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Pupils' use of school outdoor play settings across seasons and its relation to sun exposure and physical activity

Peter Pagels[1,2] | Ulf Wester[3] | Fredrika Mårtensson[4] | Peter Guban[5] | Anders Raustorp[6] | Andreas Fröberg[6] | Margareta Söderström[7,8] | Cecilia Boldemann[1]

[1]Department of Public Health Sciences, Karolinska Institutet, Stockholm, Sweden

[2]Department of Sport Sciences, Linneaus University, Kalmar, Sweden

[3]Swedish Radiation Safety Authority, Stockholm, Sweden

[4]Department of Work science, Business Economics and Environmental Psychology, Swedish University of Agricultural Sciences, Alnarp, Sweden

[5]Center for Epidemiology and Community Medicine, Stockholm County Council, Stockholm, Sweden

[6]Department of Food and Nutrition and Sport Science, University of Gothenburg, Gothenburg, Sweden

[7]Section of General Practice, Department of Public Health, University of Copenhagen, Copenhagen, Denmark

[8]Department of Clinical Sciences in Lund, University of Lund, Lund, Sweden

Correspondence
Peter Pagels, Department of Public Health Sciences, Karolinska Institutet, Stockholm, Sweden.
Email: peter.pagels@lnu.se

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Abstract

Background: Long outdoor stay may cause hazardous exposure to ultraviolet radiation (UVR) from the sun even at high latitudes as in Sweden (Spring to Autumn). On the other hand, long outdoor stay is a strong predictor of primary school children´s free mobility involving moderate to vigorous physical activity (MVPA). UV-protective outdoor environments enable long outdoor stay. We investigated the concurrent impact of different school outdoor play settings upon pupils´ sun exposure and levels of physical activity across different ages, genders, and seasons.

Method: During 1 week each in September, March, and May, UVR exposure and MVPA were measured in pupils aged 7-11 years. Erythemally effective UVR exposure was measured by polysulphone film dosimeters and MVPA by accelerometers. Schoolyard play was recorded on maps, and used areas defined as four play settings (fixed play equipment, paved surfaces, sport fields, and green settings), categorized by season and gender.

Results: During the academic year, sport fields yielded the highest UVR exposures and generated most time in MVPA. In March, time outdoors and minutes in MVPA dropped and UVR exposures were suberythemal at all play settings. In May, green settings and fixed play equipment close to greenery promoted MVPA and protected from solar overexposure during long outdoor stays.

Conclusion: More outdoor activities in early spring are recommended. In May, greenery attractive for play could protect against overexposure to UVR and stimulate both girls and boys to vigorous play.

KEYWORDS

physical activity, play settings, pupils, sun exposure

Ulf Wester: Retired 2013.

1 | INTRODUCTION

Children in Western countries increasingly sit indoors for hours on end during long, regulated schooldays.[1] Increasing time spent indoors may reduce children's opportunities for healthy levels of physical activity, defined as 60 minutes in moderate to vigorous physical activity (MVPA),[2] and occasional sun exposure, possibly enough for vitamin D production at mid-latitudes.[3]

Long outdoor stay is a strong predictor of primary school children´s PA, at least in temperate climates.[4] On the other hand, long outdoor stay may cause hazardous exposure to ultraviolet radiation (UVR) from the sun even at high latitudes as in Sweden.[5,6] Further, overexposure to UVR at an early age increases the risk of skin cancer later in life.[7] It has been established that the occurrence of skin cancer increases rapidly among adults in Sweden as well as in other Western societies.[8] Reversely, sun in winter at high latitudes cannot maintain optimal vitamin D levels.[9,10] Low levels of PA combined with low levels of vitamin D may have implications for children's bone growth.[11]

Studies on school children show the need of active intervention policies to increase PA,[12] and action to reduce sun exposure[13] whenever the risk of overexposure is high. Differences in children's UVR exposures could be explained in part by PA. For instance, passive outdoor pursuits have been associated with higher UVR exposures than outdoor PA and travel pursuits.[14] Results from the Colorado Kids Sun Care Program (a sun safety intervention trial) show that the promotion of sun safety, like avoidance of midday sun and sun protection during outdoor activities, is not likely to inhibit PA.[15] However, to the knowledge of the authors, UVR exposure and PA combined has never been studied in relation to play settings (PS).

