

PUBLIC HEALTH

DEFINING THE PHYSICAL ACTIVITY ENVIRONMENT IN PRIMARY SCHOOLS ACROSS NORTH MACEDONIA: COSI STUDY

Katerina Mihajlova¹, Lorraine Silver Wallace², Aleksandra Stamenova³, Igor Spiroski⁴¹ Ss. Cyril and Methodius University in Skopje, Faculty of Medicine, Public Health Doctoral Studies, North Macedonia² The Ohio State University; College of Medicine, Columbus, Ohio, USA³ Faculty of Medicine, Department of Social Medicine, Ss. Cyril and Methodius University in Skopje, North Macedonia⁴ Institute of Public Health of the Republic of North Macedonia; Ss. Cyril and Methodius University in Skopje, Faculty of Medicine, North Macedonia

Abstract

Citation: Mihajlova K, Wallace LS, Stamenova A, Spiroski I. Defining the physical activity environment in primary school across North Macedonia: COSI Study. North Macedonia. Arch Pub Health 2025; 17 (1) 5-13.

doi.org/10.3889/aph.2025.6125

Key words: primary schools, children, physical activity, physical activity environment, COSI

***Correspondence:** Katerina Mihajlova, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje; Public Health Doctoral Studies, Republic of North Macedonia

E-mail: kkovachovska@gmail.com

Received: 6-Aug-2024; **Revised:** 30-Dec-2024;**Accepted:** 15-Jan-2025; **Published:** 27-Jun-2025

Copyright: © 2025. Katerina Mihajlova, Lorraine Silver Wallace, Aleksandra Stamenova, Igor Spiroski. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

Competing Interests: The author have declared that no competing interests

Encouraging children to engage in physical activity (PA) is crucial for their overall development. The school environment can play a significant role in shaping children's PA habits, which in turn can positively impact their overall health and wellbeing. The aim of this study was to describe characteristics of the PA environment in primary schools across North Macedonia using data from the World Health Organization's European Childhood Obesity Surveillance Initiative (COSI)–6th round. Materials and Methods: A primary school representative (n=111) responded to questions regarding the PA environment, which included questions about having outdoor and indoor playgrounds and gymnasiums, using of outdoor playgrounds outside of the school hours and during unfavorable weather conditions and organizing PA in and outside of the school hours. Descriptive statistics were conducted to depict the PA environment in primary schools across North Macedonia. Results: Most primary schools had an outdoor playground (94.6%), provided ≥2 hours per week of physical education lessons (89.2%), and had an indoor gymnasium (83.8%). However, smaller primary schools (≤29 pupils) were significantly less likely to have an indoor gymnasium. Approximately half of the primary schools (48.5%) offered organized sport/physical activities ≥1 time per week outside of school hours. Outside of school hours, most primary schools permitted the use of outdoor play areas (77.1%). Conclusion: In conclusion, while the overall PA environments were positive, all Macedonian primary schools did not possess adequate recreational facilities and space for students to be engaged in regular PA. Thus, there is a pressing need for collaborative efforts among schools, local and national authorities to address this issue effectively, aiming to combat childhood obesity and promote increased PA among young students.

ЈАВНО ЗДРАВЈЕ

ДЕФИНИРАЊЕ НА ОКОЛИНАТА ЗА ФИЗИЧКА АКТИВНОСТ ВО ОСНОВНИТЕ УЧИЛИШТА ВО СЕВЕРНА МАКЕДОНИЈА – COSI СТУДИЈА

Катерина Михајлова¹, Лорејн Силвер Волис², Александра Стаменова³, Игор Спироски⁴¹ Универзитет „Св. Кирил и Методиј“ во Скопје, Медицински факултет, Докторски студии по јавно здравство, Северна Македонија² Државен универзитет во Охајо, Колеџ на медицина, Колумбус, Охајо, САД³ Медицински факултет, Катедра по социјална медицина, Универзитет „Св. Кирил и Методиј“ во Скопје, Северна Македонија⁴ Институт за јавно здравје на Република Северна Македонија, Медицински факултет, Универзитет „Св. Кирил и Методиј“ во Скопје, Северна Македонија

Извадок

Цитирање: Михајлова К, Волис СЛ, Стаменова А, Спироски И. Дефинирање на околината за физичка активности во основните училишта во Северна Македонија. Арх Ј Здравје 2025; 17 (1), 5-13.

