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The relationship between the use of heart rate monitors and MVPA levels of secondary school students (Grades 7-12)

Trevor McCabe
tmcca6@brockport.edu

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The relationship between the use of heart rate monitors and MVPA levels of secondary school

students (Grades 7-12).

A Synthesis Project

Presented to the

Department of Kinesiology, Sports Studies, and Physical Education

The College at Brockport

State University of New York

In Fulfillment

of the Requirements for the Degree

Master of Science in Education

(Physical Education)

by

Trevor McCabe

THE COLLEGE AT BROCKPORT

STATE UNIVERSITY OF NEW YORK

BROCKPORT, NEW YORK

Department of Kinesiology, Sport Studies, and Physical Education

The relationship between the use of heart rate monitors and MVPA levels of secondary school

students (Grades 7-12).

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Cathy Houston-Wilson

12/8/2020

Instructor Approval   Date

Accepted by the Department of Kinesiology, Sport Studies, and Physical Education, The College at Brockport, State University of New York, in partial fulfillment of the requirements for the degree Master of Science in Education (Physical Education).

Cathy Houston-Wilson

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Abstract

As people progress throughout their childhood, team sports and lifetime activities are hobbies that most adolescents choose to participate in during their secondary schooling years (grades 7-12). Lifetime activities are being taught to students in hopes that they will be able to live more active lifestyles on their own as they progress throughout life. Team sports are taught and participated through physical education lessons or organized sports. Physical activity levels are crucial for adolescents to understand in order to reach MVPA (moderate to vigorous physical activity). There are many tools that can assist with measuring these physical activity levels, however, an accessible and reliable tool would be: heart rate monitors. These heart rate monitors provide students with the information to understand multiple forms of heart rate zones and how they are connected to their physical activity levels. Most students in secondary schools begin to decline in terms of physical activity. Sports become extremely competitive as people get older and sedentary lifestyles start to become more frequent. The review of literature will examine the connection between heart rate monitors and MVPA levels in secondary school students (grades 7-12).

Keywords: Heart Rate Monitors, MVPA Levels (Moderate to Vigorous Physical Activity), Lifetime Activities, and Heart Rate Zones.

Chapter 1-Introduction

When students graduate from secondary school or high school, they are expected to become functioning members of society. In the ever-changing world that we live in, life expectancy has increased and yet, so has obesity rates (Collings et al., 2018). Students who are found to be classified as "overweight" are more prone to be susceptible in acquiring life-shortening diseases due to lack of physical activity (Yuste et al., 2015). Students must learn how to live healthy lifestyles in order to reach their full life expectancy, otherwise obesity and physical inactivity will shorten their potential lifespan (Collings et al., 2018). There are several resources available that can aide in increasing one's life expectancy through the use of the acquisition of recommended moderate-to-vigorous physical activity (MVPA) levels (Moore et al., 2013).

Although some students are able to fight obesity because of their metabolism, which is the process whereby food and drink is converted into energy, at a faster rate during their childhood years, overtime metabolic efficiency has a tendency to decrease resulting in increased weight gain unless a person maintains an active lifestyle (Hirsch 2019). People who are found to be obese or overweight during childhood are more prone to develop a metabolic health risk if it continues into adulthood (Surapiboonchai et al., 2012). If students do not consider the importance of MVPA levels, their health will significantly be affected. Further, when students eat poorly and fail to consider the sedentary lifestyle that they may be living due to the evolution of technology, they are predisposing themselves to being overweight or obese (Moore et al., 2013). Singerland et al. (2011) found students in secondary schools have lower percentages of MVPA time than their primary school counterparts. Even though the secondary school students had almost 25 minutes extra of lesson time. The increase of weekly physical activity can

tremendously help students from developing health issues when transitioning into adulthood. According to the Center for Disease Control (2019), children are recommended to achieve at least 60 minutes of MVPA per day. Many students fail to attain this amount of MVPA because the only contributors they may have to it, is their physical education classes (Costa et al., 2018). Marmeleira et al., (2012) found that physical education classes failed to meet the percentage of recommended MVPA time. Therefore, students must participate in more activities in order to generate the recommended daily amount of MVPA. Moderate and vigorous physical activity differ from light physical activity by the amount of energy exerted (intensity) while participating in an activity (Prosch, 2018). Singerland et al., (2011) indicated that the different types of physical education units that the participants engaged in, recorded different levels of MVPA. In order to better understand these physical activities, heart rate is a great indicator in recording and measuring these levels (Cuberek et al., 2017).

Hensen (2017), noted that heart rate monitors are more successful in measuring physical activity when compared to accelerometers. The Polar Heart Rate Monitor (created in Finland), was found to be used in 6 out of 13 studies that they investigated. The heart rate monitors recorded heart rates with 5 second intervals. According to Costa et al., (2018) the accuracy of the heart rate monitors when assessing physical activity levels were proven to be quite high.

Statement of the Problem

According to the Center for Disease Control (2019), children are recommended to achieve at least 60 minutes of MVPA per day. Research indicates that this goal is not routinely met by secondary students. Providing students with a mechanism to monitor and track their performance may help them realize this outcome. Heart Rate monitors have been proven to be an effective measurement instrument to monitor physical activity levels. While the relationship of

heart rate monitors and MVPA levels is very evident, the problem lies in the lack of achieving recommended MVPA levels amongst children. Factors such as the selection of activity being performed or gender, can affect MVPA levels. In terms of activities, those activities that are enjoyed by students or that can lead to competition tend to produce higher levels of MVPA. Gender also plays a role in participation levels. Researchers found that gender played a significant role in the physical activity levels that students recorded based upon grouping methods (Sarradel et al., 2011; Slingerland et al., 2013; Van Acker et al., 2010). Van Acker et al. (2010) found that engagement in single-sex physical education classes logged at an incredible 100% for both girls and boys. When students were found to be in mixed gender classes, the engagement level for both genders plummeted. The highest rate of engagement when the genders were mixed, resulted in a mere 37.5% to 62.5%.

Furthermore, the achievement of recommended MVPA levels can be assessed when using heart rate monitors throughout the day. The relationship between heart rate monitors and MVPA levels is essential in students achieving their recommended amount of MVPA.

Purpose of the Study

The purpose of the study is to review literature on the relationship between heart rate monitors and MVPA levels of secondary school students (grades 7-12).

Operational Definitions

1. Heart Rate Monitors- Devices that measure a person's heart rate by beats per minute (bpm) in numerical form.

2. Heart Rate Zones- Measurable and specific numerical ranges that signify the differences regarding levels of physical activity. (Resting, Target, and Maximum zones).

3. MVPA Levels- Moderate to Vigorous Physical Activity - Physical activity or activities that increase a person's heart rate past the point of their resting heart rate and into the zones of target/maximum heart rate.

Research Questions

The research questions being studied in this synthesis include:

1. What is the relationship between heart rate monitors and secondary students MVPA levels?

2. Can secondary students increase their levels of MVPA with the use of heart rate monitors?

3. What are the barriers to using heart rate monitors to measure MVPA?

Delimitations

The following delimitations have guided this synthesis:

1. Research articles that include male and female students in grades 7-12, ages 12-18 years of age, from multiple countries (United States, United Kingdom, Portugal, Spain, Australia, Czechoslovakia, Poland, Belgium, and the Netherlands).

2. Studies which took place in physical education classes as well as competitive sport environments which used heart rate monitors to measure MVPA levels.