In a systematic review examining children's and adolescent's PA during school recess, Ridgers et al found a positive correlation between the provision of loose equipment (eg, balls and skipping ropes) and MVPA.[16] Further, playground markings (for games and sports) and physical structures have been shown to increase school children's PA during recess.[12,17] In 11- to 12-year-old pupils, ball play areas may be related to even higher PA intensity levels, which are maintained with increasing age, especially in boys.[18] Woodland may serve as an opportunity for boys and girls to be physically active while playing together.[19] Studies of preschool environment show that greenery promotes physical activity in shelter from excessive UVR during free play.[20,21] For preschool outdoor environment, more specific configurations of factors inviting to behaviors that serve multiple health gains have been defined,[21-23] factors deemed relevant for school children only to a certain extent.[19]

Impact of season, time outdoors, and amount of free sky upon UV exposure from the sun[5] and impact of area surface upon MVPA[24] have been previously investigated in this study population, but without relating the outcome to play settings. In this study, we investigated the concurrent impact of different school outdoor PSs upon Swedish pupils' sun exposure (UVR) and PA across different ages and seasons during one academic year.

2 | METHODS

2.1 | School sites and study sample

For this repeated measurement study (September, March, and May), four municipal elementary schools in southern and middle Sweden were selected (latitudes 56.4-60.3°N). They were attended by 400-500 1-9th graders and located in medium-sized cities with similar socio-economy (European socio-economic classification, ISCO, 1988). Further, the selection was based upon environmental characteristics considered typical for schoolyards in Sweden such as the amount of open paved space, vegetation, fixed play equipment, and sport fields. Of 246 eligible pupils at the selected schools, 166 (67.5%) participated, 77 2nd graders and 89 5th graders. The school management, the pupils, teachers, and parents received detailed information about what the study would imply for the children. The parents and their participating children signed a written consent form. The study was approved by the Regional Ethics Committee of Stockholm (# 2011/370-31).

2.2 | Participants

Initially, 159 pupils aged 7-11 years, 73 (34 girls) 2nd graders (9% loss) and 86 (44 girls) 5th graders (8% loss), participated. The girls of the 2nd grade were aged 8.6 years (±0.5) and the boys 8.5 years (±0.5). Among 5th graders, the girls were aged 11.5 years (±0.3) and the boys 11.6 (±0.4). Mean measured days per child were 3.9 (±0.9), 4.3 (±0.9), and 4.1 (±0.9) in September, March, and May, respectively. Fifty-nine percent of the pupils attended all 5 days of fieldwork each season.

2.3 | Play setting and weather observations

During fieldwork the observers were in charge of one class each (in mean 16 pupils/class), using a class specific protocol with the pupils' names to record arrivals and departures from the school premises, as well as in- and outdoor times (recesses and occasional outdoor lessons). Each child was categorized as being indoors when observed participating in activities inside the school building. Outdoor activity was categorized from the moment the child stepped outside onto the schoolyard area. On a map (A3 format) of the school environment, each observer marked the pupils' positions by different markings for girls and boys and types of activity they engaged in whenever outdoors. Accordingly, mean values were registered based on the dominating group visiting a particular PS. One map was used per outdoor episode at each school, season, grade, and day. Characteristic patterns of how children's activities distributed across the schoolyard were related to attributes of the physical environment and formed distinct PSs. The four dominating types of settings typically available to children at the schools were (a) fixed play equipment, (b) paved surfaces, (c) sport fields, and (d) green settings (Figure 1).

Weather conditions were recorded during all days of fieldwork and maximal day temperatures obtained from the Swedish Meteorological and Hydrological Institute (SMHI).

2.4 | Assessment of individual UVR exposure

For individual assessment of erythemally effective UV radiation exposure, calibrated polysulphone film dosimeter badges[25,26] were applied at the shoulder in horizontal position.[27] The dosimeters were calibrated at the University of Manchester, School of Earth, Atmospheric and Environmental Sciences, UK, and returned and analyzed there after exposure with results listed as Standard Erythema Doses "SEDs" (1 SED = 100 J/m^2).[28] The absorbance of dosimeters at 330 nm is measured before and after exposure, and the difference entered into a polynomial function empirically formulated to give approximate results expressed as erythemal UV exposures weighted according to CIE's erythema reference action spectrum.[28] Polysulphone film dosimeters are proven to be reliable tools to measure personal UV exposures.[29] For diurnal measurement of global UVR, three of the same dosimeters as worn by the children were mounted on the school roof or a high building nearby with free horizon and changed each night to obtain daily available exposures on a horizontal surface. To compute available global UV exposure at 5-minute epochs, a UV-index monitoring instrument from Davis Instruments, USA CA (Weather link 5.8.2) was used. The instrument had been factory calibrated to record UV index values, but was in this study used for relative measurements. The sensor of the Davis instrument was taped down close to the roof dosimeters. The readings' distribution in time over a day, integrated and normalized to an average of the three roof dosimeters, was used to assess global UV exposures during the children's outdoor stays each particular day.

