>.696</td>
<td>11.139</td>
<td>5</td>
<td>.049</td>
<td>.800</td>
<td>.869</td>
<td>.333</td>
</tr>
</tbody>
</table>

Greenhouse-Geisser Correction of % MVPA

Table C4

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Powera</th>
</tr>
</thead>
<tbody>
<tr>
<td>%MVPA</td>
<td>Sphericity Assumed</td>
<td>.174</td>
<td>3</td>
<td>.058</td>
<td>6.27</td>
<td>.001</td>
<td>.164</td>
<td>18.832</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>.174</td>
<td>2.40</td>
<td>.072</td>
<td>6.27</td>
<td>.002</td>
<td>.164</td>
<td>15.065</td>
</tr>
<tr>
<td>Error(PercMVPA)</td>
<td>Sphericity Assumed</td>
<td>.887</td>
<td>96</td>
<td>.009</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>.887</td>
<td>76.7</td>
<td>.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Computed using alpha = .05
## Pairwise Comparisons of % MVPA

### Table C5

<table>
<thead>
<tr>
<th>(I) PercMVPA</th>
<th>(J) PercMVPA</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>-.002</td>
<td>.020</td>
<td>.900</td>
<td>-.043</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>.002</td>
<td>.021</td>
<td>.941</td>
<td>-.041</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>-.084*</td>
<td>.026</td>
<td>.002</td>
<td>-.136</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>.002</td>
<td>.021</td>
<td>.900</td>
<td>-.038</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>.004</td>
<td>.019</td>
<td>.829</td>
<td>-.034</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>-.082*</td>
<td>.030</td>
<td>.010</td>
<td>-.142</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>-.002</td>
<td>.021</td>
<td>.941</td>
<td>-.044</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>-.004</td>
<td>.019</td>
<td>.829</td>
<td>-.042</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>-.086*</td>
<td>.026</td>
<td>.002</td>
<td>-.138</td>
</tr>
</tbody>
</table>

*: The mean difference is significant at the .05 level.

## Trends % MVPA

### Table C6

<table>
<thead>
<tr>
<th>Source</th>
<th>PercMVPA</th>
<th>Type III Sum of Squares</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>%MVPA</td>
<td>Linear</td>
<td>.102</td>
<td>8.733</td>
<td>.006</td>
<td>.214</td>
<td>8.733</td>
<td>.817</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>.057</td>
<td>5.113</td>
<td>.031</td>
<td>.138</td>
<td>5.113</td>
<td>.592</td>
</tr>
</tbody>
</table>
APPENDIX D

Scenario Two Tables

Mauchly's Test of Sphericity for Time in MVPA

Table D1

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly's W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon Greenhouse-Geisser</th>
<th>Epsilon Huynh-Feldt</th>
<th>Lower-bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMVPA</td>
<td>.991</td>
<td>.723</td>
<td>2</td>
<td>.697</td>
<td>.991</td>
<td>1.000</td>
<td>.500</td>
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</table>

Greenhouse-Geisser Correction of Time MVPA

Table D2

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMVPA Sphericity Assumed</td>
<td>723.213</td>
<td>2</td>
<td>361.607</td>
<td>5.376</td>
<td>.006</td>
<td>.064</td>
<td>10.751</td>
<td>.837</td>
</tr>
<tr>
<td>Greenhouse-Geisser</td>
<td>723.213</td>
<td>1.982</td>
<td>364.945</td>
<td>5.376</td>
<td>.006</td>
<td>.064</td>
<td>10.653</td>
<td>.834</td>
</tr>
<tr>
<td>Error(TM VPA) Sphericity Assumed</td>
<td>10628.3</td>
<td>94</td>
<td>158</td>
<td>67.268</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Greenhouse-Geisser</td>
<td>10628.3</td>
<td>156.5</td>
<td>67.889</td>
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</table>

^a. Computed using alpha = .05
### Mauchly's Test of Sphericity % MVPA

**Table D3**

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly's W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon Greenhouse-Geisser</th>
<th>Huynh-Feldt</th>
<th>Lower-bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMVPA</td>
<td>.889</td>
<td>5.627</td>
<td>2</td>
<td>.060</td>
<td>.900</td>
<td>.933</td>
<td>.500</td>
</tr>
</tbody>
</table>

### Greenhouse-Geisser Correction % MVPA

**Table D4**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Powera</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMVPA</td>
<td>Sphericity Assumed</td>
<td>.110</td>
<td>2</td>
<td>.055</td>
<td>5.464</td>
<td>.006</td>
<td>.100</td>
<td>.839</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>.110</td>
<td>1.801</td>
<td>.061</td>
<td>5.464</td>
<td>.007</td>
<td>.100</td>
<td>.808</td>
</tr>
<tr>
<td>Error(PMVPA)</td>
<td>Sphericity Assumed</td>
<td>.982</td>
<td>98</td>
<td>.010</td>
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<td></td>
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<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>.982</td>
<td>88.23</td>
<td>.011</td>
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</tr>
</tbody>
</table>

*a. Computed using alpha = .05*
Pairwise Comparisons for % MVPA

Table D5

<table>
<thead>
<tr>
<th>(I) PMVPA</th>
<th>(J) PMVPA</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>-.008</td>
<td>.016</td>
<td>.626</td>
<td>-0.041 - 0.025</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>-.061*</td>
<td>.022</td>
<td>.008</td>
<td>-.106 - -.016</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>.008</td>
<td>.016</td>
<td>.626</td>
<td>-0.025 - 0.041</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>-.053*</td>
<td>.021</td>
<td>.015</td>
<td>-.095 - -.011</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>.061*</td>
<td>.022</td>
<td>.008</td>
<td>.016 - .106</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>.053*</td>
<td>.021</td>
<td>.015</td>
<td>.011 - .095</td>
</tr>
</tbody>
</table>

*. The mean difference is significant at the .05 level.

Trends for % MVPA

Table D6

<table>
<thead>
<tr>
<th>Source</th>
<th>PMVPA Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Powera</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMVPA</td>
<td>Linear</td>
<td>.093</td>
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<td>7.533</td>
<td>.008</td>
<td>.133</td>
<td>7.533</td>
<td>.767</td>
</tr>
<tr>
<td>Quadratic</td>
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<td>.017</td>
<td>1</td>
<td>2.163</td>
<td>.148</td>
<td>.042</td>
<td>2.163</td>
<td>.303</td>
</tr>
<tr>
<td>Error(PMVPA)</td>
<td>Linear</td>
<td>.604</td>
<td>49</td>
<td>.012</td>
<td></td>
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<td>.378</td>
<td>49</td>
<td>.008</td>
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</tbody>
</table>

a. Computed using alpha = .05
APPENDIX E

Lesson Content

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<tr>
<th>Day</th>
<th>Lesson Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chest Pass/Bounce Pass</td>
</tr>
<tr>
<td>2</td>
<td>Dribbling</td>
</tr>
<tr>
<td>3</td>
<td>Lay-ups</td>
</tr>
<tr>
<td>4</td>
<td>Set- shot</td>
</tr>
<tr>
<td>5</td>
<td>Free Throw</td>
</tr>
<tr>
<td>6</td>
<td>Game Pig and Lightning</td>
</tr>
<tr>
<td>7</td>
<td>Stations (passing, dribbling, lay-ups, pig, and lightning)</td>
</tr>
<tr>
<td>8</td>
<td>Stations (passing, dribbling, lay-ups, pig, and lightning)</td>
</tr>
</tbody>
</table>
APPENDIX F

Peak Heart Rate

Figure F1. Peak HR for the HRM levels