3. Articles used in this synthesis were published between 2010 and present.

4. All articles came from academic journals that were full-text and peer reviewed.

Chapter 2-Methods

The purpose of this chapter is to review the methods and procedures used to determine the relationship between the use of heart rate monitors and MVPA levels of secondary school students (grades 7-12). In this chapter, methodology pertaining to the discovery of literature being used in this synthesis project will be explained. All of the literature was found using the SUNY Brockport online library data base. Specifically, EBSCO database, which gave access to SPORTDiscus with full text and Academic Search Complete. In these specific search engines, key terms were used to narrow down the search of articles pertaining to the purpose of the study.

Some contributing factors that influenced the articles selected, were those published during or after the year of 2010 and if the articles were in peer-reviewed journals. Each article chosen was also classified as a "full text" article that could be downloaded in a pdf format. Keywords were crucial in delimiting the number of articles collected in order to find relative documents. These keywords included: Heart Rate Monitors (1,723), Physical Education (154,983), Physical Activity (93,506), MVPA (1,492), Secondary Schools (277,779), Middle School (108,296), and High School (998,143). All the combined keywords yielded a resounding 1,635,922 results. After careful analyzation and configuration, implementing the publication year would be best in narrowing the findings even more by limiting the search to articles published during or after the year 2010. The total findings for the articles was reduced to a decreased 1,076,093 results. The next factor to be investigated was the classification of academic journals pertaining to the keywords regarding grade levels. Out of all the grade levels that were analyze (grades 7-12), the keywords of Secondary Schools, Middle Schools, and High Schools were filtered to find 3,047 academic journals.

Narrowing the search by adding additional keywords, including: heart rate monitors, physical education, physical activity, and MVPA also helped to delimit the articles used for this synthesis. When searching the keywords through SPORTDiscus and Academic Search One, three keywords were searched at a time in order to find articles. The first combination included Physical Education, Physical Activity, and Heart Rate Monitor. The trio resulted in a total of 84 articles in SPORTDiscus and 94 articles in Academic Search Complete. The second combination was comprised of Heart Rate Monitor, Physical Activity, and MVPA. The search yielded 11 articles from SPORTDiscus and 15 articles from Academic Search Complete. The third combination of words used to facilitate results included Physical Education, Heart Rate Monitor, and MVPA. 3 articles in both SPORTDiscus and Academic Search Complete were then found. Finally, the fourth and final combination of keywords were created using Physical Education, Physical Activity, and MVPA. The last combination of keywords constructed a total of 508 articles in SPORTDiscus and 725 articles in Academic Search Complete.

The next step in slimming down the number of articles to be reviewed, was to modify the search to only include articles that have full text. The number of articles decreased to 354 articles in SPORTDiscus and 473 articles in Academic Search Complete. Out of the remaining articles, evaluation of participants regarding their educational level (grades 7-12) and age (12-18), delimited the final findings to a remarkable 55 articles in SPORTDiscus and 78 in Academic Search Complete. Out of the pool of 133 articles that met within the criteria for participants, forms of assessment were used to find an even smaller population of articles. Articles were then ultimately chosen for final review if they included heart rate monitors or accelerometers as a form of data collection which specifically measured physical activity levels. A total of 32 articles matched this complex criterion and were considered for final use. Out of these potential articles,

the selection of 13 articles was decided because they fully matched the topic of the synthesis project and fit within the boundaries of the delimitations.

The 13 articles selected were taken from multiple sources including: *Education and Sport, European Journal of Human Movement, European Physical Education Review, International Journal of Medicine and Sciences of Physical Activity and Sport, International Journal of Sports Science & Coaching, Journal of Physical Education and Health, Journal of Physical Education and Sport, Journal of Sports Sciences, Physical Education Sport Pedagogy, and Sport International*.

Research obtained for this synthesis represent an international perspective. Three articles came from the United States and three articles came from Portugal. Two articles came from the Netherlands and two articles came from Spain. Finally, there was one article from each of the following countries, the United Kingdom, Australia, Czechoslovakia/Poland, and Belgium. This wide variety of countries provided quantitative data assessing the heart rates associated with recorded MVPA levels in students located in secondary schools throughout their respective countries.

The critical mass of participants throughout the studies in this synthesis yielded 3,240 students. Out of these students, 1,924 were female and 1,316 were male. The secondary schools located in the articles contained the earliest age of students being 12 years old and the oldest age of students being 18 years old. Each of the articles collected and used for this project included heart rate monitors and/or accelerometers as a form of measurement for quantitative data. Other tools that were possibly used to measure MVPA and heart rate included: accelerometers, body mass-index, and pedometers. Differences between regular physical activity and MVPA were distinguished to assess the benefits of participating in more intense physical activity.

Chapter 3-Review of Literature

The purpose of this synthesis project was to review literature on the relationship between heart rate monitors and Moderate to Vigorous Physical Activity (MVPA) levels of secondary school students (grades 7-12). In particular, the following topics will be reviewed: effects of heart rate monitors on moderate to vigorous physical activity, association of heart rate monitors and MVPA, using heart rate monitors to increase MVPA, and barriers to using heart rate monitors.

Effects of Heart Rate Monitors on Moderate to Vigorous Physical Activity

Heart rate monitors have been shown across many studies to record accurate levels of MVPA following data analysis (Costa et al., 2018). Many tools have been used to record MVPA levels such as pedometers, accelerometers, SOFIT forms, yet, none come as close to being more accurate than heart rate monitors (Cuberek et al., 2017). The accessibility and availability of using heart rate monitors puts the tool at a level that more people are inclined to use than others (Yuste et al., 2015). Heart rate monitors have a positive effect on MVPA by being a valuable tool to use for data collection.

Association of Heart Rate Monitors and MVPA

Collings et al. (2016), conducted a longitudinal analysis of obesity amongst youth participants over the course of 2.5 years. 728 participants from the region of Cambridge, United Kingdom, had their baseline fitness levels recorded via heart rate, questionnaires, and body fat measurements (Collings et al., 2016). The purpose of the study was to evaluate how MVPA levels fluctuated throughout childhood/puberty while other variables (socioeconomic status, height, and energy levels) influenced the study. The research was conducted in three waves (wave 0, 1, 2), each being conducted at different times throughout the study. Wave 0 and 1 were

used to establish baseline data on MVPA levels as well as body fat composition. Heart rate monitors played an essential role in the methods and procedures used to collect data because it was necessary to record accurate data regarding MVPA levels in order to classify participants activity levels. The results indicated that as the participants aged, their physical activity levels declined (Collings et al., 2016). The evaluation of heart rate throughout the study proved to be beneficial in establishing connections related to physical activity levels. The next study specifically looks at this aspect through physical education classes.

In Portugal, a study was conducted by Costa et al. (2018), to evaluate the heart rates of students during various phases of their physical education classes. The researchers wanted to understand why sedentary lifestyles worldwide were becoming more frequent. The purpose of the study was to evaluate if the type of activity (individual or team oriented) impacted physical activity levels amongst participants. The methods and procedures classified the physical education lessons into three phases consisting of different activities for students to participate in (gymnastics/basketball, gymnastics/basketball/gymnastics, and basketball). Heart rate monitors were given to students to wear around their chest region. Heart rates were recorded more frequently as the participants progressed through the phrases due to the increase in MVPA levels through different activities given by the teachers (Costa et al., 2018). Researchers found that basketball drills increased MVPA levels. The researchers concluded that the heart rate monitors provided them with accurate and efficient data allowing them to draw conclusions based upon the types of activities used during physical education classes (Costa et al., 2018).