The pupils' mean daily UVR exposures (J/m^2) were calculated from measured accumulated week exposures of the individual pupils' UV dosimeters, however, without considering variations in global UVR due to different weather conditions from day to day as the dosimeters were not time-stamped.[5] The mean values were then compared with a three-step scale of exposures ranging from suberythemal and possibly insufficient to form vitamin D to suberythemal but potentially sufficient for vitamin D depending on clothing and up to erythemal. A "standard vitamin D dose" or "SDD" has been suggested[10] equivalent to the exposure of sun-sensitive persons (skin type I) to ¼ or less of a "Minimal Erythemal Dose" (1/4 MED) of ¼ of the skin area every other day, for example, equal to exposure every second day of hands, face, and arms 15-25 minutes at noon and at mid-latitude in March or equal to an oral dose of about 1000 IU.[10,30] In this study, UV fraction (%UV) is the ratio of accumulated exposure of each individual dosimeters to ambient accumulated available UVR during each individual child's stay outdoors at their respective sites. Available ambient UVR was calculated from the roof-top dosimeter readings modulated by the relative measurements of the UV-index meter—absolute calibration at the Davis factory was irrelevant in this study.

2.5 | Assessment of physical activity

For assessment of MVPA, hip-worn accelerometers (Actigraph GT3X+) were used and set to record movement in 10-second epochs with a sampling frequency of 60 Hz to get detailed PA data.[31,32]

The sum of counts in each epoch was categorized into MVPA, using validated and recommended cut points (>383 counts/10 s) for MVPA [33,34]). All 10-second epochs reaching the limit for MVPA were summarized into total daily minutes spent in MVPA. As a supplement to ocular observation, a built-in light sensor (Actilux) of the accelerometers was used to

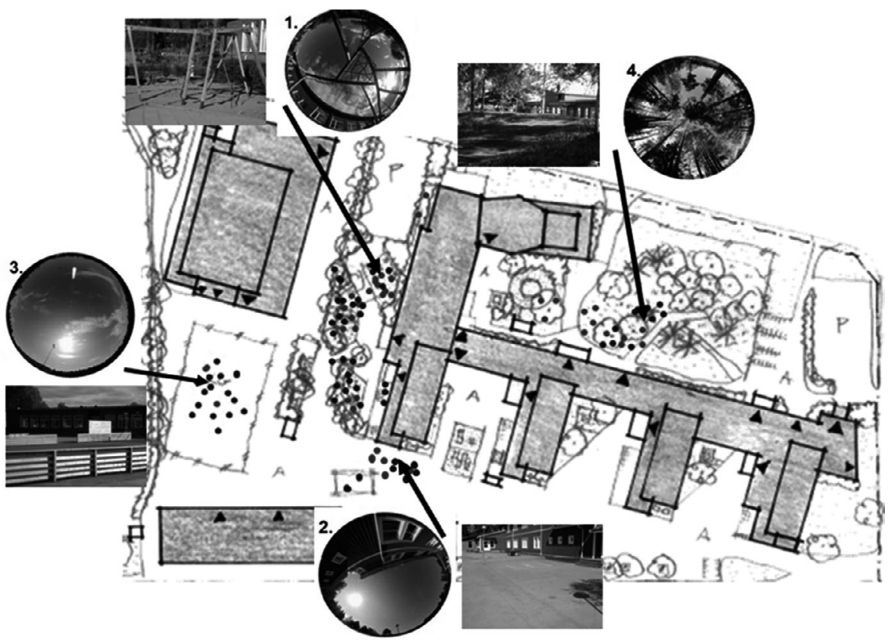

FIGURE 1 Example of PSs at school no.1; 1-fixed play equipment. 2- paved surfaces. 3-sport fields. 4-green settings

separate outdoor MVPA from indoor MVPA, as only outdoor MVPA was analyzed in this study. This procedure is clarified somewhere else.[24]

2.6 | Evaluation and statistical analysis

The SPSS™ (Statistical Package for the Social Sciences for Windows, 22.0, 2014, SPSS Inc) and SAS for Windows software packages (9.4) were used for analysis. Accelerometer data were processed using Acti Life 6.0 (Actigraph) and Microsoft Excel 2010 (Microsoft Corporation). Mean and standard deviations (±SD) for erythemal UVR exposures (J/m^2) and minutes in MVPA during outdoor stay at each PS were calculated for days and different seasons. Accelerometer data gathered for 2 days or more, >120 minutes in total and >5 minutes outdoors during each day of each measurement period (season), were used in the analysis. PS were used as independent variables vs UVR exposure and MVPA outdoors and categorized along season, school, grade, and gender.

A one-way ANOVA test was conducted to evaluate the significant impacts of PS upon UVR exposures and minutes spent in MVPA outdoors and across different seasons, grades, and gender. A Bonferroni post hoc test was conducted for any statistically significant difference for the PS variable.

