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CARDIOVASCULAR STRAIN IMPOSED BY PHYSICAL EDUCATION CLASSES CONSIDERING DIFFERENT CONTEXT VARIABLES

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Abstract:
Physical education (PE) classes provide a unique opportunity for a practice of regular physical activity (PA) to a significant parcel of the population that isn't sufficiently active. The curriculum of this discipline aims, among other goals, the development of cardiovascular capacity and there is an international calling to raise physical activity levels during these classes. However, there aren't regular objective assessments that allow determining the level of achievement of those goals. Thus, the aim of this study was to characterize cardiovascular strain during PE classes and its variation according to the level of education, gender and type of exercises. Method: 159 heart rate (HR) recordings of 24 male and 24 female Portuguese students of the basic level of education were assessed during 3 weeks. We observed that students spent only 32.1% of classes' time in moderate-to-vigorous activity (MVPA). Students of first level of education spend less time in MVPA ($p<.01$). Boys presented a higher percentage of time in VPA than girls ($p=.02$). In small-sided games students showed a higher relative percentage of classes' time in VPA compared to analytical exercises ($p=.003$). Given the cardiovascular strain presented in this study, PE classes have only a small contribution towards the international recommendations of weekly MVPA for children (420 minutes).

Keywords: physical activity levels, physical education classes, cardiovascular strain, heart rate, small-sided games, analytical exercises

1. Introduction

In the literature are presented multiple benefits derived from regular physical activity (PA). It is mentioned that PA contributes to the improvement of the cardiovascular capacity, physical fitness and bone health in children and youth (Hallal, Victora, Azevedo, & Wells, 2006; Strong, et al., 2005). It also represents an important role in the combat to several chronic diseases, namely hypertension, diabetes, cancer, obesity,

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osteoporosis and premature death (Warburton, Nicol, & Bredin, 2006). Thus, PA it`s a behavior that might contribute to the improvement of the quality of live (Sallis & Patrick, 1994).

However, a considerable number of children and youth, at least 50%, doesn`t seem to be active enough to obtain health benefits from PA (Biddle, et al., 2004). According to Mota (1997), the evolution of the modern society contributes to that, and stresses that its transformation represents an invite to physical inactivity. Therefore, physical education (PE) might have an important role in our society, since this discipline provides an unique and regular opportunity for regular PA (Fairclough & Stratton, 2005). Portuguese national program of the discipline contemplates the development of physical fitness, namely the cardiovascular strain as one of its purposes (Ministério da Educação, 2001). Stratton (1997) points out that, given the importance that might have in public health, it is important that PA levels are measured objectively during PE classes. Despite that, over the last decades, very few objective assessments have been made that allow to analyze the level of achievement of this goal in portuguese reality. The studies performed in this subject (Marmeleira, Aldeias, & Graça, 2008; Mota, 1994; Wang, Pereira, & Mota, 2005), only investigated one year of scholarship and none studied the first level of education, neither studied two or more levels simultaneously.

Thus, the present investigation aims to bring some new data regarding the gaps mentioned previously and its objectives are: 1) to determine students` cardiovascular strain during PE and 2) to describe its variation according different variables like the level of education, gender and type of exercise (small-sided games vs analytical exercises).

2. Material and Methods

2.1 Design

Classes from the first (1-4th year), second (5 and 6th year) and third (7 to 9th year) levels of education were selected, aiming to describe the PA levels from first to the ninth year of Portuguese education.

Two years of scholarship were selected from the first level of education due to curriculum differences. The first and second years curriculum present manipulation and balance exercises while the third and fourth year contemplate the initiation to collective sports.

On the third level of education was also selected two years of scholarship, since it`s a relative long time period and because it is a stage that literature states to be a time where are variations on PA levels (Gao, Hannon, & Carson, 2009), namely its decrease (Stratton, 1997).

It is important to point out that the classes investigated on the first level of education were of Physical Activity and Sports, inserted in the Activities of Curricular

Enrichment, which are not mandatory, but lecture by a standard PE teacher. During this article, Physical Activity and Sports classes will be also called of PE.

This investigation occurred during the second school period, in 2011, during 9 weeks. A total of 39 classes were observed, where collective sports were taught, with the exception of the second year of the scholarship, since this activities aren`t presented in the curriculum of the discipline. In which each class, 3 boys and 3 girls were previously selected to wear heart rate telemeters.

This study was subject of consent by the City Hall, school`s board and children`s parents.

2.2 Participants

48 students from the first (6-10 years of age), second (10-12 years of age) and third (12-15 years of age) level of education participated in this study.