Marmeleira at al. (2012), conducted a study during thirty physical education lessons. The nature of the study was similar to that of Costa et al. (2018), yet, the purpose of the study was different. 46 students across 3 high schools in Portugal participated in the study to determine

why levels of MVPA had been declining. The purpose of the study was to evaluate the physical activity levels as well as internal motivation (Marmeleira et al., 2012). During the lessons, students were provided with heart rate monitors after they changed attire and the monitors recorded heart rates in 5 second intervals. At the conclusion of the lesson, the devices were collected and recorded for statistical analysis. This study is the first in this collection of literature to use pedometers and the creation of HRR (Heart Rate Reserve) to measure MVPA levels as well for the participants. Research found the average heart rate for students during the physical education lessons was calculated at a mean of 135.2 bpm. Alternatively, to the Costa et al. (2018) study, this study found wearing the heart rate monitors during individual activities recorded higher levels of MVPA.

The preceding studies examined physical education lessons to determine which types of activities produced greater levels of MVPA. McCormick et al. (2012), researchers chose to study 12 boys from a high school basketball team. The purpose of the study was to analyze the influence that full-sided (5v5) and small-sided (3v3) games had on the amount of times players touched the basketball as well as their MVPA levels. When teams were created and game play was ready to begin, players were given the heart rate monitors during warm up and could not start the game until every player's monitor was on. The monitors recorded heart rates every 15 seconds and were water resistant to avoid malfunction from sweat. Researchers compared the heart rate monitor to that of ECG readings and determined the monitors to be the "most accurate" tool for recording heart rates (McCormick et al., 2012). Results found participants to receive more Offensive Played Balls (OPB) in small-sided games when compared to the full-sided games. In terms of heart rate, the average heart rate was found in small sided games to be 166.82 bpm, 1.82 bpm higher than participants in the full sided games. The results also found there to be

a higher percentage in moderate intensity for small sided games and a higher percentage in vigorous intensity for full sided games. Furthermore, the study found heart rates in a team sport game to be higher in modified game play (3v3). The factor and influence of gender has yet to be a topic in studies that have been discussed. The next study in this chapter will introduce it as a significant factor while conducting research.

Van Acker et al. (2010), the study looked at the role of gender and the effect modified game play had on heart rate regarding participants. The purpose of the study was to examine 13-year old students and their physical activity levels during single sex and coeducational classes. This study is one of a few other studies to take place in multiple countries (Belgium and Portugal). Participants were monitored and evaluated while playing modified games of Korfball (a popular game in Europe characterized by components of basketball and netball). Researchers used Polar Heart Rate Monitors (Polar, Finland), to measure heart rates for the participants. The monitors measured heart rates every 15 seconds. Researchers found MVPA levels to be higher in single sex classes in both Belgium and Portugal. The study also found male students to have increased MVPA levels in physical education classes containing ability grouping when using heart rate monitors. Girls were found to have increased MVPA levels in non-ability grouped classes. Overall, Van Acker et al. (2010) found girls to have higher levels of MVPA when participating in all physical education lessons (single sex and coeducational) and using heart rate monitors to record heart rate.

The relationship between heart rate monitors and MVPA levels among secondary school students proved to be positive. Heart rate monitors have proved to be a pivotal tool in accurately recording and monitoring the heart rate of participants during many studies. This has provided researchers with qualitative and quantitative research to draw conclusive results regarding their

study. With the accuracy of the heart rate monitors regarding MVPA levels in secondary

students, the fluctuation of these heart rates will be another factor to evaluate and the influence

these monitors have on students.

Using Heart Rate Monitors to Increase MVPA

The accuracy and accessibility of heart rate monitors make them a tool that is very

difficult to compromise. MVPA levels are subject to fluctuation throughout the duration of

measurements. When using new or added equipment, participants are more prone to be

motivated to participate in physical activity (Marmeleira et al., 2012).

The study of Ambegaonkar et al. (2018) is very much based off the similar foundation of

participants and gender variables with studies such as McCormick et al. (2012) and Van Acker et

al. (2010). Researchers evaluated the role of single sex activity (dance and various forms of it)

and how it relates to MVPA levels (enjoyability and heart rates). Researchers evaluated 10 girls

during their physical education lessons and measured their heart rates using a monitor called the

Zephyr Bioharness 3 Sensor. The device can be worn inside the arm or around the torso of the

participants (Ambegaonkar et al., 2018). Physical activity levels were calculated through the

heart rates recorded for each participant during the physical education lessons. When collecting

data, heart rates below 50 bpm and over 200.5 bpm were excluded from to avoid skewing the

data. The results classified distinct levels of physical activity: Very Light, Light, Moderate,

Vigorous, and Near Max to Max. Researchers found the girls to have increased levels of MVPA

while using the heart rate monitors. Thus, establishing that the participants spent roughly 23

minutes out of their 30-minute PE classes attaining their recommended levels of MVPA. The

next study goes further into understanding this topic while in the country of Spain.

Sarradel et al. (2011), wanted to evaluate the difference in activity levels amongst students in Spain, while analyzing gender. The participants had their baseline data recorded by measuring BMI (Body Mass Index) and conducting skinfold caliper testing. The heart rate monitors were given to students to use during physical education classes (45 minutes long) and the monitors recorded heart rates in 5 second intervals. Researchers provided participants with two weeks of training experience before recording data. The results showed girls to be more active in terms of MVPA levels than boys during all activities in their respective physical education classes. The widest margin of MVPA levels between the two genders was in the activities of dance. Girls averaged 21.3% higher in MVPA than their male counterparts. The amount of training given to the participants led to an accurate collection of heart rates. This allowed students to understand the value of heart rates and how to increase it during physical education class.

Another study which took place in the country of the Netherlands looked specifically at how physical education lessons contributed to the students' MVPA levels. Another purpose of the study was to investigate the affects different activities had on the intensity levels. The study was conducted using 40 secondary schools throughout the Netherlands and 10 students (5 boys and 5 girls) were randomly selected in each lesson to have their heart rates recorded (Singerland et al., 2011). The researchers used the Polar Team System Heart Rate Monitor, which has also been used in other studies throughout this collection of literature. Secondary school lesson time ranged between 40-120 minutes long (varying upon the school). The results found students in 12th grade to have the highest levels of MVPA between grades 8-12. Researchers also discovered that boys recorded higher MVPA percentages in each grade level when compared to females. The heart rate monitors were worn around the chest area of the participants. The placement of

the heart rate monitors contributed to the 46.7% of physical education lesson time spent in

MVPA for students in secondary schools accurately recording heart rates.

Similar to Singerland et al. (2011), Yuste et al., (2015) goes further analyzed the intensity

levels of various activities conducted during physical education classes for students in secondary

schools in the country of Spain. The purpose of the study was to determine whether or not

physical education classes alone could achieve recommended MVPA levels for students.

Researchers used the Polar Team 2 Heart Rate Monitors to determine intensity levels. The

monitors recorded heart rates of each student in 1-second intervals and the study was conducted

over 9 physical education lessons. This frequency in data collection allowed the researchers to

establish connections relating to MVPA levels in physical education classes. The average

physical education lesson lasted 45 minutes. Researchers found students to be engaged in MVPA

levels 21.62% of the time during physical education lessons. This finding establishes the need for

more research to be conducted regarding the various types of activities and their connections to

MVPA levels amongst students in secondary schools.

