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Student Physical Activity Patterns: Grade, Gender, and Activity Influences

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The purpose of this study was to determine how physical education students' cardiovascular responses as determined by mean heart rate, standard deviation of heart rate, and percentage of time in target heart rate zone varied according to student characteristics. Participants were 505 students in Grades 3 through 12. The Polar Accurex Plus heart rate telemetry system was used to measure the physiological load on the cardiovascular system. Three-way ANOVA results suggested that heart rate patterns in physical education varied according to gender, grade, and activity. For example, secondary school girls were more active in individual activities while secondary school boys were more active in team sport activities. Elementary students were the most active group and had the most variability in their heart rate patterns.

Key Words: heart rate, physical education, activity levels

Individuals begin to attain and establish patterns of health-related behaviors during childhood and adolescence. Thus, if the exercise behaviors of adults are to stem from a positive influence, it is critical that as young people they be physically active. Schools have the potential to improve the health of youth by providing instruction, programs, and services that promote enjoyable lifetime physical activity (Centers for Disease Control [CDC], 1997).

National recommendations for school physical education programs include requiring comprehensive, daily physical education for students in Grades K–12 (CDC, 1997) and providing at least 50% of class time in physical activity (U.S. Dept. of Health and Human Services, 2000). Scientists have consistently shown, however, that physical education programs are not meeting the Healthy People 2010 goal of a minimum of 50% of class time spent in physical activity (U.S. Dept. of HHS, 1996).

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The following review examines three major factors—grade, gender, activity type—related to student physical activity in physical education classes, focusing on studies using heart rate telemetry. There is some evidence to suggest that differences in moderate-to-vigorous physical activity (MVPA) in physical education classes are related to the grade/age of the students. Stratton (1997) found that MVPA increased from 9 to 10 years of age to peak at 11 to 12 years of age and then decreased in later school years. Klausen, Rasmussen, and Schibye (1986) also found that heart rates were lower in older children (ages 12 to 13) than in younger children (ages 10 to 11). Decreased MVPA during middle school and high school may reflect youths' waning enthusiasm for physical education or a change in how physical education programs are delivered (Stratton, 1997). Participation in all types of physical activity declines dramatically with increases in age and grade level during adolescence (U.S. Dept. of HHS, 1996).

Few researchers have investigated possible gender differences in MVPA using heart rate telemetry. Some have suggested that boys and girls might have different physical activity patterns in physical education classes. Telemetry studies have shown girls' heart rate values to be higher than those of boys performing the same activities (Bar-Or, 1983; Stratton, 1995) while others have shown no gender differences in heart rate values (e.g., Klausen et al., 1986).

Gender differences in activity during physical education classes have also been investigated using other types of instrumentation. McKenzie, Marshall, Sallis, and Conway (2000a), using the System for Observing Fitness Instruction Time instrument (SOFIT), found that boys were more active than girls overall and during skill drills, game play, and free play. Girls were also less likely to visit activity areas and participate in physical activity before school and during lunch (McKenzie, Marshall, Sallis, & Conway, 2000b). Sarkin, McKenzie, and Sallis (1997), using accelerometers (Caltrac), did not find any gender difference in physical activity during physical education classes; however, during recess they found that boys were more active than girls. Boys have higher MVPA participation levels than girls (Simons-Morton, McKenzie, Stone, et al., 1997*;* Sallis, Hovell, Hofstetter, et al., 1990), and overall, female adolescents are much less physically active than males (U.S. Dept. of HHS, 1996).

It is logical to assume that the type of physical activity performed would influence the time spent in MVPA during physical education classes. Strand and Reeder (1993a), using an intervention study whereby teachers were given strategies to increase MVPA in physical education, found that students spent 50% of class time in their target heart rate zone. Students were able to attain their target heart rate participating in nine different activities, although the time spent in the target heart rate zone varied.

Several studies have shown sport activities to produce equal or greater time in MVPA than other activities (Hannon & Pellett, 1998; Stratton, 1997). McKenzie et al. (2000a) also reported that activity levels varied according to the content, with fitness activities producing the most physical activity, followed by free play, game play, and skill drills. Differences in MVPA have been shown both between and within activities.