For confounder control, bivariate analysis was carried out from diary records (health status and PA outside school). None of them being significantly related to MVPA.[24]

3 | RESULTS

3.1 | Environmental conditions

Apart from temperature, the weather in terms of sky conditions did not differ significantly between seasons and schools. The sky was partly cloudy and overcast and clear in between with only one rainy day in September at one of the schools. The mean maximal outdoor temperature during the week of fieldwork was 16.2°C (±0.7) in September, 1.1°C (±3.7) in March, and 15.9°C (±0.7) in May. Weekly mean noon-time UV index and the max UV index were in September 1.7 and maximal 4.3, in March 1.4 and 3.1, and in May 3.3 and 6.9 (readings from the Davis UV monitor). The solar zenith angles were similar during each measurement period at each school with a seasonal mean (range between sites) of 54.5° (3.2) in September, 62.1° (3.5) in March, and 40.2° (2.1) in May.

3.2 | Overall use of play settings

Based on the analysis of totally 143 maps retrieved from all outdoor episodes during the academic year, boys most commonly used sport fields (47.2%), and girls fixed play equipment (32.2%). In September and May, sport fields were used by 44% of all pupils. In March, green settings and paved surfaces were most commonly used by 35% and 36%, respectively. Divided by age, the 2nd graders mostly favored sport fields in May (56.2%) and September (40.3%) and paved surfaces in March (43.9%). The 5th graders mostly used fixed play equipment in September (44.2%), green areas in March (40.5%), and sport fields in May (36.3%) (Figure 2).

3.3 | UVR exposure at different PS's and seasons

Weekly available UVR (CIE-weighted, erythemally effective [28]) during school time varied between 76 and 1060 J/m^2. Due to the amount of UVR exposures at sport fields in May (146.5 J/m^2), there was a risk of overexposure to UVR, and UVR exceeded one MED in 14 pupils, all 2nd graders. During March, there was no risk of overexposure to UVR (Figure 3). In September, paved areas yielded the

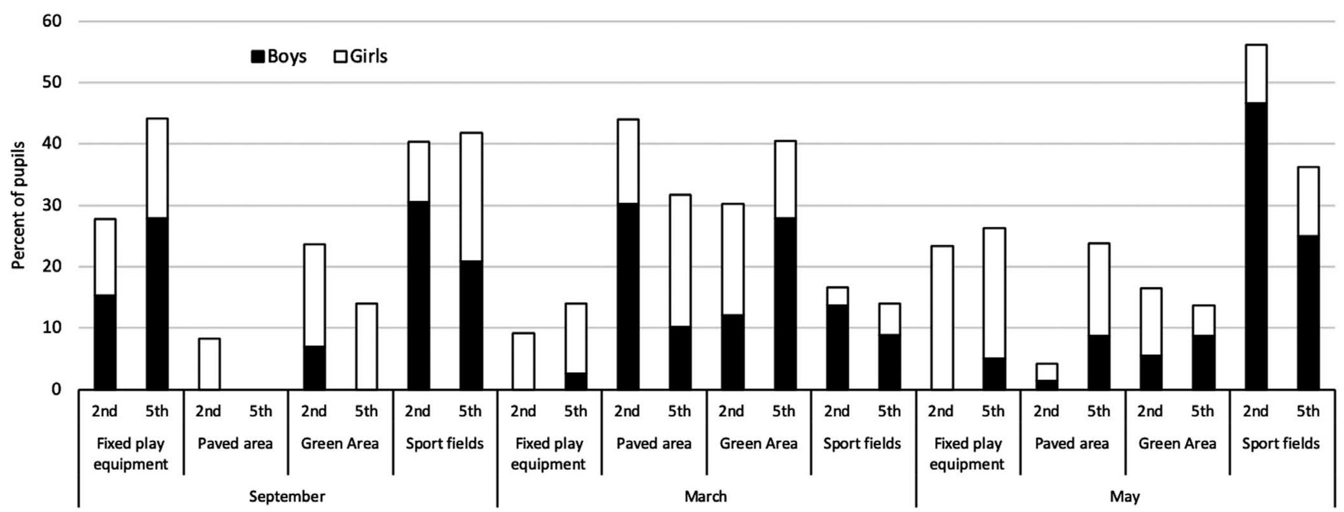

FIGURE 2 Swedish pupils use of different outdoor play settings in different seasons, ages, and gender (% of all pupils in each season and in each age)

highest UVR exposures (107.3 J/m^2) whereas sport fields showed the highest UVR fraction (39.3%) (Table 1).

3.4 | MVPA at different PS's and seasons

Over the whole year, sport fields generated more minutes in MVPA than any other PS ($P < .01$) (Table 2). Contrary to sport fields, paved areas yielded fewest minutes of MVPA, whereas green settings accumulated the next to most minutes of MVPA in combination with being protective against overexposure to UVR even in May. In March, the levels of MVPA were at the lowest compared with the other seasons. In September and May, boys were more active than girls in terms of MVPA, irrespective of grade ($P < .05$). In May, sport fields yielded more than half of the daily need of MVPA, and 18 pupils (12%) obtained ≥60 minutes of MVPA during school time (Table 2).