doi.org/10.3889/aph.2025.6125

Клучни зборови: основни училишта, деца, физичка активност, средина за физичка активност, COSI

***Кореспонденција:** Катерина Михајловска, Медицински факултет, Универзитет „Св. Кирил и Методиј“ во Скопје, Република Северна Македонија. E-mail: kkovachovska@gmail.com

Примено: 6-авг-2024; **Ревизирано:** 30-дек-2024; **Прифатено:** 15-јан-2025; **Објавено:** 27-јуни-2025

Печатарски права: ©2025. Катерина Михајлова, Лорејн Силвер Волис, Александра Стаменова, Игор Спироски. Оваа статија е со отворен пристап дистрибуирана под условите на неопределена лиценца, која овозможува неограничена употреба, дистрибуција и репродукција на било кој медиум, доколку се цитираа оригиналните автор(и) и изворот.

Конкурентски интереси: Авторот изјавува дека нема конкурентски интереси.

Охрабрувањето на децата да се вклучат во физичка активност (ФА) е од клучно значење за нивниот развој. Училишната средина може да игра значајна улога во обликувањето на навиките за ФА кај децата, што, пак, може позитивно да влијае на нивното целокупно здравје и благосостојба. Целта на оваа студија беше да се опишат карактеристиките на околината за ФА во основните училишта низ цела Северна Македонија користејќи податоци од 6-тиот круг на Иницијативата за следење на дебелината кај децата во Европа (COSI) на Светската здравствена организација. Материјали и методи: Претставник на основно училиште (n=111) одговори на прашања во врска со средината за ФА, кои вклучуваа прашања за поседување на надворешно и внатрешно игралиште и сала, користење на надворешното игралиште надвор од училишните часови и во неповолни временски услови и организирање на ФА во и надвор од училишните часови. Беше спроведена дескриптивна статистика за да се прикаже средината за ФА во основните училишта во Северна Македонија. Резултати: Повеќето основни училишта имаа надворешно игралиште (94,6%), обезбедуваа ≥2 часа неделно часови по физичко образование (89,2%) и имаа внатрешна сала (83,8%). Сепак, основните училишта со помал број на запишани ученици (≤29 ученици) имаа значително помала веројатност да имаат внатрешна сала. Приближно половина од основните училишта (48,5%) нудеа организирани спортски/физички активности ≥еднаш неделно надвор од училишните часови. Надвор од училишните часови, повеќето основни училишта дозволуваа користење на надворешните простори за игра (77,1%). Заклучок: Ико целокупните средини за ФА беа позитивни, сите македонски основни училишта не поседуваат соодветни рекреативни објекти и простор за учениците да се вклучат во редовна ФА. Оттука, постои итна потреба за заеднички напори помеѓу училиштата, локалните и националните власти за ефективно решавање на ова прашање, со цел да се борат против дебелината кај децата и да се промовира зголемена ФА меѓу младите ученици.

Introduction

Globally, physical activity (PA) is on the decline, with less than 50% of European children and adolescents meeting recommended criteria.¹ As children's participation in PA declines, risk of various chronic diseases such as obesity, hypertension, type 2 diabetes, and cancer increases.^{2,3} The World Health Organization (WHO) defines PA as any bodily movement fueled by skeletal muscles requiring energy expenditure, encompassing various activities such as play, sports, transportation, recreation, and physical education.⁴ Regular PA has been shown to promote children's mental health and psychological well-being,^{5,6} while also being tied to improved academic performance.⁷⁻¹⁰

During the academic year (~9 months annually), European children spend most of their weekdays at school, where they sit for extended periods during academic lessons. Data from longitudinal studies with objective measures of PA suggest that the standard model of a school is poorly suited for the promotion of PA as MVPA (moderate to vigorous physical activity) begins to decline and sedentary behavior begins to increase from around the time young children first enter schools.¹¹

In response to rising obesity rates, North Macedonia recently amended its law to increase the amount of time children spend in physical education classes per week, but also proposed strategies to promote PA throughout each school day.¹² The potential impact of this new law in North Macedonia could be far reaching in not only increasing daily PA but also mitigating obesity risk among young

children. A recent school-based physical education intervention program in Lithuania resulted in not only increased PA engagement, but also positively affected somatic anxiety, personality anxiety, and social anxiety among children aged six to nine years.¹³

Recognizing that many children do not engage in regular PA for a variety of reasons (e.g., psychological, social, environmental, and demographic factors)^{4,14-16}, primary schools can potentially offer an environment to promote regular PA. The aim of this study was to describe the characteristics of the PA environment in primary schools across North Macedonia using data from the 6th round of the WHO's European Childhood Obesity Surveillance Initiative (COSI).

