The study of children's physical activity

Peter Pagels[1] Cecilia Boldemann[2] Anders Raustorp[3]

[1]PhD student in public health sciences at Karolinska Institutet, senior registrar at Linnaeus University, Kalmar. E-mail peter.pagels@lnu.se. [2]Associate professor, public health sciences, Karolinska Institutet, and Centre for Epidemiology and Community Medicine. E-post: Cecilia.Boldemann@ki.se. [3]Associate professor, physiotherapy, and senior lecturer, University of Gothenburg. E-mail: anders.raustorp@gu.se.

Preschool children's physical activity is an important health promoter against several of the lifestyle diseases. Therefore it is important that the preschool environment encourages preschool children to healthy physical activity. In the Kidscape project we studied preschool children's physical activity during their stay at the preschool. The aim was to identify factors in the outdoor environment that influence children's activity patterns. Activation patterns were studied with both subjective methods (CARS and qualitative observation) and objective methods (pedometri and accelerometry). The results showed that preschool children's physical activity was higher in preschools with a good schoolyard environment. Conclusion: preschool outdoor environment can promote a healthy physical activity in preschool children.

Background

Why should we measure physical activity in children at preschool?

From an early childhood man has a unique capability of moving around in a lot of different ways by walking, running, cycling, swimming etc. From a biological perspective it is obvious that these capabilities were created in order to adapt to a multitude of environments in the search for food and other things necessary to sustain life. Some historians believe that mankind some 10000 years ago switched from living like nomads to a rather stationary life in organized societies. Even in those days we probably started developing certain health problems directly related to a physically less demanding life. In the modern society of today with its decreasing demand of occupational physical effort these health problems have escalated. Motion sensors such as accelerometers and pedometers are today commonly used in research as these devices store information in an unobtrusive and objective way, and are easy to handle.

There are serious consequences in the form of increasing prevalences of lifestyle diseases such as cardiovascular and metabolic diseases, certain cancers such as bowel cancer, and musculoskeletal diseases (O'Keefea JO et al. 2011).

Medical research has shown that important medical preventive action against these conditions is to decrease

sedentariness and to increase physical activity from a very early start, in fact as early in life as possible (Guinhouya BC & Hubert H, 2011, Oliver M et al. 2007). In order to develop and to specify these actions the focus of research should be as early as at preschool level, as it offers opportunities for early action to impact life style patterns, as well as opportunities to have an influence on the physical environment that the children are confined to during the major part of the day. Play and locomotion fuel children's development. Running around, climbing and bouncing are a part of verbal, emotional and social development. The vital importance of physical activity for people's health has been in focus since the mid-90s. (USDHHS, 1996). Research has shown that even moderate physical activity yields considerable health gains (Blair SN & Morris JN, 2009). It has also been stated that activity patterns established in childhood tend to have long-term effects up to adult age (Telama R. et al., 2005). Recommendations for preschool children state 60-180 minutes of at least moderate physical activity (Strong et al. 2005).

Definitions

Physical activity is defined as all movement carried out by skeletal muscles that contribute to metabolic increase (Caspersen et al. 1985). This concept is to be seen as an umbrella concept for human behavior that includes daily activities, transports, occupational activity, housework, gardening, aerobics etc. (USDHHS, 1996). There are some factors which are significant for the impact of physical activity, namely frequency, duration, intensity and type of activity. Frequency refers to how often physical activity takes place, commonly the number of episodes of moderate to vigorous physical activity during the course of a week or a day. Its duration refers to all uninterrupted time spans of physical activity.

Method

How do we measure physical activity?

Measuring the relationship between physical activity and health impact in preschool children requires reliable methods to assess frequencies (regularity), intensity (level of activity), duration, and that also gives a picture of the type of activity that is carried out. Subjective as well as objective methods (direct observation, self-reports) and objective measurement (heart rate, motion sensors) may be applied in measuring physical activity (Welk et al. 2002). Applying a mix of both subjective and objective methods may be preferred when studying children's physical activity patterns, especially when it comes to making changes in the physical environment or to bring about behavior change. Subjective measurement will amongst others tell you about the type of physical activity that is carried out, and the way children have experienced it, whereas objective measurement give a detailed picture of the duration, intensity and frequency of the physical activity.