4 | DISCUSSION

Based on season and gender, the main finding was that school outdoor environments impact UVR exposures and minutes in MVPA in 7- to 11-year-old pupils differently depending on PS.

The higher levels of MVPA at sport fields correspond with the results from systematic reviews of PA showing that school facilities, playground markings, and unfixed equipment have a potential to increase PA levels during recess.[12,16]

A previous study pointed out the important role of paved open spaces for PA as children tend to run a lot in many of the traditional schoolyard games including elements of hide and seek and chasing.[19] Our results, showing the lowest level of MVPA counts at paved open spaces, possibly depend on the fact that children with woodland at hand get more inclined to use these rather than the open paved areas. This is in line with Andersen et al 2015, showing that solid surfaces on the schoolyard such as paved areas generate less MVPA than other surfaces.[35] Low activity at sun-exposed paved spaces in May could also be explained by thermal discomfort due to high temperatures.

The gendered character of school play is well documented.[36] The present study shows that in September and March, boys had a significantly higher level of MVPA than girls, irrespective of grade. The gender differences showing that boys accumulate more MVPA than girls align with previous research.[37] Also, a decline of MVPA by age has been reported in several cross-sectional studies.[37,38]

According to the result of this study, we would suggest as a routine to add trees and other greenery in proximity to sport fields to add sun protection as such fields are known to be well-used settings generating high levels of MVPA. Surface reflectance is another factor to consider. Graveled surfaces were common on soccer fields and under fixed play equipment and pupils who were active there were the ones most highly exposed to UVR. Graveled surfaces may reflect up to 25% of UVR whereas grass is almost non-reflectant.[39] This could explain some of the differences in UVR exposure between PSs. Grassy sport fields in green surroundings could lower the risk for hazardous UVR exposure in May, apart from taking opportunities to schedule outdoor activities in the mornings and late afternoons. Further, the greening of sport fields as well as of paved areas and of areas with play equipment is motivated as the presence of trees and other greenery is known to increase the play value and thereby make outdoor settings more attractive for children.

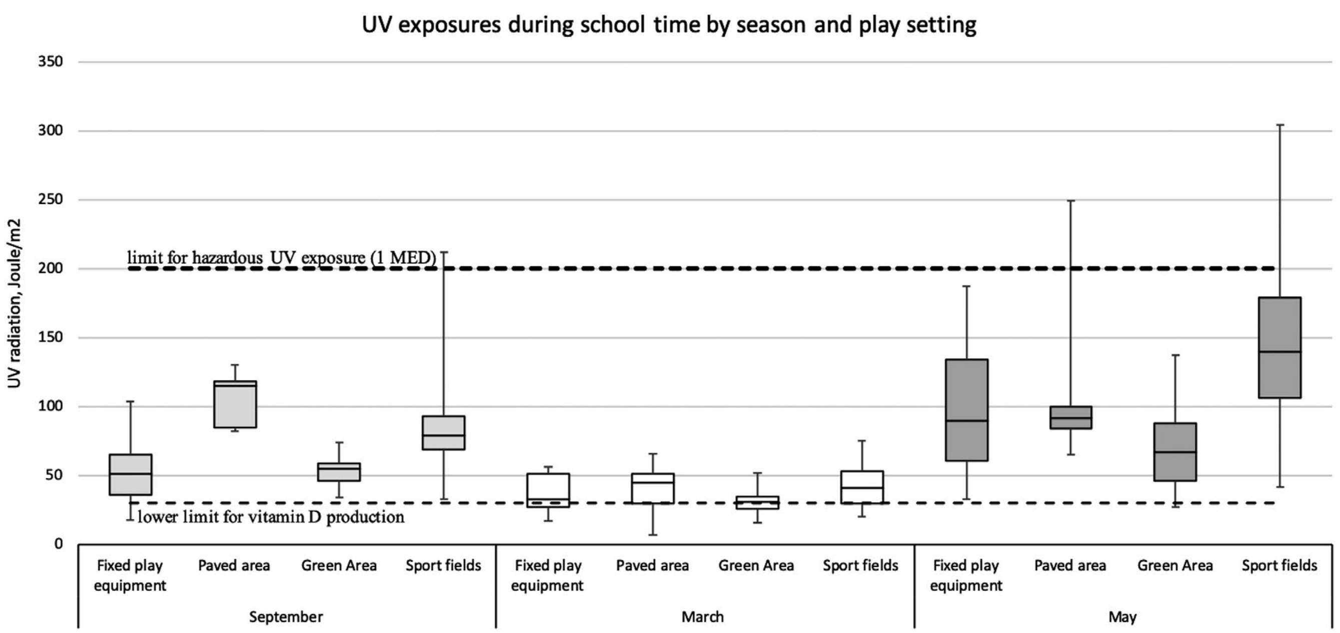

FIGURE 3 Mean UV exposures during school time by season and play setting. Total for 2nd and 5th graders and genders. The dotted black line represents the limit for hazardous UV exposure (1 MED), and the lower dotted gray line represents the lower limit for vitamin D production