The idea and realization that students are being measured through the use of heart rate

monitors has been shown to increase MVPA levels. The various studies conducted in different

countries has provided researchers with the understanding of how well heart rate monitors can

help intensify activity levels with students from across the world. With the strengths being

highlighted in this section of the literature, it begs the question of what the barriers are to using

heart rate monitors.

Barriers to Using Heart Rate Monitors

While specific heart rate monitors and the intervals in which they record data prove to be

accurate, there are some limitations that should be taken into consideration after reviewing the

previous literature. Like anything in life, heart rate monitors have barriers that may prove to cause more difficulty at times than what they are worth when compared to other tools (pedometers, accelerometers, etc.). The goal of this compilation of studies is to identify and highlight barriers to using heart rate monitors for research purposes.

In Cuberek et al. (2017), objective measurements were lacking multiple forms of data collection that needed to be revamped or recreated in order to successfully collect qualitative data for researchers to make conclusions regarding their findings. The purpose of their study looked to measure load intensity of specific time segments throughout the day in Czech and Polish secondary school students. The three types of time specific segments that were created were classified as "pre-school, school, and post-school". Participants were provided with an ActiTrainer device which is compiled of multiple devices such as an accelerometer and heart rate monitor. The aspects of the heart rate monitor were derived from the Polar S610 TM device. The results indicated that there were many discrepancies between the accelerometer and the heart rate monitor. The largest differences in results occurred during light and moderate intensity activities. The smallest differences were found during activities that were vigorous. Students were found to be the least active during the "pre-school" time segment and the most active during the "post-school segment". The study also found the heart rate monitor to have difficulty recording MVPA levels regarding low intensity activities (cycling, walking, static exercise, etc.).

Moore et al. (2013), looked at factors that could potentially influence the MVPA levels of secondary school students. The study took place in the southeastern region of the United States of America. The purpose of the study was to understand the relationship between physical activity, sedentary time, and cardiorespiratory fitness in youth. Researchers provided participants with accelerometers that recorded physical activity levels in 30 second intervals over the course

of 7 days. Polar heart rate monitors were given to participants to establish cardiorespiratory

fitness levels through further testing. 285 participants were considered for the final sample of

data collection right before data analysis occurred. Results found that different levels of MVPA

yielded different relationships to cardiorespiratory fitness. Surprisingly, moderate physical

activity did not have a very significant relationship when connecting it to cardiorespiratory

fitness. In addition to the Cuberek et al. (2017) study, intervals for physical activity data

collection proved to be essential when finalizing conclusions. Conducting tests that restrict the

participants to an established baseline of heart rate proves to constrain results when trying to

identify them.

While using heart rate monitors to collect data, many factors can affect this process such

as the location, interval timing, and collection of these devices upon completion of activity can

all drastically affect the results. In Slingerland et al. (2013), researchers highlighted that young

people understand how important it is to receive physical activity. The problem lied in where and

when young people can attain this physical activity. 216 participants were measured during

physical education classes to see how physical activity levels fluctuated during single gender and

mixed sessions in their basketball unit. Students were provided with a Polar Heart Rate Monitor

that was worn around their chest during physical education classes and data immediately

collected upon the conclusion of their class. The heart rate monitors recorded the participants'

heart rates in 5-second intervals. Thus, allowing there to be time between data collection where

heart rate could have fluctuated within several beats per minute. Furthermore, the results found

the main component of gender having the largest impact on boys having significantly more

levels of MVPA than girls. While the data collected proved to be qualitative, the concern is the

interval gap within the heart rate collection period. Studies that have had heart rates recorded

more frequently (Singerland et al., 2011), provided researchers with more data that provides greater results yielding significant discoveries.

When comparing heart rate monitors with other common devices such as pedometers, accelerometers, and many more, heart rate monitors appear to be fairly accurate. decently. Surapiboonchai et al. (2012), examined a new device called the "Simple Activity Measurement (SAM)". The device was created out of a pilot study developed to evaluate physical activity as it pertains to students in physical education lessons. The purpose of the study was to focus on the SAM device and how to improve it for future studies regarding physical activity in students. 48 students participated in the study during physical education lessons that lasted between 45-50 minutes. Upon the completion of class, heart rate monitors had to be collected and immediately downloaded. This opens the possibility to false or unqualified information if certain situations were to arise (student forgets to turn the monitor on/off, a device breaks, electronical errors, etc.). The SAM device doesn't have this problem because the results are recorded and automatically entered via the device itself. Surapiboonchai et al., (2012) noted that approximately 25% of student heart rate records were lost when using the heart rate monitors. If this can happen in one study, surely it occurs in many others. The results from the study found that students acquired their recommended MVPA levels 50% of the time in middle school participants (grades 6-8) and 36.50% of the time in high school participants (grades 9-12). The SAM device proved to record accurate measurements to that of heart rate monitors in students in middle school, yet, varied amongst some of the high school measurements. If the SAM device can be mass produced, it has the potential to be more accessible and used widely.

Summary

In conclusion, there has been a well-established connection between heart rate monitors and MVPA levels amongst secondary school students over the past decade. As heart rate monitors were used time and time again in a multitude of studies, results found the devices to accurately measure the changing heart rates of participants during research testing. The heart rates provided researchers with the ability to identify and classify data in an organized manner to display results. The relationship between heart rate monitors and MVPA levels among secondary school students proved to be a positive one as many studies found an increase in MVPA levels.

Heart rate monitors have also been found to increase MVPA levels amongst participants using these devices through various versions of different physical education units and sports. The studies that were highlighted in this chapter dove into many controversial factors such as time intervals, type of heart rate monitor, and data collection processes, all of which played significant roles in outlining the accuracy and efficiency of the tool. By using these heart rate monitors, researchers found studies to have increased MVPA levels post-testing when compared to baseline measurements of the participants. With these positive, beneficial experiences of utilizing heart rate monitors when measuring MVPA levels, there were some barriers to navigate for researchers.

Heart rate monitors were shown to have a multitude of barriers when recording data. Some of the most important aspect of the studies were almost compromised due the data collection and data analysis of research from the heart rate monitors. It took immediate action and careful handling of the monitors post-testing to ensure accurate results. The practice of understanding how to use the heart rate monitors properly for participants was proactively pursued before testing occurred during most studies. Each heart rate monitor in the studies

shared similar characteristics to some degree but, differed amongst methods and procedures utilized by researchers.

Furthermore, the studies collected for this literature outlined the strong connection heart rate monitors had to MVPA levels in secondary school students. The benefits of the monitors outweighed the cons as many proactive measures can be taken in order to avoid potential pitfalls while using these devices. The monitors also provided researchers with an understanding of the reality of MVPA levels amongst secondary school students throughout various countries.

Chapter 4

Results, Discussion, and Future Recommendations for Future Research

The purpose of this chapter is to present the results of the review of literature on the relationship between heart rate monitors and MVPA levels of secondary school students (grades 7-12) in reference to how these results align with the implied research questions which guided this synthesis project. Additionally, recommendations for future research as it relates to the relationship between heart rate monitors and MVPA levels of secondary school students are presented.