Subjective methods in the Kidscape project

One subjective method that was used in the Kidscape project when studying the preschool children's physical

activity during outdoor stay in KIDSCAPE. It is a mode of quantitative observation termed Children´s Activity Rating Scale (CARS). CARS categorizes physical activity into five escalating intensity levels (Puhl et al.1990) which have also been tested and validated on young children (Durant et al. 1993). These intensity levels are defined as follows: 1) stationary without movement (the child is quite still), 2) stationery and moving (the child sits or stands on the same spot but moves its torso, arms or legs), 3) slow translocation e.g. ambling around, 4) medium-intensive translocation e.g. walking quickly, 5) rapid translocation, e.g. running. The observations were made when the children were outdoors. For speedy registration and download of each separated child's CARS data we used a pre-programmed PDA device. Observations were carried out systematically with the outdoor environment being divided into sections (behavior settings) which were scanned in a set order. Each section was observed from the right to the left and as soon as a child was seen in the range of vision its CARS value was registered. At the same time a mark was made on a map of the outdoor area of where that observation had taken place (Figure 1). This method,"behavior mapping", is in detail described by Cosco et al. (2010). Opposite to motion sensors such as pedometers and accelerometers, bodily movements e.g. without moving the torso such as ballgames, digging in the sandbox, tricycling may be registered by CARS.

During outdoor stay qualitative observations were made of the children's physical activity. During these observations the observer slowly wandered about registering the type of physical activity, and whether this took place alone, by two, three or in a group. Interaction and use of the physical en-

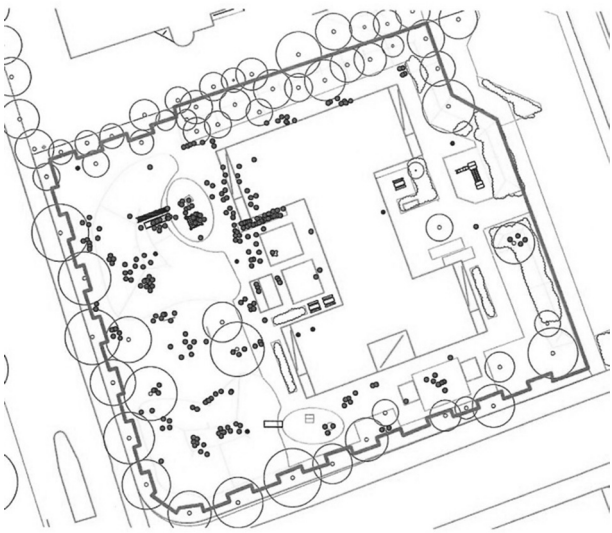

Figure 1. Mapping of the preschool children's location in the outdoors. One dot corresponds to one child.

vironment was also registered during these observation rounds. Maps were used to register these observations.

Objective methods for the measurement of physical activity

Motion sensors such as accelerometers and pedometers are today commonly used in research as these devices store information in an unobtrusive and objective way, and are easy to handle.

Pedometry

Pedometers are cost-effective, reliable and yield summed-up total data for one measurement period which may be useful for screening, guidance, surveillance and evaluation (Tudor-Locke C & Bassett DR Jr. 2004, Welk et al. 2000). Pedometers are very suitable when to convey an easily understandable message - and thereby a public health goal - to a general public audience, as data such as steps per day are easy to assimilate. The downside of the pedometer is the inability to measure intensity other than as steps per minute, and that it is not time-stamped. From the viewpoint of medical research it is data of the quality of movement that is important i.e. its intensity and exactly when it took place. The pedometer does not yield reliable values for certain common types of physical activity such as cycling, swimming and weight-carrying activities. On the other hand a conversion formula for e.g. cycling has been elaborated (Raustorp et al. 2013). The pedometer is also highly unreliable in "wrong" positions, for instance if being mounted upside down which easily happens in field studies with small children, especially if the device is attached to a removable belt instead of to the band of the trousers.