TABLE 1 UVR exposure at different PS's in Swedish pupils

	Play setting	Dosimeter exposure J/m^2 (95% confidence interval) Mean	Lower	Upper	UV fraction (%)[a] (95% confidence interval) Mean	Lower	Upper
Academic year	Fixed play equipment	65	58.1	71.9	31.1	29.1	33.1
	Paved area	63	54.6	71.7	38.2	35.8	40.6
	Sport fields	107	97.6	116.1	39.3	37.5	41.1
	Green settings	46	41.7	50	27.6	26	29.3
September n = 158	Fixed play equipment	51.4	46.5	56.4	31.2	28.3	34.2
	Paved area	107.3	86.8	127.9	29.5	24.9	34.1
	Sport fields	85.7	77.6	93.7	39.9	37.3	42.4
	Green settings	53.4	49.9	56.9	28.5	24.7	32.2
March n = 145	Fixed play equipment	37.4	30.4	44.5	29.1	24	34.3
	Paved area	41.8	37.9	45.7	35.1	32.7	37.5
	Sport fields	43.2	36.4	49.9	35.1	30	40.1
	Green settings	31	28.9	33.2	25.6	23.8	27.5
May n = 153	Fixed play equipment	98	84.4	111.6	31.9	28.5	35.2
	Paved area	103.7	84.9	122.5	48.2	44	52.4
	Sport fields	146.5	132.7	160.4	40.1	37.3	42.9
	Green settings	69.8	58.5	81.2	31.1	27.2	35.2

[a]UVR fractions refer to the ratio of exposure to accumulated amount of ambient UV radiation that was available during outdoor time.

The results indicate that the chances to acquire vitamin D from solar exposure in March were low. Depending on clothing and thus sun -exposed skin area, all 2nd graders and more or less all 5th graders were potentially sufficiently exposed to UVR for own vitamin D production during September and May which applied only to a few 2nd graders and none of the 5th graders in March. Prolonged outdoor stay during sunny days may be recommended during early spring and fall at high latitudes. It was obvious that playing soccer, floor ball, or basketball on vast open sport fields increased MVPA levels and UVR exposures, with high but yet suberythemal UVR exposures in September.

In March, both daily minutes in MVPA outdoors and UVR exposures were low during play throughout all PSs, and only play at sport fields had some potential to generate MVPA during outdoor stay. This could be explained by the clear drop of outdoor time during March. Adding balls and other loose equipment[16] would likely make outdoor stay more attractive during chilly seasons at high and mid-latitude locations, and thus prolong outdoor stay without any risk of overexposure to UVR. The fact that the green PSs were the ones most used during March also deserves attention. To the knowledge of the authors, no studies of school children's play activities have been carried out during the cold season (except this one), but rather in early autumn[19,40] when greenery contributes with many affordances.[41] Thus, these studies need to be supplemented with investigations outside the growing season when the surroundings are more plain.

The significance of a strategic design to reduce UVR exposures during play and to extend safe outdoor stays has been stressed in a recent study[42] and in numerous shade policies around the world. The relevance of shade planning is obvious from this study as well.

No interrater reliability testing of the observers was performed, but the observers were trained in studying pupils' movements and PA behavior in school environments. As the same population of pupils was studied during the three study periods, each observer became familiar with his/her assigned class of pupils, which simplified the task. Yet, as the children were not individually tracked, the results have to be interpreted with caution. The fact that the values varied widely may also be a consequence of this, as PSs may trigger children differently. For example, paved areas or fixed play equipment may spur active play in some, while others pursue passive activities in one spot. Apart from widely differing MVPA, this has also implications for UVR exposures depending on season and location of passive play. Pupils may have no exposure at all if these locations are shaded (March) or be overexposed if they are in the open (May). Therefore, at any rate, triggering vigorous play may help to balance UVR exposures as the children move in and out of the open and shaded areas which,