Materials and Methods

Data utilized in this study were collected between October and December 2022 as part of the 6th round of WHO COSI in North Macedonia. Comprehensive WHO COSI methodology reports have been previously published.¹⁷ The Ethics Committee of the Ss. Cyril and Methodius University - Faculty of Medicine in Skopje approved the North Macedonia WHO COSI-6th round protocol (approval 03-2140/1 from 06.05.2022).

A representative sample of primary schools (n=111), located within each of the ten regional Centers of Public Health, participated in the survey.

Following completion of data collection, research assistants from the Institute of Public Health of North Macedonia reviewed each school form for accuracy. Next, these data

were entered into WHO-COSI's electronic software system (Open Clinica—Open Clinica LLC, Waltham, MA, USA) and then electronically transferred to the Regional European WHO Office for quality review and verification.

Primary School Physical Activity Environment Assessment

A designated primary school representative (e.g., headmaster/headmistress, principal) completed the mandatory WHO COSI-6th round school form that included questions regarding the primary school PA environment. The following six questions used a dichotomous response format (yes or no): (1) Does your school have an outdoor playground?, (2) Does your school have an indoor gymnasium?, (3) Is it permitted to use the outdoor playground in extreme weather conditions?, (4) Is it permitted to use the outdoor playground outside of school hours?, (5) Is it permitted to use the gym outside of school hours?, and (6) Does your school organize any sport/physical activities at least once a week for primary school children outside school hours?

Two questions were combined to assess the frequency of physical edu-

cation lessons, including: (1) Does your educational program include physical education? and (2) In this current school year, how much time each week does your school provide physical education lessons for the pupils of each class participating in this project? To align with national physical education guidelines in North Macedonia,¹¹ responses were dichotomized as either yes (≥ 2 hours per week physical education lessons) or no (< 2 hours per week physical education lessons).

Statistical Analyses

Descriptive analyses were conducted to illustrate the prevalence of primary school PA environment indicators overall and across second grade enrollment size in North Macedonia. Second-grade enrollment, at each primary school, was used to classify schools as either small (≤ 29 pupils) or large (≥ 30 pupils). Chi-square (χ^2) analyses were performed to examine differences based on primary school enrollment size. Statistical significance was set at $p < 0.05$ *a priori*. The IBM® Statistical Package for the Social Sciences, ® Version 28.0.1.1(14) (SPSS+, Chicago, Illinois) was used for all statistical analyses.

Results

Table 1. Second-grade enrollment of primary schools participating in World Health Organization European Childhood Obesity Surveillance Initiative—6th Round

Second Grade Enrollment	Schools %	Pupils M $\pm$ SD
Small (≤ 29 pupils)	47.7	20.5 $\pm$ 5.5
Large (≥ 30 pupils)	Pupils M $\pm$ SD	45.2 $\pm$ 14.7

In North Macedonia, a total of 111 primary schools participated in the WHO-COSI-6th round. As shown in

Table 1, slightly less than half (47.7%) of primary schools enrolled ≤ 29 pupils in the second grade.

The prevalence of PA environment indicators of primary schools participating in the WHO COSI-6th round are shown in Table 2. Most primary schools had an outdoor playground (94.6%), provided ≥ 2 hours per week of physical education lessons (89.2%), and had an indoor gymnasium (83.8%). However, smaller primary schools (≤ 29 pupils) were sig-

nificantly less likely to have an indoor gymnasium.

Approximately half of the primary schools (48.5%) offered organized sport/physical activities ≥ 1 time per week outside of school hours. Outside of school hours, most primary schools permitted use of outdoor play areas (77.1%).

Table 2. Prevalence of physical activity environment indicators of primary schools

Physical Activity Environment Indicators	Overall %	Second Grade Enrollment	
		Small (≤ 29 pupils) %	Large (≥ 30 pupils) %
Indoor gymnasium (gym)	83.8	75.5	91.4
Outdoor playground (play) area(s)	94.6	96.2	93.1
≥ 2 hours per week of physical education lessons	89.2	86.8	91.4
School organizes sport/physical activities, ≥ 1 time per week, outside of school hours	48.5	52.1	45.5
Use of outdoor play areas permitted during extreme weather conditions	14.0	17.3	10.9
Use of outdoor play area(s) permitted outside of school hours	77.1	82.0	72.7
Use of indoor gym permitted outside of school hours	21.6	22.4	20.8

Bold text denotes statistically significant differences between primary school enrollment ($p < 0.05$).

