MENTAL LOAD AND ITS COMPENSATION BY PHYSICAL ACTIVITY IN ADOLESCENTS AT SECONDARY SCHOOLS

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SUMMARY

Aim: Sedentary behaviour and increasing mental load in adolescents is one of the major health problems of the contemporary youth. The aim of the study is to analyze the associations between mental load and physical activity (PA) in adolescents in school-day segments.

Methods: 381 adolescents (120 boys, 261girls) took part in the research which was conducted in 19 secondary schools in the Czech Republic. Participants throughout the whole day (1–3 days) wore an ActiTrainer accelerometer that monitors PA and heart rate (HR). The reports covered 727 school days. The participants were divided into two groups with lower and higher mental load.

Results: Boys and girls with higher mental load in lessons do not compensate this load in neither volume nor intensity of PA during recess in greater amount than those who had lower mental load. In the individual school-day segments (apart from the time before school) no significant differences between the groups were found.

Conclusion: When creating a habit of immediate compensation for mental load in lessons by PA, it is necessary to pay attention to boys and girls with higher mental load in lessons. The adoption of the habit should be supported by adequate physical literacy of both students and teachers and by changes in the school programme.

Key words: school physical activity, physical education, recess, health education, recommendation

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INTRODUCTION

Effective health education of students is one of the great challenges of secondary education. It includes acquiring a sufficient level of physical literacy in adolescents, healthy lifestyle in relation to physical activity (PA), and also support of their health-related fitness (1–4). Schools should strive to ensure that each student experiences a sense of satisfaction from PA, to support objective awareness of their own lifestyles and to promote adopting such habits which are necessary for the realisation of daily, weekly, seasonal, annual, and potentially lifelong PA. It is an imperative that school administrators as well as teachers and students engage in a joint quest for the best ways of effective compensation for school sedentary behaviour of both students and teachers. Meeting such difficult tasks relies heavily on support from the state, general health and school health policies, appropriate social, communal and family support as well as on developing consistent solutions to problems related to adolescents' risk behaviour (5–11).

School mental load should be primarily compensated with school recesses and physical activity lessons (PELs) which are absolutely crucial in terms of school PA of students (12–14). On a daily basis, mental load is compensated by leisure time activities performed after school; on a weekly basis, mental load is compensated by weekend activities; and on a yearly basis by one-day and more-day physically oriented activities and by a system of vacation days (15, 16). The compensation of students' mental load in school cannot be provided solely by PELs and during students' leisure time outside school time. The schools cannot refuse their responsibility to ensure immediate compensation for mental load and to instil in students the habit to react immediately to mental load by adequate compensation activities. School PA has the primary role in compensations for mental load of students and it can be more easily monitored than other types of compensation.

In central Europe, the same form of educational process organisation in secondary schools has been in place for a long period of time and therefore it does not adequately address the ongoing negative effects on health and trends among the younger generation (17). We are also aware of the fact that during school hours, boys and girls have fewer recesses in sedentary time than during any other period of weekday or weekend (18). Therefore, the worldwide attention is focused on the role of recesses and increasing number of PELs in school. The positive effects of school recesses for increase in daily PA is well documented particularly in children (13, 14, 19–21). Fewer studies have been conducted in regards to the role of recesses in adolescents at secondary schools (22, 23). The information about the type and intensity of PA during recesses is also insufficient (13, 24). Studies addressing the relationship between the type of lesson and the subsequent recess in terms of compensation for mental load in adolescents are also lacking. Positive influence of good indoor and outdoor school facilities on physical activity recesses as well as on dealing with high obesity and low PA levels among secondary school students has been proven (22, 25).

Therefore, the objective of the study was to determine the association between physical inactivity, mental load and physical activity of boys and girls in time segments spent in school and in the whole school day. Furthermore, the purpose of the study was to propose a set of recommendations in order to improve school lifestyle of adolescents.