There are some activities that have been both successful and unsuccessful in producing MVPA. Data from gymnastics lessons (Stratton, 1997) and swimming lessons (Faulkner, Greey, & Hunsicker, 1963) have shown significant daily vari-

ance in mean heart rate. It is difficult to determine, however, whether mean heart rate differences are due to the activity, the teaching method, or other exogenous variables.

Further study of MVPA in physical education classes using heart rate telemetry and other techniques is particularly critical, given the potential role of physical education in helping youth develop lifetime physical activity behaviors. This study is part of the larger effort to have physical education be a main player in the move to reach health objectives. The specific purpose guiding this study was to determine how student physical activity in physical education classes, as determined by mean heart rate, standard deviation of heart rate, and percentage of time spent in the target heart rate zone, varied according to endogenous characteristics of the students including grade and gender as well as type of activity performed.

Method

Participants and Classes

Participants in this study were 505 students in Grades 3 through 12. They represented 21 schools located in 8 districts in suburban and urban settings from a large metropolitan area in the Midwest. Although data were not collected from the parents or students on their ethnic background, ethnicity data from the district provides general information about the ethnic heritage of the participants. The urban district was composed of 90.9% African American, 4.7% Caucasian, 3.0% Hispanic, 1.1% Asian, and 0.2% Native American students. Average ethnic background percentages for the suburban districts were 83.57% Caucasian, 10.32% African American, 2.83% Native American, 2.57% Asian, and 0.69% Hispanic students. Students participated in regular physical education classes taught by 21 full-time certified physical education specialists. Classes included instruction in 13 activities. Actual class time was calculated based on the duration of time the heart rate monitors were activated during the lesson. Several minutes of class time were allocated to putting the monitors on and for the research team to start and stop all monitors. Table 1 provides descriptive information for the students, schools, and teachers.

Recruitment

Approval for the study was first obtained for each district, then from the principals and teachers. Participants were recruited through phone calls from a large group of teachers (N = 342) who had completed a survey instrument for another study. Two criteria were used to select teachers from this pool: (a) urban or suburban setting and (b) their scores on a physical activity belief system instrument used in another study. An effort was made to recruit teachers from both urban (n = 9) and suburban (n = 12) settings as well as from the high physical-activity-and-fitness (n = 9) belief and low physical-activity-and-fitness (n = 12) belief groups.

Interested teachers provided informed consent to participate in this study. They also gained consent for their students to participate by distributing a passive consent form to the parents. Parents who did not want their child to participate contacted the teacher and alternate arrangements were made for the child on the day of testing. All of the students from the 29 classes in the 21 schools involved in

Table 1 Student, Teacher, and School Descriptive Information

School and Teacher Descriptives	Mean	*SD*	Range
Allocated class time	30.83 min	4.99 min	24–45 min
Actual class time	27.62 min	6.78 min	13.54–41.77 min
Actual elementary class time	28.18 min	6.09 min	18.94–36.46 min
Actual secondary class time	27.02 min	7.64 min	13.54–44.77 min
Teacher age	43.90 yrs	10.50 yrs	28–62 yrs
Teacher years of experience	16.40 yrs	11.00 yrs	1–33 yrs

Student and Teacher Frequencies	
Students (N = 505):	284 boys and 221 girls
Grade level:	265 in elementary school and 240 in secondary school
Teachers (N = 21):	6 males and 15 females
Degrees:	11 bachelors degrees and 10 masters degrees
Ethnic background:	12 Caucasian, 7 African American, and 2 Hispanic American
School setting:	9 urban and 12 suburban

this study whose parents had provided consent, and who were present on the day of data collection and dressed for activity, chose to participate.

Instrument and Procedures

The heart rates of the participants were successfully measured during one physical education class, with all students wearing a heart rate monitor during the lesson. Data were collected by four of the authors during March through June 1999, with at least two authors collecting data at each school. The researchers underwent training with the heart rate monitors prior to data collection.

The Polar Accurex Plus heart rate telemetry system was used to measure the physiological load on the cardiorespiratory system of children and adolescents. The Accurex Plus is a third-generation heart rate monitor that has demonstrated even more accuracy than earlier models, such as the PE 4000 (Boudet & Chamoux, 2000, 2001). Before the lesson began, all participants attached the heart rate telemetry system to their chest (after applying moisture under the electrode) and wrist with the assistance of the researchers. The researchers started and stopped each monitor at the beginning and end of class. Monitors recorded the heart rate every 15 seconds to address the concerns of Rowlands, Eston, and Ingledews (1997) about the lag between heart rate response and movement, as well as evidence that 60-second interval recordings may be unreliable (Stratton, 1999). The heart rate monitors were then interfaced with the corresponding Polar/IBM interface and data were downloaded for statistical analyses.