The results demonstrated heart rate monitors have a strong relationship amongst MVPA levels amongst secondary school students. Throughout the collection of the literature, studies varied in fluctuation of MVPA levels. Some variables that accounted for this change in MVPA levels included the setting of the study (physical education class, practice, competitive sports, etc.), the type of activities that students were participating in, and the demographic makeup of students (gender). While heart rate monitors have proven to be effective tools to measure MVPA levels, there are some barriers such as data collection errors, that have provided the argument against the use of them.

Discussion

Interpretations

Through the development of this synthesis, several research questions were used in order to guide the findings relevant to the purpose of the study. When discussing heart rate monitors and MVPA levels amongst secondary school students, the type of relationship between the two topics was imperative to understand in order to draw upon conclusion. The first research question analyzed the relationship between heart rate monitors and MVPA levels amongst

secondary school students (grades 7-12). The results were inconclusive. The results from almost

all of the studies found that some of the recommended daily and weekly MVPA was achieved

but, not all of it. Marmeleria et al., (2012) reported physical education classes to contribute half

(30 minutes) of the daily recommended MVPA levels to students. This finding was close to other

studies that were conducted during physical education classes. A wide variety of heart rate

monitors that were used throughout the studies featured devices such as the ActTrainer, Polar

Heart Rate Monitors, Polar E600, SAM, etc. Some heart rate monitors weren't always found to

be in the same body region of all participants. Van Acker et al., (2010) had students wear the

heart rate monitors across their chests instead of the more common area the bodies scuh as their

wrists. The relationship between heart rate monitors and secondary student's MVPA levels

proved to be different throughout each study dependent on the type of activity participants were

engaged in.

The second research question that was analyzed during this synthesis asked if secondary

school students were able to increase their levels of MVPA with the use of heart rate monitors.

Many variables that can significantly affect the correlation between the monitors and students are

those consistent with physical education units, activities being studied in, and genders of the

participants. Yet, none of the studies reported results directly identified heart rate monitors as

being a determinant in the increase of MVPA levels. Ambegaonkar et al., (2018) found girls to

have reached a majority of their recommended MVPA levels when being studied during dance

lesson in their physical education classes. The study also had girls fill out a survey that measured

how they emotionally felt about the lesson and class. The results of the girls' opinions recorded a

3.9 average score out of a 5-point scale, meaning the participants enjoyed partaking in dance

lessons which intrinsically motivated them to reach their MVPA levels with the use of heart rate

monitors (Ambegaonkar et al., 2018). Physical education units can fluctuate MVPA levels based upon secondary school students due to the nature of subliminal judgement during class (Sarrdel et al., 2011). Team sports that are widely accepted and considered "cool" by secondary school students provided greater input for athletically inclined students. The same can be said about the engagement of non-athletic students regarding activities that are selected for physical education lessons and sporting events. Sarradel et al., (2011) found that different types of activities such as fitness and individual activities contributed at least 30% to upward of 46% of daily MVPA levels for students. Girls recorded higher heart rates in every category from team sports to fitness to tennis to much more. Thus, highlighting the discovery that secondary school students only had the monitors measure the fluctuation of their MVPA levels. They played no role in changing the levels directly.

Data collection can vary and be different amongst multiple brands of heart rate monitors as well. Intervals that record heart rates can range anywhere from 1-second to 15-seconds depending on the brand, which can significantly affect the data collected from studies. Slingerland et al., (2013) had heart rate monitors that were used during the study collect heart rates in 5 second intervals. Many people would say that is too long and that heart rate could potentially change within that allotment of time. This then prompted the comparison of the monitors to other potential instruments such as accelerometers and self-created devices like the ActiTrainer (Cuberek et al., 2017) or the Simple Activity Measurement device (Surapiboonchai et al., 2012). Heart rate monitors proved to be the most efficient in terms data collection when compared. The AcTtrainer recorded heart rates within 15-second intervals and the Simple Activity Measurement (SAM) device clocked in at 60 seconds. The heart rate monitors consistently had the best results, having the time of a third of the next closest device in that of the

ActiTrainer. Accessibility to the monitors can prove to be difficult due to lack of funding from schools or educational institutions. Many settle for cost effective purposes, to use pedometers as a way for physical education teachers to measure MVPA levels, however, they have more barriers to interpretation of data collection than that of heart rate monitors. Thus, making heart rate monitors the optimal and one of most desired choices when assessing MVPA levels amongst students in secondary schools.

Implications

The conclusions made from the results found in the collection of studies gathered for this synthesis, have proven to successfully provide answers to all of the research questions. There hasn't been a direct relationship between heart rate monitors and MVPA levels amongst secondary school students, however, there has been the discovery with MVPA levels while using heart rate monitors. The relationship that has been found between heart rate monitors and MVPA levels is that of a mutual association with other variables affecting the fluctuation of them. Therefore, the relationship between heart rate monitors and MVPA levels exists together with secondary school students.

The second question of the synthesis analyzed whether students were able to increase their levels of MVPA while using heart rate monitors. It was determined that the monitors recorded data but, did not influence student engagement to the point where MVPA levels drastically improved. Instead, determinants such as physical education units, activities, and gender all played overwhelming roles in the evaluation of the MVPA levels in secondary school students. Previous studies have investigated topics such as intrinsic motivation and their connection to MVPA levels, yet, in Marmeleira et al., (2012), the findings have concluded that there is no association between the two factors. The conclusion of secondary students increasing

their MVPA levels with the use of heart rate monitors has yet to be confirmed and only exists as a potential theory.

Heart rate monitors have been proven to be the most efficient and well-developed tool in order to accurately measure heart rates pertaining to MVPA levels. While there is the possibility of varying intervals and possible data collection errors upon conclusion of activities, the benefits of these devices outweigh the cons when compared to other devices. This conclusion agrees with previous studies conducted which use other devices to test the consistency of the heart rate monitors. The only practical implications of the heart rate monitors include interval time, data collection errors, and environmental factors.

Recommendations for Future Research

In reviewing the data based on the relationship between heart rate monitors and MVPA levels amongst secondary school students (grades 7-12), the following limitations were noted regarding the studies under review. To begin, it cannot be overlooked that the direct lesson or practice plans of the studies conducted were not thoroughly provided. Much time is lost in physical education classes and sporting practices due to transitional time from between activities or drills. That transitional time could impact the heart rates recorded from the monitors to make the participants seem as though they had lower levels of MVPA than what they were truly engaged in. Another limitation that must be considered is the length of the study to which most of the studies collected in this review of literature were investigated. Only one study was considered a longitudinal study (Collings et al., 2018) out of the thirteen selected. Many of the studies were only conducted over several weeks. Meaning, that the period of time that the study took course over could have had an influence on student engagement.

Based on these limitations and other insights related to the literature, the following recommendations for future research should be considered:

1. Future studies should look to evaluate if there is a direct relationship between heart rate monitors and whether MVPA levels increase because of the addition regarding the monitors.

2. Future studies should investigate the transitional time during physical education lessons and sporting events as it affects secondary school students' heart rates.

3. Future studies should look to conduct similar studies over longer periods of times to determine if the results would change (months and/or years).

Summary

Overall Summary

The purpose of this review of literature was to determine the relationship between heart rate monitors and MVPA levels amongst secondary school students (grades 7-12). Delimiting variables were used to do an exhaustive data-based search which yielded 13 peer-reviewed articles. These articles were then used to gather research and findings that clarified the relationship between the two topics.