TABLE 2 Minutes in MVPA and percent in MVPA at different PS's in Swedish pupils

		Time outdoors (minutes/d)	Daily minutes in MVPA outdoors (95% confidence interval)			Percent in MVPA outdoors (95% confidence int.)		
	Play setting	Mean	Mean	Lower	Upper	Mean	Lower	Upper
Academic year	Fixed play equipment	74	19.8	17.6	22.1	27.9	25.8	29.9
	Paved area	77	15.7	13.8	17.6	21.8	20.1	23.5
	Sport fields	105	30.2	28.1	32.2	30.4	28.9	32
	Green settings	74	18.2	16.5	19.9	26.2	24	28.3
September n = 158	Fixed play equipment	62	18.6	16.1	21.1	30.9	28	33.9
	Paved area	137	28	22.9	33.1	20.8	17	24.6
	Sport fields	98	26.9	24	29.8	29.1	26.8	31.5
	Green settings	90	21.7	19,1	24.3	26.3	22.9	30.4
March n = 145	Fixed play equipment	65	13.5	8.5	18.5	20.9	16	25.7
	Paved area	75	14.8	12.4	17.2	21.5	19.2	23.8
	Sport fields	79	21	16.6	25.3	29.4	25.2	33.6
	Green settings	64	14.4	12.2	16.6	23.9	21	26.9
May n = 153	Fixed play equipment	96	24.6	19.8	29.4	26.3	23.1	29.4
	Paved area	66	14.5	11.3	17.7	22.9	20.3	25.6
	Sport fields	120	36.1	33.1	39.1	31.9	29.5	34.4
	Green settings	77	22.5	18.1	26.9	30.6	25.4	35.8

according to this and previous studies, is most likely to occur in grassy sport fields and woodland.

5 | CONCLUSION

A set of defined common and well-used PSs in the outdoor environments of primary schools may promote children's health when better adapted to different seasons and children's grades and gender. More outdoor activities in early spring are recommended. In May, greenery attractive for play could protect against overexposure to UVR and stimulate both girls and boys to vigorous play.

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ORCID

Peter Pagels https://orcid.org/0000-0003-3030-6716

REFERENCES

1. Cleland V, Timperio A, Salmon J, et al. Predictors of time spent outdoors among children: 5-year longitudinal findings. *J Epidemiol Community Health*. 2010;64(5):400-406.
2. World Health Organization W. Global recommendations on physical activity and health 2010:58.
3. Webb AR, Kazantzidis A, Kift RC, et al. Meeting vitamin D requirements in white Caucasians at UK latitudes: providing a choice. *Nutrients*. 2018;10(4):497.
4. Dessing D, Pierik FH, Sterkenburg RP, et al. Schoolyard physical activity of 6–11 year old children assessed by GPS and accelerometry. *Int J Behav Nutr Phys Act*. 2013;10:97.
5. Pagels P, Wester U, Soderstrom M, et al. Suberythemal sun exposures at Swedish schools depend on sky views of the outdoor environments - possible implications for pupils' health. *Photochem Photobiol*. 2016;92(1):201-207.
6. Narbutt J, Philipsen PA, Lesiak A, et al. Children sustain high levels of skin DNA photodamage, with a modest increase of serum 25-hydroxyvitamin D3, after a summer holiday in Northern Europe. *Br J Dermatol*. 2018;179(4):940-950.
7. Whiteman DC, Whiteman CA, Green AC. Childhood sun exposure as a risk factor for melanoma: a systematic review of epidemiologic studies. *Cancer Causes Control*. 2001;12(1):69-82.
8. Lucas RM, McMichael AJ, Armstrong BK, et al. Estimating the global disease burden due to ultraviolet radiation exposure. *Int J Epidemiol*. 2008;37(3):654-667.
9. Persson K, Ohlund I, Nordstrom L, et al. Vitamin D deficiency at the Arctic Circle - a study in food-allergic adolescents and controls. *Acta Paediatr*. 2013;102(6):644-649.
10. Webb AR, Engelsen O. Calculated ultraviolet exposure levels for a healthy vitamin D status. *Photochem Photobiol*. 2006;82(6):1697-1703.
11. Faulkner RA, Bailey DA. Osteoporosis: a pediatric concern? *Med Sport Sci*. 2007;51:1-12.
12. Escalante Y, Garcia-Hermoso A, Backx K, et al. Playground designs to increase physical activity levels during school recess: a systematic review. *Health Educ Behav*. 2014;41(2):138-144.