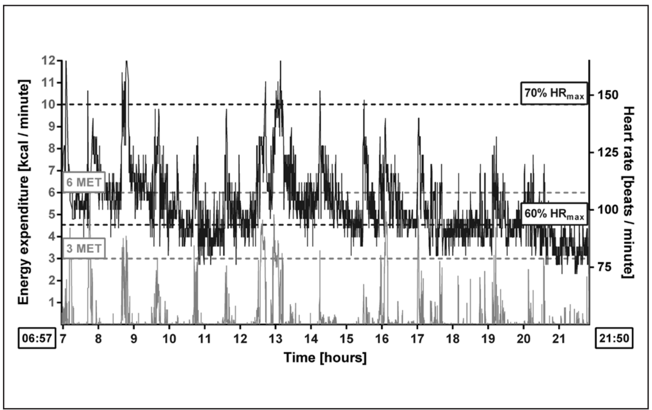

Fig. 1. Example of data provided on the course of monitoring a 17 year old girl during a school day.

MATERIALS AND METHODS

Participants

The research was conducted in 2012–2013, in 19 secondary schools in the Czech Republic and at the places of residence of students practicing PE. In total 120 boys and 261 girls participated in the research (Table 1). More than 90% of students and their parents agreed with the research in each class. When processing data, 133 participants were excluded from the study due to incomplete records of whole-day PA. Participants were divided according to the amount of mental load into groups with lower and higher mental load in individual lessons or in sum for the period of four lessons. Participants with higher mental load (HML) did not reach the level of 3 metabolic equivalents (METs) during the monitoring of PA in individual lessons; however, during heart rate (HR) monitoring they overcame the load limit at 60% HRmax. In participants with lower mental load (LML), no differences between the intensity of PA and HR values were recorded.

Procedure

The ActiTrainer^{TM} accelerometer, Florida, USA was used to monitor PA. This accelerometer enables to monitor both PA (counts) and HR (beats per minute) at the same time using a single device. Participants from each school were given information regarding the course of research by the same research team at the introductory meeting. They were provided with the information related to the principles of monitoring, the way of wearing and removing the device, the measuring process of HR, and the way of completing the supplementary records (time period of a day, time record of each segment of a day and PA type). Data regarding the age, height and weight were taken from current school documentation. Participants were also familiarised with the procedure for measuring heart rate at rest in the morning immediately after waking up. Three individual readings of HR (3 times repeatedly) were averaged. The average value was subjected to continuous checking and adjusted if necessary according to the lowest reading of HR taken in a day by the ActiTrainer device.

Participants received individual results of daily PA monitoring (time records of PA and inactivity, load in METs and HR ranges, energy expenditure, HR records and step count) within two weeks from the completion of research (example of a part from individual feedback is shown in Fig. 1).

Monitoring and Data Processing

Throughout the day the participants recorded time periods to recording sheets: before school, during school time in accordance with the timetable and recess periods, after school and for the whole day. Apart from time characteristics, the participants also recorded types of physical activities and inactivity/sitting/lying (television, computer, in school, commuting, culture/spectatorship). For the purposes of data processing (15 sec interval records), a specially designed software program IntPA13 was employed. The program processes data of PA and inactivity duration in minutes. The level of PA intensity was determined according to HR from 30 to 100% of HRmax in 10 percent increments and in METs in 1 MET increment. To identify the HR ranges, we applied a universal formula to calculate maximum HR (for boys, HRmax = 220 – age; for girls, HRmax = 226 – age). The load zones were classified into low (50–59.9% HRmax; <3 METs), and moderate to vigorous (≥60% HRmax; ≥3 METs). Resting metabolic rate was determined according to the following formula: ((473*weight as lb.) + (971*height as in.) – (513*age) + 4,687))/100,000 for male subjects and ((331*weight as lb.) + (352*height as in.) – (353*age) + 49,854))/100,000 for female subjects. To convert the counts values to kcals/min values and subsequently to METs values, the following formula was applied: (kcals/min = 0.0000191*counts/minute*body mass in kg). The physical inactivity cut-points were set at <25 counts per 15 seconds.