Research revealed that while there is a relationship between heart rate monitors and MVPA levels amongst the secondary school students, the monitors only serve as a guide to measuring the levels. The devices aren't meant to increase or decrease the levels of students during physical education classes or sporting events. Secondary school students prove to be the target audience for the conduction of these studies in order to receive accurate data for multiple reasons. The students are mature and intelligent enough to follow the directions to avoid collection errors. This can prevent additional barriers to the use of these devices from arising.

Future studies should take into consideration the recommendations made previously for the heart rate monitors and MVPA amongst secondary school students. The proper evaluation of these recommendations can provide researchers with a much more detailed understanding of the relationship and could unlock the potential for more findings in future studies.

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Appendix A

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations	Research Notes – Commonalities/ Differences
Ambegaonkar, Pierce, Cortes, Marttinen, & Caswell (2018)	Physical activity and enjoyment during dance-focused physical education classes in middle school girls	International Journal of Physical Education	The purpose of the study was to evaluate how much physical activity occurs during dance focused PE lessons and the enjoyment participants received from it.	10 middle-school girls had their heart rates evaluated while participating in 6 dance classes. Surveys were used to determine whether the students enjoyed them. The girls were also provided with heart rate monitors.	Heart rates were recorded using a Zephyr Biohames3 sensor. The surveys were constructed by using the 12-item physical activity enjoyment scale. The scoring was determined using a 5-point Likert Scale.	Researchers found participants to be engaged in MVPA for approximately 23.3 minutes during the lessons. The mean heart rate for the participants was averaged at 116.2 bpm. Students indicated on the survey that they enjoyed the lessons on an average score of 3.9/5.	The research has found that dance-focused PE lessons provided participants with almost all of their recommended MVPA (30 minutes). 7 dance styles were discovered to raise physical activity levels more than other youth sports when compared to prior research. Future studies should focus on various forms of dance and other physical activity that	The article was focused on a specific unit/activity (dance) when evaluating the connection to MVPA levels. The study is similar to others in using heart rate monitors to track heart rates and physical activity. The research is impressive because it almost meets the recommended levels of MVPA.

							allows students to reach their recommended MVPA levels.	
Collings, Wijndaele, Corder, Westgate, Ridgway, Sharp, Atkin, Stephen, Bamber, Goodyer, Brage, & Ekelund (2016)	Objectively measured physical activity and longitudinal changes in adolescent body fatness: an observational cohort study	Pediatric Obesity	The purpose of the study was to analyze the participant's original PA levels and measure changes in them over 2.5 years into their adolescent years.	728 students amongst 18 secondary schools located in Cambridgeshire, UK, were selected for the study. Students were measured to see how their physical activity and heart rate fluctuated during physical education classes.	Heart rates were monitored using water-resistant monitors worn around the chest of participants. Physical activity levels were measured using the heart rate of participant and comparing them to estimated physical activity levels.	Researchers found that there were positive associations between baseline volume and intensity regarding adiposity in the 2.5 years measured. This includes the years from 15-17.5 years old in middle to late adolescence.	Future studies should measure body fatness and PA at the same time throughout the various waves of study (0-2). This can provide more detailed information as to fat gain/loss and how physical activity plays a role in that fluctuation.	The study is different than others, as it measures the participants over a longer period. This study is the only one that is conducted in the United Kingdom. The study used water resistant heart rate monitors which is the only kind in this collection of literature.
Costa, Figueiredo, Duarte, Honório, O'Hara,	ANALYSIS OF HEART RATE IN DIFFERENT TYPES OF	Journal of Physical Education & Health	The main purpose of the study was to analyze the physical	182 students were selected from five different high schools in	Heart rates were recorded every 1 second	The average heart rate of students during PE lessons	The value of MVPA recorded amongst students during	The study is similar to others as the research is conducted during physical education time. The study also uses heart

Vincente, & Martins (2018)	CLASSES OF PHYSICAL EDUCATION		activity levels of adolescents during physical education class using heart rate monitors.	Portugal (97 boys and 85 girls). Students had their baseline height and weight taken before testing began. Students were given heart rate monitors and assessed over 9 PE lessons encompassing different types of units.	interval by the monitors. At the end of lessons, the monitors were gathered, and the data was downloaded. Mean and standard deviations were constructed upon completion of the data. One-way ANOVA was used to determine differences amongst MVPA and MVPA values in the different types of units.	ranged at 132.25 bpm. In the lesson, 21 minutes of PE time accounted for MVPA. Girls averaged higher heart rates and MVPA levels than the boys. The type of lesson did not influence MVPA levels according to calculations of the one-way ANOVA.	the PE lessons proved to be under 50%. Which means that the PA is under the recommended average to fight against obesity and metabolic diseases. The research recommends for future studies to investigate physical education activities and to analyze them more in depth. Specifically, looking at activities that provide physiologic exercise for the students.	rate monitors like the others. The study was conducted in Spain like one other in this collection. Heart rates were recorded every 1 second to be accurate like one other study. The findings concluded that PE accounted for some PA but, not as much as the recommended number of minutes per week.
Cuberek, Fromel,	Differences between an	Journal of Physical	The purpose of the study is	573 girls from Czech	Researchers used a	Researchers found the	The largest difference	This is the only study that used a ActiTrainer

| Groffik, & Jakubec (2017) | accelerometer and a heart rate monitor in monitoring non-training-related load in adolescents: an opportunity to distinguish between the physical and mental load | Education and Sport | to assess the differences between accelerometers and heart rate monitors in non-training related load measurement in relation to physical or mental load throughout the school day. | and Polish secondary schools were selected to participate in the study. Each student was given an ActiTrainer device which includes an accelerometer and a heart rate monitor. Students had their day divided into three segments in which, their activity was logged. | software called IntPal13 to record variances between the accelerometer and heart rates. The ActiTrainer recorded information in 15 second intervals. Students who: wore the device before school for 15 minutes, wore it for 180 minutes during school, 120 minutes after school, and 600 total minutes throughout the day had their data | biggest disparity between PA and inactivity was before school (53% active). The most amount of VPA was found to be after school for students. The heart rate monitors had higher numbers of bpm as compared to the accelerometers. | between the accelerometers and heart rate monitors were shown in LPA. The smallest occurred in VPA. Overall, there are many disparities between the accelerometers and heart rate monitors when determining time amongst load intensity-based activities. Recommendations for future studies include the analyzation of specific activities when using these devices. Instead of measuring time, the type and frequency of activities should be | device (which incorporated an accelerometer and heart rate monitor). This study is similar to others because it has a certain requirement for minutes that participants had to meet while using the device to move forward in the study. |

					recorded for further analysis.		looked at more carefully when using an accelerometer and heart rate monitor.	
Marmeleira, Aldeias, & Graca (2012)	Physical activity levels in Portuguese high school physical education	European Physical Education Review	The purpose of the study is to evaluate physical activity levels of high school students during physical education class and what factors motivate them to participate during class.	46 students from three high schools participated in the study. Over 6 weeks, students had their physical activity levels assessed in one of two PE lessons.	Students were measured using heart rate monitors, pedometers, and Borg's rate of perceived exertion. Numeric values were grouped together in a table format found in table 2.	Researchers found students were engaged in MVPA and VPA during 33% of the time. The average heart was 135.2 BPM. Vigorous physical activity occurred most during mixed activity lessons.	The research found PE to be a small contribution to the 60 minutes of physical activity recommended for moderate PA. Future recommendation calls for evaluation of PE and why it only contributes 50% of the recommended contribution in young people.	This study uses PE lessons to evaluate students' physical activity levels. This study is the only one that uses Borg's Rate of Perceived Exertion. This study is one of three that were conducted in Portugal when compared to other literature collected. This study also found PE class to contribute only a portion of the recommended MVPA levels to students.
McCormick, Hannon, Newton, Shultz, Miller, & Young (2012)	Comparison of Physical Activity in Small-Sided Basketball Games Versus	International Journal of Sports Science & Coaching	The purpose of the study was to compare small-sided basketball games with	12 boys at 15 years old who were freshman in high school participated in the study.	After each game, players had the monitors collected and the researcher	The researchers found that offensive played balls were higher in small-sided	As compared to practical application, small-sided games allow players to focus more on their	The study evaluated the unit of basketball and the various forms of lessons that PE teachers use during class. Like other studies here, the data was immediately collected