Data Analysis

A mean heart rate (termed MNHR) was determined for each student; MNHR = Σ(HR in a PE class) /n. A mean score also was calculated for the variability of each student's heart rate scores or the standard deviation of the heart rate (termed SDHR); SDHR = sqrt [Σ(heart rate – MNHR)^2 / n]. In addition, a percentage was calculated for the time each student spent in his or her target heart rate zone (termed HR Zone). HR Zone = (number of heart rate inside zone / n) × 100, where HR = heart rate, PE = physical education, n = number of readings in a class. Students were assigned target heart rate zone values according to the average age for each grade level. For example, average age used for third grade was 8.5. The American College of Sports Medicine (ACSM) guidelines (2000) of 60 to 90% of maximum heart rate (220 – age) were used to determine HR Zone (i.e., 127 to 190 bpm).

Descriptive statistics were calculated for the three measures—MNHR, SDHR, HR Zone—of student physical activity described earlier. Grade levels were recoded into a new variable with two levels, that is, Grades 3–6 as elementary and Grades 7–12 as secondary in order to have an adequate number of students of each grade and gender to conduct the 3-way ANOVA analyses. Activities were also recoded into traditionally recognized team sports and other activities that do not require team membership (Strand & Wilson, 1993). Team sport activities included basketball, soccer, softball, and volleyball, and classes included official rules games, modified games, and station work. Individual activities included bowling, calisthenics (e.g., jumping jacks, sit-ups), elementary games (e.g., stick-in-the-mud), fitness, golf, gymnastics, hula-hoop, modern dance, and weight training. The MNHR, SDHR and HR Zone were also calculated for all 13 activities.

Three separate factorial analyses of variance (ANOVAs) were conducted to investigate differences among the groups, one for each physical activity measure as the dependent variable (i.e., MNHR, SDHR, HR Zone). The factors were gender (female, male), grade (elementary, secondary), and activity (team sports, individual activities).

Supplemental Analyses

ANOVA was also used to determine differences in heart rate values among students participating in the 13 different physical activities (e.g., basketball), with MNHR, SDHR, and HR Zone as the dependent variables. Similarly, differences among elementary, middle/junior high, and high school students' heart rate values were also investigated using ANOVA. Significant ANOVAs were followed by Duncan's Multiple Range Tests to probe where differences existed at $p \leq .05$.

Results

The descriptive results indicate that students' mean heart rate was 140.29 bpm, with a range of 92.40 to 188.20 bpm. The standard deviation of the heart rate showed considerable variability, ranging from 1.70 to 64.80 (M = 28.90). The time students spent in their target heart rate zone varied from 3.08% to 100% of class time, with a mean of 51.02%. At least two factors contributed to the large variabil-

Table 2 Mean Heart Rate, Standard Deviation of HR, and % Time in Target HR Zone by Activity Performed and Grade Level

Activity & Grade	*N*	MNHR (bpm) *M*	*SD*	SDHR (bpm) *M*	*SD*	HR Zone (% time) *M*	*SD*
Basketball							
Grade 7	76	138.54	(16.11)	24.69	(8.02)	56.78	(22.39)
High school	42	143.32	(19.87)	26.05	(8.63)	60.07	(24.94)
Bowling							
Grade 5	15	135.31	(10.63)	26.82	(6.61)	51.25	(16.92)
Calisthenics							
Grade 6	17	133.51	(9.54)	28.89	(6.62)	54.58	(11.13)
Dance (modern)							
High school	8	131.13	(12.83)	33.11	(11.63)	28.87	(16.31)
Elementary games							
Grade 5	14	158.08	(14.50)	31.96	(7.46)	58.06	(12.11)
Fitness							
Grade 4	45	140.94	(14.50)	27.86	(5.65)	59.06	(18.38)
Grade 5	24	153.83	(16.41)	30.90	(7.52)	54.01	(13.37)
Grade 6	26	140.67	(15.19)	33.62	(11.40)	49.86	(18.19)
Golf							
Grade 7	36	147.26	(29.05)	31.86	(8.53)	29.38	(16.12)
Grade 8	26	122.88	(10.40)	33.05	(8.79)	24.57	(16.46)
Gymnastics							
Grade 3	18	140.69	(13.65)	35.80	(11.68)	50.38	(17.19)
Hula-Hoop							
Grade 2	18	154.28	(9.04)	32.07	(9.13)	64.05	(10.65)
Soccer							
Grade 4	16	140.76	(9.25)	26.93	(8.59)	53.87	(15.75)
Softball							
Grade 3	37	135.72	(14.27)	34.71	(8.42)	34.41	(7.63)
Grade 4	13	155.32	(6.86)	29.81	(5.49)	66.53	(12.90)
Volleyball							
Grade 5	22	141.50	(11.30)	29.22	(7.47)	61.15	(18.84)
High school	19	133.02	(15.27)	22.85	(8.29)	56.19	(27.49)
Weight training							
High school	33	130.54	(13.29)	22.45	(7.19)	53.55	(25.22)