Table 1: Participants` characterization

Level of education	Gender	Age $\bar{x} \pm Dp$	Weight $\bar{x} \pm Dp$	Height $\bar{x} \pm Dp$	BMI $\bar{x} \pm Dp$	Max. HR $\bar{x} \pm Dp$	Rest. HR $\bar{x} \pm Dp$
First	B	7.7 ± 0.78	31.6 ± 6.47	1.3 ± 0.07	16.6 ± 3.47	202.6 ± 0.54	90.3 ± 10.58
	G	7.7 ± 0.78	33.3 ± 7.95	1.3 ± 0.06	17-2 ± 4.89	202.6 ± 0.54	84.2 ± 13.21
	n	7.7 ± 0.76	32.5 ± 7.14	1.3 ± 0.07	16.9 ± 4.16	202.6 ± 0.53	87.2 ± 12.11
Second	B	11.2 ± 0.41	54.2 ± 5.74	1.6 ± 0.05	21.5 ± 1.75	195.7 ± 12.52	70.7 ± 12.04
	G	11.2 ± 0.41	47.8 ± 7.23	1.5 ± 0.05	20.1 ± 3.39	198.7 ± 10.63	79.5 ± 4.51
	n	11.2 ± 0.39	50.9 ± 7.26	1.6 ± 0.05	20.8 ± 2.68	197.2 ± 11.18	75.1 ± 9.8
Third	B	13.3 ± 1.51	50.7 ± 12.78	1.6 ± 0.12	20.0 ± 3.72	196.7 ± 10.27	66.0 ± 8.25
	G	13.1 ± 1.21	46.57 ± 7.28	1.5 ± 0.07	19.9 ± 1.77	202.4 ± 7.81	76-1 ± 15.93
	n	13.2 ± 1.30	48.5 ± 9.95	1.6 ± 0.09	19.9 ± 2.71	199.8 ± 9.13	71.5 ± 13.53
Total	M	9.9 ± 2.63	42 ± 13.32	1.5 ± 0.16	18.7 ± 3.78	199.4 ± 8.26	79.3 ± 15.10
	F	10.0 ± 2.57	40.5 ± 10.19	1.4 ± 0.12	18.7 ± 4.03	201.6 ± 6.47	80.8 ± 12.65
	n	10 ± 2.57	41.2 ± 11.73	1.4 ± 0.14	18.7 ± 3.87	200.5 ± 7.40	80.1 ± 13.78

2.3 Procedures

2.3.1 Cardiovascular strain

Students' HR, which was recorded every 5 seconds, was continuously monitored by portable heart rate telemeters *Polar Team System (Polar Electro Oy, Kempele, Finland*).

Before the beginning of each class, under supervision and help of the investigator, students putted their respective HR telemeters, which had been previously assigned.

HR telemeters and investigator`s clocks were previously synchronized.

2.3.2 Maximal HR

Students from the first level of education were considered too young to be submitted to a maximal protocol of exertion. Thus, their maximal heart rate (MHR) was defined by the formula 208 – 0.7(age), which can closely predicted children MHR in children (Mahon, Marjerrison, Lee, Woodruff, & Hanna, 2010).

For students in second and third level of education, MHR was determined through *Yo-Yo Intermittent Recovery Test.* According to Bangsbo, Iaia, & Krustrup (2008), this is a more suitable field test to less trained individuals and that allows to determine rapidly their MHR.

2.3.3 Resting HR

Resting heart rate (RHR) was determine through the procedures described by Fairclough and Stratton (2005b).

2.3.4 HR data analysis

The different levels of intensity were defined through the method of heart rate reserve (HRR), since this method contemplates age and sex differences and might be the best method to determine thresholds related to health and fitness in children (Stratton, 1996).

Three levels of intensity were considered: bellow MVPA, moderate PA (MPA) and VPA.

To determine the intensity of MPA the following formula was used: (MHR–RHR)*50%+Resting HR. According to Stratton (1996), 50-75% of the heart reserve represents the intensity of MPA. VPA was considered to values of 75% or higher of heart rate reserve (Fairclough & Stratton, 2005), which represents an intensity that might stimulate improvements on the cardiovascular system (Morrow & Freedson, 1994).

The number of minutes spent in each level of intensity was divided by the total time of the class, in order to determine the percentage of the lesson time spent in intensities bellow MVPA, MPA and VPA.

2.4 Statistical analysis

Statistical analysis was performed by SPSS (*Statistical Package for the Social Sciences*) – version 17.0 for *Microsoft Windows*, and relative frequencies, means and standard deviations were determined.