Table 1. *Sample characteristics*

Characteristics	n	Age (years)		Weight (kg)		Height (cm)		BMI ($kg \cdot m^{-2}$)		HRrest ($beats \cdot min^{-1}$)	
		M	SD	M	SD	M	SD	M	SD	M	SD
Boys	120	16.77	1.13	71.78	12.63	178.62	7.84	21.51	3.79	59.86	6.54
Girls	261	16.72	0.96	59.60	9.94	167.07	6.41	21.43	3.08	63.28	6.93

M – mean; SD – standard deviation; BMI – Body Mass Index; HRrest – resting heart rate

The results of the monitoring included participants who wore the measuring device at least 15 minutes before school, at least 180 minutes without PELs at school, at least 120 minutes after school and between 600 and 1,080 minutes during the whole day. A total of 727 school days were monitored. Data were processed separately for each lesson and the subsequent recess and also for the school time and school day in the aggregate.

Data Analysis

For statistical processing in the SPSS 22 program and Statistica 12, we used descriptive statistics, Kruskal-Wallis test, one-way ANOVA, cross tabulation tables, and also "effect size" coefficient η^2 a ω^2.

The research design and documentation received ethical approval from the Faculty of Physical Culture Ethics Committee, Palacký University in Olomouc.

RESULTS

The differences in PA during the first recess after the first lesson ($F = 3.03$; $p = 0.029$; $\omega^2 = 0.008$) between the boys with LML and HML in first lesson ($p = 0.083$) and equally between the girls ($p = 0.843$) were not statistically significant (Fig. 2). Only boys with LML reached on average ($M = 2404$ steps·hour^{-1}) more steps than girls with LML ($M = 1749$ steps·hour^{-1}), which was statistically significant ($p = 0.006$). Boys with HML were least physically active in the first recess making only 1,434 steps·hour^{-1} on average.

Also during the second recess after second lesson, the differences in PA ($F = 1.59$; $p = 0.191$; $\omega^2 = 0.002$) between boys with LML and HML in the second lesson ($p = 0.257$) and equally between girls ($p = 0.427$) were not statistically significant (Fig. 3). While boys with HML were the most physically active making 2,037 steps·hour^{-1} on average, the least physically active were girls with LML making 1,433 steps·hour^{-1}.

During the third recess, boys and girls with LML were more active than those who were more mentally loaded in the third lesson, but the differences were not statistically significant ($F = 0.81$; $p = 0.490$; $\omega^2 = 0.002$) (Fig. 4). While boys with LML were the most physically active during the third recess (1,974 steps·hour^{-1}), the least physically active were girls with HML making 1,542 steps·hour^{-1}.

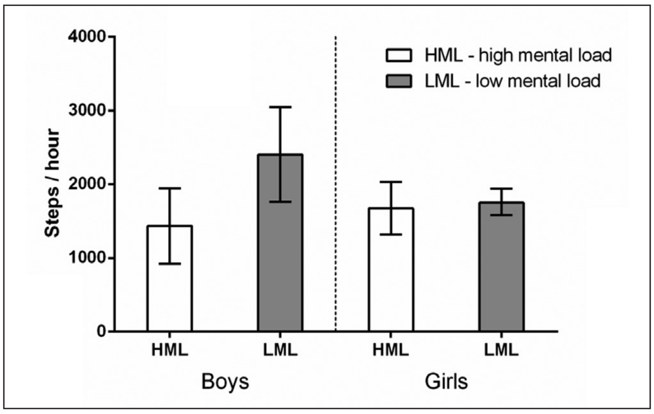

Fig. 2. Physical activity during the first recess (M ± CI steps/hour) of less and more mentally loaded boys and girls in the first lesson.