Note: All high school classes were composed of students at multiple levels.

ity in the time students spent in their target heart rate zones: the time spent starting and stopping the watches and some noise interference. Heart rate values lower than 50 or higher than 220 were deleted to reduce experimental bias due to measurement error caused by noise interference. The skewness measures for the three dependent variables were small (MNHR = 0.19, SDHR = 0.19, and HR Zone = –0.13), indicating that the data were normally distributed. The MNHR, SDHR, and HR Zone for students participating in the 13 physical activities by grade level are listed in Table 2.

Results for the three-way ANOVAs are presented next for the three dependent variables—MNHR, SDHR, and HR Zone. For mean heart rate (MNHR) the analysis detected a main effect on Grade, $F(1, 497) = 13.29$, $p < .01$. Also the interaction was significant among Grade, Gender, and Activity, $F(1, 497) = 7.22$, $p < .01$. Simple mean effect analysis on Grade, Gender, and Activity indicated that for secondary students, girls' team sport activities ($M = 133.77$, $SD = 16.49$) and boys' individual activities ($M = 131.09$, $SD = 21.25$) resulted in lower MNHRs.

Analysis for the standard deviation of heart rate (SDHR) detected main effects on Grade, $F(1, 497) = 33.26$, $p < .01$; and Activity, $F(1, 497) = 5.77$, $p < .05$. The interaction was also significant between Grade and Activity, $F(1, 497) = 11.16$, $p < .01$. Subsequently, simple mean effect analyses indicated that students in elementary grades ($M = 31.19$, $SD = 8.33$) produced higher SDHR than secondary students ($M = 24.85$, $SD = 8.24$) did in team sport activities but not in individual activities.

The heart rate zone (HR Zone) analysis detected main effects on Grade, $F(1, 497) = 6.49$, $p < .05$; and Activity, $F(1, 497) = 17.31$, $p < .01$. Also the interaction between Grade and Activity was significant, $F(1, 497) = 51.05$, $p < .01$. Simple mean effect analyses indicated that, in elementary physical education classes, individual activities ($M = 55.47\%$, $SD = 16.11$) resulted in a higher percentage of time in the target heart rate zone than did team sport activities ($M = 49.37\%$, $SD = 18.80$). In secondary physical education classes, however, team sport activities ($M = 57.70\%$, $SD = 23.80$) resulted in a higher percentage of time in the target heart rate zone than did individual activities ($M = 35.87\%$, $SD = 22.92\%$). Gender and other interactions were not significant. See Table 3 for means and standard deviations for the Gender × Grade × Activity groups for the three dependent variables of MNHR, SDHR, and HR Zone.

As predicted, the ANOVAs examining differences among children performing the various physical activities suggested there were differences in MNHR, $F(12, 492) = 4.50$, $p < .01$; SDHR, $F(12, 492) = 7.95$, $p < .01$; and HR Zone, $F(12, 492) = 12.50$, $p < .01$. Follow-up analyses indicated that elementary students participating in games and hula-hoop activities had significantly higher heart rates than children performing the other 11 physical activities. Students performing gymnastics had significantly more variability in their heart rate than students in all other activities, while students participating in weight training had significantly less variability than students in other activities. Finally, students participating in hula-hoop activities, volleyball, elementary games, and basketball spent significantly more time in their target heart rate zone, while those participating in modern dance and golf spent significantly less time in their target zone.