In order to determine differences, regarding the cardiovascular strain, by gender and type of activity was used the independent t-test. It was also used to investigate gender differences concerning the perceived exertion. To determine differences, regarding cardiovascular strain and perceived exertion, by the level of education was used ANOVA with repeated measure, being the multiple comparisons made by the *Bonferroni post hoc test*. Person`s correlation was used to analyze the correlation between HR and perceived exertion data. In every test, significance level was set at $p<.05$.

3. Results

3.1 Students` cardiovascular strain during PE

Children investigated spent less than 50% of effective class time in MVPA.

Table 2: Percentage of the effective time spent in each level of intensity defined, and mean and relative heart rate during PE classes

	Bellow MVPA	MPA	VPA	Mean HR	Relative HR
% of effective class time	47.4 ± 23.07 (3.3-100)	32.1 ± 15.41 (0-62.7)	20.5 ± 18.57 (0-83.5)	143.9 ± 16.22 (93-183)	71.8 ± 8.37 (45.8-91.2)

3.2 PE contribution for international recommendations of PA

PE classes contributed, on weekly basis, with 64.5 minutes of MVPA, which represents only 15.4% of PA recommended for children – 420 minutes (U. S. Department of Health and Human Services, 2008).

Table 3: PE classes contribution for the international recommendations of PA for children

Class duration	PE class (minutes)	PE contribution for international recommendations (%)
	MVPA	MVPA
45 minutes	16.6	3.9%
90 minutes	47.9	11.4%
Total (per week)	64.5	15.4%

3.3 Analyses through level of education

Students of the third level of education spent lower periods in intensities bellow MVPA compared to students of the first (p<.001) and second (p=.001) levels of education. Regarding the time spent in MPA, children on first level of education spent a lower time fraction compared to students of the second (p<.001) and third (p<.001) levels of education. Students on the third level of education spent higher percentage of time in VPA compared to the second (p<.001) and first (p=.013) levels of education.

Table 4: Percentage of effective class time spent in each level of intensity, and mean and relative heart rate during PE classes of the levels of education investigated

Level	N	Bellow MVPA	MPA	VPA	Mean HR	Relative HR (%)
1rst	70	57.6 ± 22.11	22.4 ± 11.18	19.9 ± 17.56	143.0 ± 17.99	70.6 ± 8.92
2nd	39	48.5 ± 21.18	41.1 ± 14.47	10.5 ± 10.47	138.0 ± 12.06	69.6 ± 6.53
3rd	50	32.2 ± 17.15	38.6 ± 13.62	29.2 ± 20.76	149.9 ± 14.64	75.3 ± 7.88
F		22.6	36.0	12.8	6.6	6.9
p		.000[1]	.000[1]	.000[1;2]	.002[1]	.001[1]

[1]Differences between third level and others (p<.001)
[2]Differences between the first level and others (p<.019)

3.4 Analysis by gender

Boys spent a higher percentage of class time in VPA compared to girls (p=.020).

Table 5: Gender differences regarding the percentage of effective class time spent in each level of intensity, and mean heart rate and relative heart rate during PE classes

Gender	Bellow MVPA	MPA	VPA	Mean HR	Relative HR (%)
Boys	45.8 ± 25.19	30.5 ± 15.16	23.8 ± 21.07	144.3 ± 18.66	72.1 ± 9.38
Girls	49.2 ± 20.43	33.9 ± 15.59	16.9 ± 14.61	143.6 ± 13.08	71.5 ± 7.11
t	-.935	-1.381	2.353	.264	.517
p	.351	.169	.020	.792	.606

3.5 Type of exercise

Children spent a higher percentage of effective class time in VPA during small-sided games compared to analytical exercises.

Table 6: Type of exercise differences regarding the percentage of effective class time spent in each level of intensity, and mean and relative heart rate during PE classes

	Analytical exercises	Small-sided games	t	p
Absolute time (min)	**8.56**	**19.26**		
Relative time (%)	**15**	**41**		
Bellow MVPA	32.0 ± 32.53	26.1 ± 26.11	1.264	.208
MPA	49.4 ± 27.59	41.6 ± 24.32	1.857	.065
VPA	18.6 ± 22.61	32.4 ± 31.23	-2.936	**.004**
Mean HR	145.7 ± 21.48	155.3 ± 18.94	-2.924	**.004**
Relative HR	73.1 ± 10.95	77.7 ± 9.58	-2.809	**.006**