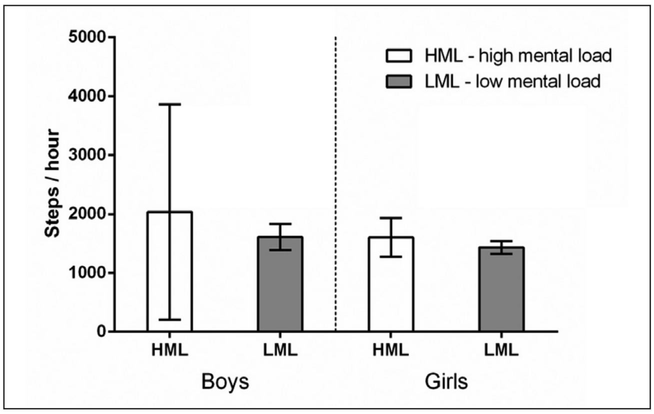

Fig. 3. Physical activity during the second recess (steps/hour) of less and more mentally loaded boys and girls in the second lesson.

The differences in PA during the fourth recess between variously mentally loaded groups in the fourth lesson were not statistically significant ($F = 2.12$; $p = 0.096$; $\omega^2 = 0.005$) (Fig. 5). Boys with LML were the most physically active during the fourth recess (2,780 steps·hour^{-1}), the least physically active were boys with HML making 1,733 steps·hour^{-1}.

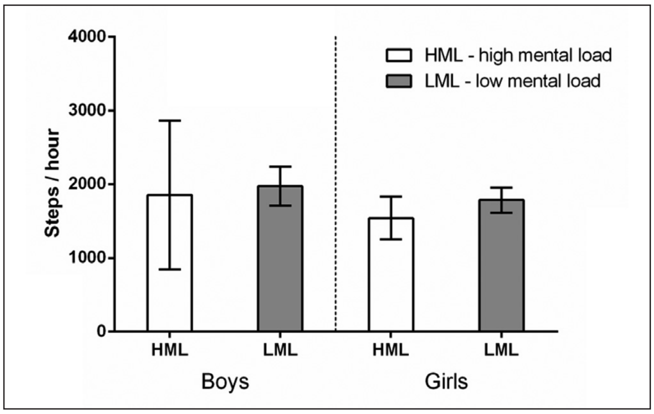

Fig. 4. Physical activity during the third recess (steps/hour) of less and more mentally loaded boys and girls in the third lesson.

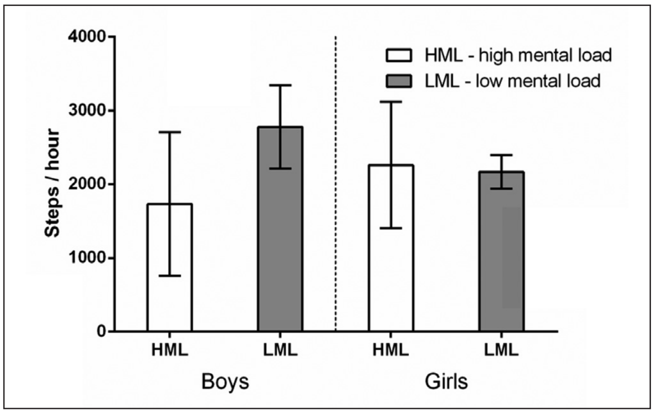

Fig. 5. Physical activity during the fourth recess (steps/hour) of less and more mentally loaded boys and girls in the fourth lesson.

In the total recess time, no significant differences in MVPA (≥3 METs min·hour^{-1}) (Table 2) were found between boys and girls with various mental load. Only boys with LML spent more time in MVPA than girls with LML (p = 0.027). However, the monitoring of HR in the zone ≥60% HRmax (min·hour^{-1}) documents significantly higher load during recesses in both genders with HML in lessons as opposed to the intensity expressed in METs.

The differences between PA in boys and girls with varying sums of mental load in individual segments of a school day document significant differences only in the time before school (Table 3). Girls with HML in lessons had significantly higher volume of PA before school than girls with LML in subsequent lessons (p = 0.003). While boys with LML made 699 steps·hour^{-1} on average in the whole day, boys with HML made only 599 steps·hour^{-1} (p = 0.009). The differences in the next segments of a school day between boys and girls with various mental loads in lessons were not statistically significant.