Discussion

This study addresses an important gap in furthering our understanding of the primary schools PA environment across North Macedonia. Findings generated in this study can be used to monitor and develop PA environment-related guidelines and interventions for primary schools in North Macedonia. Overall, the PA primary school environment in North Macedonia was found to be positive. Most schools had both an indoor gymnasium and an outdoor playground. Additionally, nine of ten primary schools provided physical

education lessons ≥ 2 hours per week. Our findings were similar to those of Korzycka's study on Polish primary schools,¹⁸ particularly in terms of the availability of indoor gym facilities, outdoor play areas, and organized sports classes. In Korzycka's study, larger primary schools, with an enrollment of 30 pupils or more, were more likely to have a gymnasium. The underlying reasons for this finding should be explored in greater detail in the future across North Macedonia. Additionally, analyses should be conducted to ascertain differences in children's PA levels in the

primary school PA environments.

In a recent study, Prosheva *et al.* conducted a comprehensive assessment of primary school physical environments (n=320) across North Macedonia.¹⁹ In relation to the PA environment within schools included in their sample, those in urban areas and attended by Macedonian or multiethnic students had significantly higher chances of using school premises for PAs outside of school hours compared to schools in rural areas and/or attended by Albanian students. Additionally, 47 primary schools reported no access to school premises for after-school physical activities, while 102 reported partial access. Another study focused on the importance of designing outdoor spaces to encourage physical activity and improve children's health. This study, conducted across five primary schools in Turkey, employed various methods such as behavior mapping, physical evaluations of schoolyards, and interviews with students, teachers, and administrators. The results highlighted common features of schoolyards and the types of activities students participated in. Active students who walked to school had lower BMI levels compared to sedentary ones, and students at schools with larger yards also tended to have lower BMI values. Most students favored larger, greener schoolyards.

One major challenge identified was overcrowding during recess, which limited opportunities for physical activity. Schoolyards with better landscape designs were more popular and positively influenced student satisfaction.²⁰

A similar study in Norway focused on monitoring schoolchildren's physical activity in relation to the availability of physical activity equipment. The study found that 73% of boys and 57% of girls in primary school reported engaging

in daily physical activity during recess, compared to only 38% of boys and 21% of girls in secondary school. Boys were generally more active than girls. The research indicated that secondary school students with more outdoor facilities were nearly three times more likely to engage in daily physical activity than those with fewer facilities. Specific features, such as soccer fields, playground equipment, and sledding hills, were linked to increased activity for boys, while sledding hills were a key factor for girls. No significant patterns were observed for primary school students, likely due to their naturally higher activity levels.²¹ In Norway, schools offer multiple recess periods and a longer after-lunch break, contributing up to 40% of the recommended 60 minutes of daily physical activity.²²

Previous research has demonstrated that school environment factors, such as the availability of outdoor equipment and the presence of supervision, can positively influence physical activity levels during recess. Adding more equipment and providing supervision has been shown to boost activity levels during school time.²³⁻²⁷

A study at Rochester Elementary School explored whether children were more physically active in an activity-friendly environment compared to a traditional school setting. It compared three environments: a traditional classroom, "The Neighborhood" (which encouraged more movement), and a "Standing Classroom" with standing desks. The study also tested replacing traditional desks with vertical workstations as a practical solution. Physical activity was measured using accelerometers, showing no significant differences between systems. The study found that "The Neighborhood" led to a 50% increase in

physical activity throughout the school day, as children walked or played while learning. When standing desks were introduced to a traditional classroom, physical activity levels were similar to those in the Standing Classroom, suggesting that the building design, not just educational technology, influenced the increase in activity. While limited research exists on modifying school environments for physical activity, previous studies indicate that access to activity-related equipment, like soccer balls, increases activity, especially under supervision.²⁸