Table 3 Mean Heart Rate, Standard Deviation of HR, and % Time in Target HR Zone for Gender × Grade × Activity Groups

Endogenous Characteristics	Activity	*N*	MNHR (bpm) *M*	*SD*	SDHR (bpm) *M*	*SD*	HR Zone (% time) *M*	*SD*
Girls								
Elementary	Indiv.	88	146.20	(16.23)	30.54	(7.43)	56.31	(15.10)
Elementary	Team	50	142.24	(14.06)	30.74	(8.22)	51.15	(19.56)
Secondary	Indiv.	35	141.11	(22.00)	28.37	(8.99)	41.60	(21.36)
Secondary	Team	48	133.77	(16.49)	21.06	(8.61)	56.65	(28.02)
Boys								
Elementary	Indiv.	89	142.11	(14.59)	30.83	(9.72)	54.65	(17.10)
Elementary	Team	38	139.31	(12.39)	31.80	(8.56)	47.04	(17.74)
Secondary	Indiv.	68	131.09	(21.25)	29.69	(9.89)	32.92	(23.30)
Secondary	Team	89	142.20	(17.29)	26.90	(7.31)	58.27	(21.34)

Note: Indiv. = individual activities, Team = team sports.

The ANOVAs examining grade level differences between elementary, middle/junior high, and high school students supported intuitive conclusions for the MNHR and SDHR values. Elementary students had significantly higher MNHR values than middle school or high school students, $F(2, 502) = 9.17$, $p < .01$. They also had the most variability in their heart rates (SDHR), followed by middle/junior high and then high school students, $F(2, 502) = 22.79$, $p < .01$. Interestingly, the high school and elementary school students spent significantly more time in their HR Zone than did the middle/junior high students, $F(2, 502) = 11.00$, $p < .01$.

Discussion

The results of this study showed that students spent an average of 51% of physical education class time in their target heart rate zones. This finding is encouraging, although it should be viewed cautiously due to the wide range (i.e., 3 to 100%). It suggests that some physical education programs are now meeting one of the Healthy People 2010 objectives, which states "Increase the proportion of adolescents who spend at least 50% of school physical education class time being physically active" (U.S. Dept. of HHS, 2000, p. 21). Previously, only intervention studies have been able to consistently document at least half of the class time spent with the students being physically active (e.g., McKenzie, Sallis, Kolody, & Faucette, 1997). The amount of physical activity participation varied by the grade and gender of the students as well as by the activity performed.

Grade Level

The variability of the heart rate and the time students spent in their target heart rate zone were both significantly related to the students' grade, the activity they were engaged in, and the interaction between grade and activity. This suggests that team sport activities and individual activities promote different types of physical activity responses (i.e., SDHR, HR Zone) based on the students' grade level.

Students at the elementary level had the highest MNHR values and the most variability in their heart rate patterns. This intermittent participation pattern is characteristic of almost all children (McKenzie, 2001; National Association for Sport and Physical Education, 1995). The high MNHR for elementary students may be influenced by growth and maturation, since children's resting heart rate gradually decreases as they get older. Average rates for ages 6–10, 10–14, and 14–18 are 95, 85, and 82, respectively (Gabbard, 1996). Interestingly, elementary students and high school students spent more time in their target heart rate zone than did middle/junior high students.

Adolescence puts youth at risk for decreased physical activity, with girls reducing their activity by approximately 7.4% and boys by 2.7% (Sallis, 1993). Studies of physical activity in middle school physical education programs have shown as little as 16% of class time spent in MVPA (Simons-Morton, Taylor, Snider, Huang, & Fulton, 1994). Participation in physical education becomes increasingly important to students as they move from elementary to middle school, as it accounts for a higher percentage of their total accrued physical activity, especially for girls (McKenzie, 2001).

High school students may be more active than middle school/junior high students because they are given more choices. For example, they are often allowed to select a physical education class of interest, rather than all students at a certain grade level participating in the same physical education class; this promotes higher levels of student interest and participation (Corbin, 1998). Pangrazi and Corbin (2000) showed that high school students who completed a health-based physical education program were more likely to meet the national health goals several years after taking the course than students in traditional physical education classes.