DISCUSSION

The results of PA monitoring during recesses have confirmed that neither boys nor girls with higher mental load in lessons have more PA during recesses than those who have lesser mental load in lessons. This finding is based on the volume of PA represented by number of steps per hour on average and on the amount of time spent in MVPA. It is therefore highly probable that boys and girls with higher mental load in lessons compensate this load with lesser amount of PA than boys and girls with lower mental load in lessons. This is further supported by the HR monitoring results. While there are non-significant differences in MVPA during recesses, boys and girls with higher mental load in lessons had significantly higher load zone of ≥60% HRmax. However, we are aware of the fact that cognitive processing and academic performance depend on regular breaks from concentrated classroom work (12). So far there have not been recommendations for compensation of mental load and PA in the literature. General recommendations for PA during recesses, addressed mainly to children, serve as guidelines for the moment, e.g. performing MVPA for 50% of the total recess time (26). The study by Mota et al. (27) shows that boys aged 8–11 spent 38% and girls 31% of recess time engaging in MVPA and a similar study by Nettlefold et al. (28) shows 20% of MVPA in boys and 28% in girls. To follow this recommendation in secondary schools is impossible for most of the students. At secondary schools, it is more adequate to follow the recommendation for adolescents – 50% of the total recess time engaging in any PA, i.e., the ratio between PI/PA is equal to 1 : 1. In the scope of our research, 51.9% of boys with LML (girls 51.0%) and 46.2% of boys with HML (girls 48.8%) would fulfil this recommendation.

Associations between mental load in lessons and recesses draw attention to the inadequate compensation for time that adolescents spend being sedentary. Besides, sedentary behaviour is significantly associated with mental health of adolescents (29). School environment should develop a programme/regime to compensate psychological load by physical load. It should also support cognitive beliefs about leading a healthy lifestyle (2). The frequency and duration of recesses should be sufficient to allow the student

Table 2. *Physical activity of boys and girls with various mental load in recess time in the aggregate*

Characteristics of MVPA	Boys				Girls				H	p-value	η²
	LML (n = 162)		HML (n = 62)		LML (n = 384)		HML (n = 129)				
	Mdn	IQR	Mdn	IQR	Mdn	IQR	Mdn	IQR			
≥3 METs (min·hour^{-1})	4.25	5.27	3.55	4.46	3.56	4.48	3.40	3.93	9.25[c]	0.026	0.013*
≥60% HRmax (min·hour^{-1})	0.00	1.71	4.00	6.40	0.70	2.50	3.60	8.13	87.79[a, b, c]	<0.001	0.121**

LML – low mental load; HML – high mental load; Mdn – median values; IQR – interquartile ranges; H – Kruskal-Wallis test; η² – coefficient effect size; *small effect size; **medium effect size; ***large effect size; [a] significant difference between groups (boys LML – boys HML); [b] (girls LML – girls HML); [c] (boys LML – girls LML); [d] (boys HML – girls HML)

Table 3. *Physical activity (steps·hour^{-1}) of boys and girls with various mental load in school days*

Characteristics of PA (steps·hour^{-1})	Boys				Girls				F	p-value	ω²
	LML (n = 162)		HML (n = 62)		LML (n = 384)		HML (n = 129)				
	M	SD	M	SD	M	SD	M	SD			
Before school	1362	871	1346	926	1312	674	1543	794	2.97[b]	0.031	0.008
Lessons	348	419	259	258	269	271	243	211	3.66[c]	0.012	0.011*
Recesses	1041	536	953	383	1055	519	1097	542	0.98	0.401	0.000
School time	484	378	391	234	424	259	422	204	2.34	0.070	0.005
After school	797	467	696	462	846	418	813	434	2.01	0.111	0.004
Whole day	699	290	599	206	708	228	692	234	3.16[a, d]	0.024	0.009