	Full-Sided Games		full-sided basketball games regarding physical activity levels. Another purpose of the study was to evaluate the influence of positioning regarding opportunities to make plays with the ball in both forms of basketball games.	After players were divided into teams, the players were given heart rate monitors with specific instructions to use before, during, and after the game. The games were also recorded via video to ensure that the heart rate monitors would work while players were moving.	downloaded the data into a Microsoft Excel worksheet to be used further for statistical analysis. The data was analyzed through a software called SPSS 20 and paired t-tests, which measured: heart rates, MVI, VI, and OPB.	games compared to full-sided, especially at the point guard position. Between the two games, the small-sided gameplay yielded higher heart rates. Players were moving more due to the increase in the amount of court they had to cover as compared to full-sided.	skills and gain more physical activity. Researchers recommend that future studies focus on using players from different teams to eliminate the involvement of coach and player positions. Also, it's recommended to treat the research in a more game like environment that has free throws and stoppages throughout the game.	from the monitors after the activity ended. This study was conducted in the United States, like two others.
Moore, Beets, Barr-Anderson, & Evenson (2013)	Sedentary time and vigorous physical activity are independently associated with	Journal of Sports Sciences	The purpose of the study was to measure the following topics such as physical	285 (113 male and 172 female) students from three middle schools located in	Before the study was conducted, students were classified amongst	Researchers found that out of the 285-final sample of participants, that time	The data from this research supports the claim that sedentary behavior and vigorous PA	This is the second study in this collection of literature to have research take place in the United States. This study used various grouping methods to classify

	cardiorespiratory fitness in middle school youth		activity, sedentary time, and cardiorespiratory fitness among participants.	adjacent counties in the United States were selected to participate in the study. Students were given accelerometers and heart rate monitors to record physical activity and heart rates. The heart rate monitor was a Polar heart rate monitor.	baseline measurements of their physical activity levels. The groups were: high sedentary/low vigorous, low sedentary/low vigorous, low sedentary/high vigorous, and high sedentary/high vigorous.	spent sedentary had a negative effect in relation to cardiorespiratory fitness. Moderate and vigorous PA were found to have a positive relationship with cardiorespiratory fitness. Heart rates for males were averaged at 144.2 bpm, which is lower than the female average of 157.0 bpm. Moderate and vigorous PA were both higher in males as compared to females.	are associated with cardiorespiratory fitness in middle school students. Moderate PA was found surprisingly not to have a strong correlation to cardiorespiratory fitness. Vigorous PA was thus, linked to cardiorespiratory fitness in a strong connection. Researchers recommend for future studies to conduct a longitudinal designed study to see how the long term effects of sedentary time, physical activity, and cardiorespirator	participants, comparable to other studies in this grid. Various, specific forms of physical activity was determined to have a connection to the topics being evaluated.

							y fitness have on participants.	
Sarradel, Generelo, Zaragoza, Clemente, Abarca-sos, Murillo, &Aibar (2011)	GENDER DIFFERENCES IN HEART RATE RESPONSES TO DIFFERENT TYPES OF PHYSICAL ACTIVITY IN PHYSICAL EDUCATION CLASSES	European Journal of Human Movement	The purpose of the study was to analyze the differences between gender amongst participants in relation to physical activity during physical education classes.	37 secondary school students (19 boys and 18 girls) both ranged at average age of 14.1-14.3 years old. Height and weight were obtained using devices, meanwhile body fat was calculated using the skinfold test.	Heart rate monitors were given to students to record their heart rates and physical activity every 5 seconds. Resting heart rate was obtained on non-PE days over the course of 7 days. The maximal heart rate was calculated during a 20-meter shuttle run. Heart rate reserve was constructed using the	The heart rates were equated into percentages based upon the different types being evaluated during the PE lessons. The data collected from the PE lessons after 64 of them, were then processed using SPSS for Windows (statistical analysis software). One-way ANOVAS were then implemented to spot significant differences in the data.	The research found to have a difference in girls regarding a greater portion of skin fold. Also, the study found girls to have lower resting heart rates than the boys. Among the participants in the study, team sports and individual activities showed to produce different heart rates between the genders. Students accrued the most MVPA during team sports among all participants. Girls also gained more	This study was the only study to conduct skinfold testing for baseline data. Similar to other studies, the heart rates had intervals of data recordings. They were recorded every 5 seconds. This study was measured over a long period of time. Not as long as the 2.5-year study, however, the amount of lessons recorded provides the findings in this research to be credible.

				difference between RHR and MHR.		MVPA during fitness as compared to the boys who achieved lower levels.	
Singerland, Oomen, & Borghouts (2011)	Physical activity levels during Dutch primary and secondary school physical education	European Journal of Sport Science	The purpose of the study was to determine overall intensity of Dutch secondary schools regarding their physical education lessons. They also evaluated the influence of the lesson's characteristics and how intensity levels fluctuated.	452 students (ages 13-18) were selected amongst 20 secondary schools from the Netherlands. In each PE lesson, a random sample of 10 students (5 boys and 5 girls) were given heart rate monitors. The heart rate monitors were Polar Team Systems, which were worn around the chest of the participants.	Physical activity levels and heart rates had groups created to classify students. Descriptive statistics and lesson time were accounted for when creating these. Individual and team sports were used during the lessons to measure accurate forms of PA levels and heart rates.	Researchers found that resting heart rates between boys and girls were lower in boys. They also found that activity levels in both moderate and vigorous physical activity, boys and girls were very similar in terms of heart rate. Yet, boys were only a couple bpm lower than the girls. The study also found older grade levels to average more MVPA time.	The findings discovered that lesson time spent in MVPA ranged at 46.7% of the time and for 21.44 minutes per lesson. In team sports, students averaged the highest MVPA levels in the study as compared to the individual sport activities. Researchers call for future studies to investigate the MVPA levels of specific activities as it relates to PE. They also	The types of units taught during PE lessons were used to measure intensity levels regarding physical activity. This study is one of two that were conducted in the Netherlands. Contrary to other studies, resting heart rates in boys were lower than the girls.