Gender

Gender alone (i.e., mean effect) did not contribute to the observed differences in student heart rate measures. There was an interaction, however, among gender, grade, and activity contributing to the differences in students' MNHR. Activity levels varied depending on gender, grade level, and whether the students had participated in team sports or individual activities in physical education classes. For example, girls at the elementary level participating in team sports had a high MNHR (i.e., 142.24 bpm), while girls at the secondary level participating in team sports had a relatively low MNHR (i.e., 133.77 bpm). The results of this study suggest that gender influences on mean heart rate vary according to the grade of the student and the activity performed.

McKenzie et al. (2000a) also found a significant gender-by-context interaction in energy expenditure for middle school students. Boys were very active in fitness and free-play activity contexts whereas girls, while also very active during fitness activities, were less active during free play, game play, skill drills and management.

Activity

Secondary students participating in team sports spent the most time in their HR Zone. Perhaps more teachers are structuring team sport activities (e.g., small group activities and modified rules) in order to maximize physical activity and skill practice. Other researchers have also shown that students participating in team sport activities have higher mean heart rates (Klausen et al., 1986) and MVPA (Stratton, 1997) than those participating in other types of activities. The next most active group (i.e., time in HR Zone) was elementary students participating in individual activities. This finding suggests it is important to consider the grade and the activity when making decisions about the physical education curriculum.

There are many factors that influence the physical activity participation of students in physical education programs, including the teaching method (McKenzie & Sallis, 1996) and the nature of the activity (Rowe, Schuldheisz, & van der Mars, 1997). This study also investigated the influence of the nature of the activity on students' heart rate patterns. The results of the supplemental analysis comparing the mean heart rates for the 13 activities indicated there were differences in physical activity patterns among students participating in these various activities in physical education classes. The MNHR was the highest for elementary games and hula-hoop. Fitness and several team sport activities followed, with moderately high mean heart rates. Hannon and Pellett (1998) reported similar findings, with students participating in team sports and fitness activities spending at least 20 minutes in a moderate heart rate training zone. McKenzie et al. (2000a) also reported that fitness activities generated the highest activity levels.

The amount of physical activity experienced by children in physical education classes has rarely been systematically and objectively assessed using heart rate telemetry. Most studies have used small homogeneous (e.g., Caucasian) samples. For example, Hannon and Pellett (1998) used one class, and the majority of researchers have used fewer than 150 participants. Thus there is a need for studies involving larger samples from different school settings. In addition, a number of the earlier studies used heart rate monitors with restricted electrodes or accelerometers (Faulkner et al., 1963; Gilliam, Freedson, Geenen, & Shahraray, 1981) that may not be as valid or reliable as monitors with chest electrodes (ACSM, 2000; Freedson, 1991).

Monitoring heart rate is an important measurement tool in health and physical education research. Previous research has revealed the potential benefits of using heart rate monitoring to assess longitudinal physical activity patterns in physical education (Strand & Reeder, 1993b). Some other countries such as China have utilized heart rate to determine the quality of school physical education. Indeed, MNHR, SDHR, and HR Zone are accurate indices for estimating cardiovascular impact and monitoring physical activity participation patterns in school physical education programs.

Limitations

One limitation of this study is that heart rate data were only collected on one day for each participant. This also limited the number of classes representing various groups, such as secondary school girls participating in team sports. However, this research design did allow the research team to study a large number of stu-

dents from different school settings. The cross-sectional nature of this work, the wide range of activities, and the variability among students' heart rates also suggest caution in making generalizations about the results. Another limitation of this study was the use of heart rate as an indirect estimate of physical activity; heart rate can also be influenced by other factors such as emotional stress and body position. It is accepted, however, that heart rate provides an adequate indication of the relative stress placed on the cardiorespiratory system from physical activity participation (Rowlands et al., 1997).

Conclusions

In summary, this is one of the first large-scale ($N = 505$) efforts to investigate heart rate patterns during physical education classes. The finding, that on average 51% of class time was spent with students participating in their target heart rate zone, was very encouraging. Findings also suggest that in order to help promote physically active classes, teachers need to consider the grade level and gender when determining the content of physical education lessons. In particular, at the secondary level, girls may be more active in individual activities while boys may be more active during team sports.

Further research in school physical education programs is needed to delineate the effects of different factors and types of classes on the students' mean and peak heart rates (Stratton, 1997). Additional large-scale studies are also needed that document the heart rate patterns of large and diverse groups over longer periods of time.

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