LML – low mental load; HML – high mental load; M – mean; SD – standard deviation; F – ANOVA test; ω² – coefficient effect size; * small effect size; [a] significant difference between groups (boys LML – boys HML); [b] (girls LML – girls HML); [c] (boys LML – girls LML); [d] (boys HML – girls HML) to mentally decompress (12). It is also important that outdoor facilities in secondary schools are associated with students' daily PA participation during school recesses (7). When analysing the role of recesses in school programmes, it is essential to respect the fact that recesses only supplement PE and do not substitute it and both activities support PA and healthy lifestyle (14).

In terms of health education and healthy school lifestyle, the actual habit to compensate the school mental load in school time is more important than the recently discovered relations between physical inactivity and the volume or intensity of PA. It is also very important to create various opportunities for any PA in lessons. The changes in posture, interruptions in stable positions, and any type of short physical periods are equally important to achieve a healthy school lifestyle of adolescents. Unfortunately, it is very difficult to monitor these changes in postures at the low level of PA or almost PI.

It is interesting that while there were no statistically significant differences between boys and girls in the volume of PA during recesses as per steps/hour, boys were more active than girls in MVPA,which is in line with many other studies (21, 23, 28, 30). The quest for new ways that would increase the physical activity of girls in school environment remains a priority (31, 32).

The ActiTrainer accelerometer proved to be adequate for the determined objectives of PA monitoring. The concurrent monitoring of PA and HR enabled analyses of the differences between the PA intensity in METs and PA intensity represented by HR which consequently pointed to the associations between mental load and PA. However, it is important to be aware of the fact that PA monitoring at population level using an accelerometer provides better predictions for low loads of physical activity than HR records (33).

Strengths and Limitations

The strength of the study lies in monitoring both the heart rate and PA by a single device – ActiTrainer, which allows more objective assessment of PA intensity and the comparison of load represented in HR, step counts and METs. Another strength may be found in the highest number of monitoring days of whole-day HR and PA in adolescents in natural school conditions without interventions into the school programme. The strong point of the study is also the reference to the importance of PA during lessons and development of habit of immediate compensation for mental load and sedentary behaviour.

The limitation of the study is that the subjective reasons for increased HR in individual lessons were not documented because of the difficulty in monitoring HR and recording time data. In the scope of this study mental load of students was derived from increased level of HR in periods of time without increased level of PA measured by the accelerometer. Nevertheless, we are aware of the fact that HR may be also increased by other effects (e.g. emotional). It was also impossible to consider the impact of fitness on the variability in HR.

CONCLUSIONS

The most mentally loaded students in lessons do not compensate for this load during recesses with PA more than less mentally loaded students. When developing habit of immediate compensation for mental load in lessons by PA during subsequent recesses, it is important to pay attention to boys and girls with higher mental load. It is necessary to support the process of adopting the habit by sufficient physical literacy of students as well as teachers and by changes in the school programme. Recommendations for schools:

- Creating space and material conditions for physically active recesses for all students.
- Offering extended physically active recesses as a flexible response to pre-planned lessons with higher mental load in students.
- Ensuring that majority of students engage in PA for at least 50% of recess time.
- In terms of the volume of PA, ensuring minimal amount of 250 steps/10-minute recess or 500 steps/20-minute recess.
- Not to shorten recesses in the school programme but to promote reducing the duration of the last lessons.
- Not to transfer the compensation for mental load of students in school solely to the PE lessons and extracurricular school programme.

These recommendations should trigger planning for changes in the traditional organisation of school education and supporting healthy and active school lifestyle of adolescents and teachers as well.

Acknowledgement

The research was supported by the Czech Science Foundation – research project "Objectification of comprehensive monitoring of school mental and physical strain in adolescents in the context of physical and mental condition" (No. GA13-32935S).

Conflict of Interest

None declared

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Received November 14, 2014
Accepted in revised form August 14, 2015