				Heart rates were recorded every 5 seconds during the lesson.			recommend more time be given to PE lessons to see how much PE helps students in their quest to gain their recommended weekly MVPA levels.	
Slingerland, Haerens, Cardon, & Borghouts (2013)	Differences in perceived competence and physical activity levels during single gender modified basketball game play in middle school physical education	European Physical Education Review	The purpose of the study is to evaluate the difference between single gender and mixed gender team sports as it relates to physical activity and perceived competence.	216 students (42% girls) between the grades of 7-9 in secondary schools located in the Netherlands agreed to participate in the study. PA levels were measured using a Polar Team Heart Rate Monitor system. Students had their perceived competence determined	To measure MVPA accurately, the researcher used a range of RHR to determine the participants' PA levels. Ages were used to provide a baseline RHR and MHR. Researchers used specific models to take into	Researchers found that the climate of game play had a strong relationship in correlation to perceived competitive climate. Girls had their MVPA levels and perceived competence increase when playing in single gender basketball. Girls' perception of competitivene	High levels of physical activity can be attained when grouping students by single gender in competitive game play. Researchers call on future studies to use a longitudinal design when conducting a similar study. They also recommend future research to further the scope of grouping	The study looks at how gender affects physical activity levels. Something that no other study specifically evaluated. This is the second study to be conducted in the Netherlands. Various forms of heart rates were used to group participants in order to classify data (MHR, HHR, RHR).

				when researchers used a sports/athletics subscale of the Children's Physical Self Perception Profile. The same two identical PE lessons were used during the same week for research purposes.	account dependent variables (MVPA and perceived competence) and interpret the collected data. All data was run through a software called MLwin version 2.23. A product-of-coefficient test was used to measure competence as well.	ss however, decreased.	students by self-selection or actual competence level.	
Surapiboonchai, Furney, Reardon, Eldridge, & Murray (2012)	SAM: A Tool for Measurement of Moderate to Vigorous Physical Activity (MVPA) in School	International Journal of Exercise Science	The purpose of the study was to measure the reliability of the SAM device when measuring MVPA levels	Students were selected from a school district located in Texas to participate. 8 students were randomly	SUUNTO Heart rate monitors were used to record the students' heart rates. Data was	The research that was collected found students in grades 6-8 (middle school) average a	The SAM device was found to be extremely reliable when comparing heart rates to MVPA levels in students.	This study is the only one that specifically investigates an unusual device such as the SAM to record data regarding PA levels and heart rates. This study is the third to be conducted in the United States. The

| | Physical Education | | of students during PE lessons. | selected and provided with the SAM device during the PE lessons and researchers also observed the lesson and completed a SOFIT form to double check the measurements recorded by the device. 6 classes were assessed while the SAM was administered and heart rate monitors were given out as well to track students' bpm. | interpreted through the SAM device that was given out to students. It was then verified with statistical analysis of SOFIT through observation. Information was put through statistical software such as an ANOVA. | higher percentage of MVPA than students in grades 9-12 (high school). The middle school students also averaged higher heart rates (156.85 bpm) as compared to the high schoolers (135.92 bpm). Middle school students were also found to exercise at 75.8% of their max heart rate while participating in MVPA for 50% of the time. High school students were seen exercising at 66.1% of their | Researchers call for future studies to measure the SAM device more, especially in relation to the reliability coefficients present in the research. They should also include more observers with larger sample sizes. Including other forms of measurement besides the SOFIT form in order to compare the SAM could prove to be quite exploratory. | findings indicated that younger participants averaged more PA levels and lower bpm when compared to their older counterparts. |

						max heart rate while participating in MVPA 36.5% of class time.		
Van Acker, Carreiro da Costa, Bourdeaudhu ij, Cardon, & Haerens (2010)	Sex equity and physical activity levels in coeducational physical education: exploring the potential of modified game forms	Physical Education and Sport Pedagogy	The purpose of the study is to promote sex equity in thirteen-year-old participants during physical activity-based lessons. Researchers also wanted to study MVPA levels of single-sex and coeducational classes with and without grouping methods.	221 participants (113 boys and 108 girls) were selected for the study. The students varied from Portuguese and Belgian PE classes (104 Portuguese and 117 Belgian). All students attended middle schools in their respective countries. The lessons revolved around the teachings of the game of	Polar Heart Rate Monitors were given to each student during class and heart rates were recorded in 15 second intervals. The monitor was worn around the chest of the participant. In both countries, a software called "Polar Precision Performanc e Software" was used to record and	The findings indicated that MVPA was highest in the lesson context when students were in a coeducation setting with grouping. It was also found for girls to have higher levels of MVPA than boys. Single sex lessons were shown to have the lowest levels of MVPA.	Over the course of all three lesson contexts, girls were found to have higher levels of MVPA. The grouping lesson contexts really had no difference between the two because of the implementation of modified game versions and drills. Out of the lessons, students spent 62.8% of the time engaged in MVPA levels. The mean heart rate of all students was averaged	The study uses Polar Heart Rate Monitors as other studies in this collection. This study also evaluates the influence of gender roles during PE lessons, similar to other studies. This study is the only one that is conducted in multiple countries. The heart rates were measured every 15 seconds, another study that had time recorded intervals regarding their heart rate monitors.

				Korfball. Four lessons were given to students in three different contexts: single-sex classes, coeducational classes without grouping, and coeducational classes with grouping.	download the data from the heart rate monitors. MVPA was calculated using the following formula: MVPA=heart rate readings higher than 145 multiplied by 15 seconds, divided by 60 seconds.		at 153.4 bpm. Researchers call on future studies to evaluate personal factors involved in the studies such as attitude, self-efficacy, and enjoyment. These factors could affect the relationship between forms of modified games and physical activity levels during physical education classes.	
Yuste, García-Jiménez, & García-Pellicer (2015)	INTENSITY OF PHYSICAL EDUCATION CLASSES IN ADOLESCENTS	Revista Internacional de Medicina y Ciencias de la Actividad Fiscia y del Deporte	The purpose of the study is to measure the intensity in physical activity for adolescents during physical education lessons.	182 students (97 boys and 85 girls) were selected from five high schools located in Spain. 9 PE lessons were used to record data from the	Polar Team 2 Heart Rate Monitors were used in recording student heart rates during the PE lessons. The	The results found that out of all of the PE lessons, the average heart rate in students was calculated at 132.25 bpm. This was then equated to	The researchers concluded that PE lesson time does not equate in meeting the recommended percentage of MVPA time for adolescents in Spain. Researchers	This study is similar to others in the way it uses physical education units to see how MVPA levels fluctuate. This relationship has been a common theme amongst a decent amount of the literature collected. The specific brand of heart rate monitors is very

					students. Four different types of physical education units were measured during this period.	monitors were set to record when the PE lessons began and recorded heart rates every 1 second. At the end of the lessons, the monitors were collected, and data was immediately recorded. MVPA levels were calculated for each student by estimating the time spent between 40-59% of Heart Rate Reserve (HRR). One-way	21.62% of MVPA during lesson time. Girls in the study were found to have higher levels of heart rate and be in a higher percentage of MVPA when compared to lesson time. The units of Team Sport and Traditional Games were shown to have the highest time in minutes regarding MVPA value (.200 for both boys and girls).	call on future studies to specifically evaluate activities within the units of this study and measure the intensity of physical activity and the effects it has on students.	notable as it proves to be reliable. Compared to another study in this collection, the monitors record data in 1 second intervals. Providing researchers with accurate data to go off of. Sadly, the PE lessons did not account for the recommended MVPA time suggested for students.

					ANOVA was used to measure statistical differences between heart rate and calculated MVPA.			