A study in Japan highlights the importance of addressing environmental factors to encourage physical activity during recess and shows that promoting positive perceptions of school facilities may be particularly effective for boys at lunch recess and for girls at morning recess. This study explored how the perceived school environment affected physical activity among elementary school children during recess. Boys who believed their school had good equipment for physical activity engaged in more moderate activity during lunch recess, and those who perceived good facilities participated in more vigorous activity and less sedentary behavior. Similarly, girls who thought the school had good facilities spent more time in moderate and vigorous activity during morning recess. However, girls who saw the equipment as good engaged in less light physical activity.²⁹

Limitations

Although there are several limitations to our research, when comparing our findings with those of other studies, we can still observe positive results. Several factors should be considered regarding the limitations of our study. Firstly,

while the WHO COSI-6th round includes a nationally representative sample of Macedonian primary schools, the cross-sectional design limits our ability to establish causality. Secondly, as with all observational studies that rely on self-reports, response bias is a potential concern. Thirdly, due to the nature of secondary analyses, we were unable to modify or expand upon the questions and responses in the WHO COSI-6th. Finally, we identified only one previously published WHO COSI study 18 that addressed similar research questions and analyses to our own.

Conclusion

In conclusion, while the overall school-related physical activity (PA) environments were positive, not all Macedonian primary schools have sufficient recreational facilities and space for students to engage in physical activities. Therefore, there is a significant need for collaborative efforts between schools and local authorities to address this issue effectively, with the goal of combating childhood obesity and promoting increased physical activity among young students.

References

1. Górna S, Pazdro-Zastawny K, Basiak-Rasała A, Krajewska J, Cichy I, Rokita A, Zatoński T. Physical activity and sedentary behaviors in Polish children and adolescents. *Archives de Pédiatrie* 2023; 30 (1): 42-47, ISSN 0929-693X. <https://doi.org/10.1016/j.arcped.2022.11.010>
2. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and

- fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7(40). <https://doi.org/10.1186/479-5868-7-40>
3. Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput J-P, Janssen I, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab.* 2016;41(6):S197–239 doi: 10.1139/apnm-2015-0663.
 4. World Health Organization 2022, accessed 9 June 2024, <https://www.who.int/news-room/fact-sheets/detail/physical-activity>
 5. Biddle SJH, Asare M. Physical activity and mental health in children and adolescents: a review of reviews. *Brit J Sports Med.* 2011;45:886–95 DOI: 10.1136/bjsports-2011-090185
 6. Babic M, Morgan PJ, Plotnikoff RC, Lonsdale C, White RL, Lubans DR. Physical activity and physical self-concept in youth: systematic review and meta-analysis. *Sports Med.* 2014;44:1589–601 DOI: 10.1007/s40279-014-0229-z
 7. Álvarez-Bueno C, Pesce C, Cavero-Redondo I, Sánchez-López M, Garrido-Miguel M, Martínez-Vizcaino V. Academic achievement and physical activity: a meta-analysis. *Pediatrics.* 2017;140(6):e20171498 DOI: 10.1542/peds.2017-1498
 8. Khan NA, Hillman CH. The relation of childhood physical activity and aerobic fitness to brain function and cognition: a review. *Pediatr Exerc Sci.* 2014;26(2):138–46 doi: 10.1123/pes.2013-0125
 9. Owen KB, Parker PD, Van Zanden B, MacMillan F, Astell-Burt T, Lonsdale C. Physical activity and school engagement in youth: a systematic review and meta-analysis. *Educ Psych.* 2016;51(2):129–45 DOI: 10.1080/00461520.2016.1151793
 10. Santana CCA, Azevedo LB, Cattuzzo MT, Hill JO, Andrade LP, Prado WL. Physical fitness and academic performance in youth: a systematic review. *Scand J Med Sci Sports.* 2017;27(6):579–603 DOI: 10.1111/sms.12773
 11. Bailey R, Ries F, Scheuer C. Active schools in Europe—A review of empirical findings. *Sustainability.* 2023 Feb 20;15(4):3806. <https://doi.org/10.3390/su15043806>
 12. World Health Organization (WHO). North Macedonia changes law to increase the amount of time for physical activity in schools. Available from: <https://www.who.int/europe/news/item/24-04-2020-north-macedonia-changes-law-to-increase-the-amount-of-time-for-physical-activity-in-schools#:~:text=North%20Macedonia%20recently%20amended%20its%20law%20to%20increase,opportunities%20for%20physical%20activity%20throughout%20the%20school%20day> Accessed: June 10, 2024.
 13. Kliziene I, Cizauskas G, Sipaviciene S, Aleksandraviciene R, Zaicenkoviene K. Effects