13. Dadlani C, Orlow SJ. Planning for a brighter future: a review of sun protection and barriers to behavioral change in children and adolescents. *Dermatol Online J*. 2008;14(9):1.
14. Wright CY, Reeder AI, Bodeker GE, et al. Solar UVR exposure, concurrent activities and sun-protective practices among primary schoolchildren. *Photochem Photobiol*. 2007;83(3):749-758.
15. Tran AD, Aalborg J, Asdigian NL, et al. Parents' perceptions of skin cancer threat and children's physical activity. *Prev Chronic Dis*. 2012;9:E143.
16. Ridgers ND, Salmon J, Parrish AM, et al. Physical activity during school recess: a systematic review. *Am J Prev Med*. 2012;43(3):320-328.
17. Van Kann DH, de Vries SI, Schipperijn J, et al. Schoolyard characteristics, physical activity, and sedentary behavior: combining GPS and accelerometry. *J Sch Health*. 2016;86(12):913-921.
18. Haug E, Torsheim T, Sallis JF, et al. The characteristics of the outdoor school environment associated with physical activity. *Health Educ Res*. 2010;25(2):248-256.
19. Mårtensson F, Jansson M, Johansson M, et al. The role of greenery for physical activity play at several grounds. *Urban For Urban Gree*. 2014;13(1):103-113.
20. Boldeman C, Dal H, Wester U. Swedish pre-school children's UVR exposure - a comparison between two outdoor environments. *Photodermatol Photoimmunol Photomed*. 2004;20(1):2-8.
21. Boldemann C, Blennow M, Dal H, et al. Impact of preschool environment upon children's physical activity and sun exposure. *Prev Med*. 2006;42(4):301-308.
22. Mårtensson F, Boldemann C, Soderstrom M, et al. Outdoor environmental assessment of attention promoting settings for preschool children. *Health Place*. 2009;15(4):1149-1157.
23. Boldemann C, Dal H, Mårtensson F, et al. Promotion of children's physical activity and sun protection may combine. Impact of preschool outdoor environment in Southern Sweden and North Carolina. *Sci Sport*. 2011;26:72-82.
24. Pagels P, Raustorp A, De Leon AP, et al. A repeated measurement study investigating the impact of school outdoor environment upon physical activity across ages and seasons in Swedish second, fifth and eighth graders. *BMC Public Health*. 2014;14:803.
25. Diffey BL. Ultraviolet radiation dosimetry with polysulphone film. In: Diffey BL, ed. *Radiation Measurement in Photobiology*. London, UK: Academic Press; 1989:135-139.
26. Herlihy E, Gies PH, Roy CR, et al. Personal dosimetry of solar UV radiation for different outdoor activities. *Photochem Photobiol*. 1994;60(3):288-294.
27. Wester U, Pagels P, Boldemann C. Solar ultraviolet radiation exposure proxy-estimated by sky view fish-eye photography - potentials and limitations from an exploratory correlation study. *Photochem Photobiol*. 2019;95(2):656-661.
28. CIE. Standard: Erythema Reference Action Spectrum and Standard Erythema dose. CIE S007/E-1998. Vienna: Commission Internationale de l' Éclairage (CIE). 1998.
29. Wester U.Polysulphone and spore-film UV-dosimeters compared to a UVI monitoring instrument and two radiation transfer model systems - Evaluations for a UV-dosimetry study 2004 of preschool children. UVNews #8, pp 6–8 Availble at: http://metrologyhutfi/uvnet/reportshtm Accessed date: 2015-03-18. 2006.
30. Dawson-Hughes B, Heaney RP, Holick MF, et al. Estimates of optimal vitamin D status. *Osteoporos Int*. 2005;16(7):713-716.
31. McClain JJ, Abraham TL, Brusseau Jr TA, et al. Epoch length and accelerometer outputs in children: comparison to direct observation. *Med Sci Sports Exerc*. 2008;40(12):2080-2087.
32. Baquet G, Stratton G, Van Praagh E, et al. Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: a methodological issue. *Prev Med*. 2007;44(2):143-147.
33. Trost SG, Loprinzi PD, Moore R, et al. Comparison of accelerometer cut points for predicting activity intensity in youth. *Med Sci Sports Exerc*. 2011;43(7):1360-1368.
34. Evenson KR, Catellier DJ, Gill K, et al. Calibration of two objective measures of physical activity for children. *J Sports Sci*. 2008;26(14):1557-1565.
35. Andersen HB, Klinker CD, Toftager M, et al. Objectively measured differences in physical activity in five types of schoolyard area. *Landscape Urban Plan*. 2015;134:83-92.
36. Paechter C, Clark S. Learning gender in primary school playgrounds: findings from the Tromboy Identities Study. *Pedagogy*. 2007;15(3):317-331.
37. Cooper AR, Goodman A, Page AS, et al. Objectively measured physical activity and sedentary time in youth: the International children's accelerometry database (ICAD). *Int J Behav Nutr Phys Act*. 2015;12:113.
38. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively measured physical activity in youth. *Med Sci Sports Exerc*. 2002;34(2):350-355.
39. Chadysiene R, Girgzdys A. Ultraviolet radiation albedo of natural surfaces. *J Environ Eng Landsc*. 2008;16(2):83-88.
40. Fjortoft I, Lofman O, Halvorsen TK. Schoolyard physical activity in 14-year-old adolescents assessed by mobile GPS and heart rate monitoring analysed by GIS. *Scand J Public Health*. 2010;38(5 suppl):28-37.
41. Lerstrup I, Dahl RA. Characteristics of forest sites used by a Danish forest preschool. *Urban For Urban Gree*. 2016;20:387-396.
42. Vanos JK, McKercher GR, Naughton K, et al. Schoolyard shade and sun exposure: assessment of personal monitoring during children's physical activity. *Photochem Photobiol*. 2017;93(4):1123-1132.

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