4. Discussion

In this study was verified that students from the first, second and third level of education investigated spent, on average, 32.1% of effective class time in MVPA. Thus, it can be affirm that international recommendations for PE classes, that suggest that students should spent at least 50% of class time in MVPA in order to increase physical activity among children and youth, wasn't accomplished (Lowry, Lee, Fulton, & Kann, 2009; Prevention, 2010). The data founded is similar to most studies in this area (Fairclough, 2003; Fairclough & Stratton, 2005; Klausen, et al., 1986; Macfarlane & Kwong, 2003; B. Strand & S. Reeder, 1993; Holli, et al., 2017) and differs to the studies conducted by Kulinna et al. (2003), Gao et al. (2009) and Raudsepp and Pall (1998). Our results are more alarming if we consider the methodological options adopted during this investigation. It was privileged classes were team sports were taught. Since this type of sports are presented as the kind of activities more propitious to higher periods of MVPA (Fairclough & Stratton, 2005; Stratton, 1997; Stratton, 1996; Klausen et. al, 2007; Strand & Reeder, 1993; Fairclough, 2004), higher MVPA values were expected. Nevertheless, it is important to stress that HR is an indirect measure of PA and that can be influenced by temperature, motivation, stress, among other factors, that weren't controlled during this investigation.

PE classes contributed with 41.82 minutes of MVPA per week, on the second and third level of education, which represents only 9.96% of the weekly MVPA

recommended for children – 420 minutes, considering that most of the portuguese schools have, on weekly basis, 135 minutes of this discipline. Thus, keeping in mind the international recommendations for children and youth (Lowry et. al, 2009), it can be concluded that PE has a limited contribution for the maintenance and improvement of students health. These results are especially concerning regarding the first level, mainly because the effective class time was only 62% of the total possible time. That highlights the need for proper planning and execution of managerial tasks, which has being pointed as possible motive for low MVPA during PA (Wallhead, 2006; Armstrong, 1998).

Through analyses by the level of education, it was verified that students of the first level of education spent more than 50% of effective class time in intensities bellow MVPA. While, the data found in literature stresses that the levels of PA tends to decrease through the age (Armstrong, 1998; Biddle, et al., 2004), in this study was found that the time spent in intensities bellow MVPA during PE decreased through age and levels of education. Since primary schoolchildren tend to be more active in school days than in non-school days (Gavarry et al., 2003), and that they engage in PA most of the time of school recess (Beighle et al., 2006), it can be supposed that are variables specially related to the context of PE classes that result in lower periods of MVPA in the first level of education. Those variables can be related with class environment, students` characteristics, discipline`s program and the available material conditions. One of the teachers` obligations is to plan his classes, and therefore, each class should be a planned and organized session of PE. That might restrict students PA levels, since it is suggested that children are capable of participating in higher periods of MVPA in non-organized situations (Pate et al., 1996). On the other hand, the program of the discipline for the first level of education might be another factor, since it doesn't contemplate activities that aren't very favorable to a higher cardiovascular strain like manipulation, balance and coordination exercises, and gymnastics that has been point as the activity in which students present the lowest HR values (Marmeleira, et al., 2008; G. Stratton, 1996). Finally, several studies have pointed out the lack of material resources as one of the biggest limitations of the discipline on the first level of education (Brandão, 2010; Silveira, 2007). Thus, the material recourses might have conditioned PA levels detected.

Boys spent a higher percentage of effective class time in VPA than girls. This data is similar to other studies (Fairclough & Stratton, 2005b; Gavarry, et al., 2003; Tanaka, et al., 2018) and it might be due to the fact of girls do not considered PE as part of the curriculum and their difficulties in overly exert themselves during the classes (Fairclough & Stratton, 2005b). Additionally, since students are more active during their favorite activities (Wang, et al., 2005), boys prefer collective sports (Evans, 1986) and girls present higher HR during individual sports (Kulinna, et al., 2003), might justify the data found, since during this investigation, classes were collective sports were taught were privileged.

Results showed that students spent a higher percentage of effective class time in VPA during small-sided games than analytical exercises. In both situations, children

spent more than 50% of effective class time in MVPA, data similar to study conducted by Arnett and Lutz (2003), although it was only related to small-sided games. To the best of our knowledge, this is the first study that analyses the differences between small-sided games and analytical exercises regarding the cardiovascular strain. Further studies should address this subject, and, if possible, contemplate more information related to variables as field dimension, number of students, teacher incentive, since those contribute for HR variation during small-sided games in a training context (Hill-Haas, Coutts, Dawson, & Rowsell, 2010; Rampinini, et al., 2007), and eventually, analytical exercises as well. Psychological variables, such as enjoyment of PE classes and the modality practiced should also be taken in account.

5. Conclusions

The data from this study showed that students did not achieved the international recommendations that calls for at least 50% of classes' time in MVPA. Students of first level of education spend less time in MVPA compared to the second and third levels. Boys showed a higher percentage of time in VPA than girls. Small-sided games are more effective than analytical situations to promote higher percentage of time in VPA.

Competing Interest
The author declares no competing interests.

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