- of a physical education program on physical activity and emotional well-being among primary school children. *Int J Environ Res Public Health*. 2021;18(14):7536. DOI: 10.3390/ijerph18147536
14. Hallal PC, Bo Andersen L, Bull FC, Guthold R, Haskell W, Ekelund U, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*. 2012;380:247–57 DOI: 10.1016/S0140-6736(12)60646-1
 15. Centers for Disease Control and Prevention. Cancer prevention and control. Current physical activity guidelines. Atlanta, USA2016. Retrieved March 18, 2019 Available from: https://www.cdc.gov/cancer/dcpc/prevention/policies_practices/physical_activity/guidelines.htm
 16. Welk GJ. The youth physical activity promotion model: A conceptual bridge between theory and practice. *Quest*. 1999;51:5–23. doi:10.800/00336297.1999.10484297
 17. Breda J, McColl K, Buoncris- tiano M, et al. Methodology and implementation of the WHO European Childhood Obesity Surveillance Initiative (COSI). *Obesity Rev* 2021; 22(S6):e13215. doi:10.1111/obr.13215
 18. Korzycka M, Jodkowska M, Oblacińska A, Fijałkowska A. Nutrition and physical activ- ity environments in primary schools in Poland – COSI study. *Ann Agric Environ Med*. 2020; 27(4): 605–612. doi: 10.26444/aaem/114223
 19. Prosheva S, Kjosevska E, Velikj Stefanovska V. Assessment of the physical environment situ- ation in primary schools in the Republic of North Macedonia. *Arch Pub Health* [Internet]. 2020;12(3):5-15. doi.org/10.3889/aph.2020.5418
 20. Ozdemir A, Yilmaz O. Assess- ment of outdoor school envi- ronments and physical activity in Ankara's primary schools. *Journal of Environmental Psy- chology*, 2008; 28(3):287-300. <https://doi.org/10.1016/j.jen- vp.2008.02.004>
 21. Haug E, Torsheim T, Sallis JF, Samdal O. The characteristics of the outdoor school environ- ment associated with physi- cal activity. *Health Education Research*. 2010;28(2):248-256. <https://doi.org/10.1093/her/ cyn050>
 22. Ridgers ND, Stratton G, Fairclough SJ. Physical activity levels of chil- dren during school playtime. *Sports medicine*. 2006;36:359- 71 DOI: 10.2165/00007256- 200636040-00005
 23. Sallis JF, McKenzie TL, Con- way TL, Elder JP, Prochaska JJ, Brown M, et al. Environmental interventions for eating and physical activity: a random- ized controlled trial in middle schools. *American journal of preventive medicine*. 2003; 24(3):209-17. doi: 10.1016/s0749- 3797(02)00646-3.
 24. Verstraete SJ, Cardon GM, De Clercq DL, De Bourdeaud- huij IM. Increasing children's physical activity levels during recess periods in elementary schools: the effects of provid-

- ing game equipment. *The European Journal of Public Health*. 2006;16(4):415-9. doi: 10.1093/eurpub/ckl008.
25. Stratton G, Mullan E. The effect of multicolor playground markings on children's physical activity level during recess. *Preventive medicine*. 2005;41(5-6):828-33. DOI: 10.1016/j.ypmed.2005.07.009
 26. Ridgers ND, Stratton G, Fairclough SJ, Twisk JW. Long-term effects of a playground markings and physical structures on children's recess physical activity levels. *Preventive medicine*. 2007;44(5):393-7. DOI: 10.1016/j.ypmed.2007.01.009
 27. Barnett TA, O'Loughlin J, Gauvin L, Paradis G, Hanley J. Opportunities for student physical activity in elementary schools: a cross-sectional survey of frequency and correlates. *Health education & behavior*. 2006;33(2):215-32. DOI: 10.1177/1090198105277855
 28. Lanningham-Foster L, Foster RC, McCrady SK, Manohar CU, Jensen TB, Mitre NG, Hill JO, Levine JA. Changing the school environment to increase physical activity in children. *Obesity* 2008; 16: 1849-1853. <https://doi.org/10.1038/oby.2008.282>
 29. Ishii K, Shibata A, Sato M, Oka K. Recess physical activity and perceived school environment among elementary school children. *International Journal of Environmental Research and Public Health*. 2014; 11(7):7195-7206. <https://doi.org/10.3390/ijerph110707195>