Accelerometry

The accelerometer too is a reliable motion sensor with a basic function resembling that of the pedometer, i.e. the mechanism is a little sensor that responds to change in direction. The accelerometer used in the Kidscape I project is an Actigraph GT1m which has been calibrated for children against heart rate, (Janz KF et al. 1994), indirect calorimetry (Melanson EL et al. 1995), observations (Fairweather SC et al. 1999) and metabolism by doubly labeled water (Ekelund U et al. 2001). Actigraph GT1m's register translocation (as does the pedometer) at one horizontal level, but the Actigraph GT3X available nowadays enables the registration of movements at three different levels at the same time: horizontal, frontal and transversal. Further, this time-stamped device registers the intensity of translocation at these levels and when it takes place. This is of great significance when it comes to assessing the quality of physical activity and thereby the pattern of activity. Accelerometers are able to distribute translocation data according to a preset registration epoch. Epochs ranging from a few up to 60 seconds are applied in research (McClain JJ et al. 2008). The sum of translocation during one epoch may be used to distribute the material along different intensity levels such as inactivity, light, moderate or vigorous physical activity. The threshold values of the different levels are set using so-called cut points, a pre-determined number of entries during one epoch

Table 1. Cut points according to Sirard et al. (2005)

Age	Inactivity	Light activity	Moderate activity	Vigorous activity
3-year-old	0-301	302-614	615-1230	>1230
4-year-old	0-363	364-811	812-1234	>1235
5-year-old	0-398	399-890	891-1254	>1254

that needs to be obtained for a certain activity level. Cut points may be changed in the accelerometer which makes it possible to adjust the device to various ages. Unfortunately there are no general guidelines for these cut points, however, some review articles supply good information for the determination of cut points (Sirard et al. (2005), Trost et al. 2010, Kim Y. et al. 2012). In Kidscape I we applied cut points according to the recommendations by Sirard et al (Table 1).

Apart from the cost the downside with the accelerometer is that it is likewise unable to yield reliable values of cycling, swimming and weight-carrying activities. Moreover, reliability decreases at high intensities. Fuzzy guidelines for the determination of cut points and the length of epochs are also a problem.

Results

Quantitative observations of physical activity as assessed by CARS was made at two preschools in downtown

Table 2. CARS observed values, F1.

F1	Outdoor education		CARS (Mean value)	P-value	
	All	N=352	2.51	0.038*	F1 & 2
Gender	Boys	n=196	2.61	0.016*	Boys-Girls
	Girls	n=156	2.38		
Social interaction	Alone	n=65	2.83	0.089	Alone- 1 playmate
	1 playmate	n=106	2.59	0.03*	1 playmate- Group
	Group	n=176	2.36	0.0005**	Alone- Group
			*Significance level<0.05,	**Significance level <0.001	

Table 3. CARS observed values, F2.

F2			CARS (Mean value)	P-value	
	All	N=429	2.37		
Gender	Boys	n=177	2.53	0.0025*	Boys-Girls
	Girls	n=252	2.26		
Social interaction	Alone	n=148	2.51	0.01*	Alone-1 playmate
	1 playmate	n=143	2.25	0.394	1 playmate-Group
	Group	n=135	2.34	0.128	Alone-Group
			*Significance level <0.05	**Significance level	<0.001

Table 4. Step count during preschool time, as measured by pedometry, and translocation intensity simultaneously measured by accelerometry.

	Indoors					Outdoors				
	STEPS	Inactive	Light activity	Moderate–Intensive activity	TIME	STEPS	SED	LIGHT	MV	TIME
Preschool 1	1973	122 min	14 min	3 min	139 min	6517	252 min	51 min	15 min	318 min
Preschool 2	2826	247 min	24 min	6 min	277 min	2731	82 min	33 min	9 min	124 min

Malmö, preschool 1(F1) practicing outdoor education, with 70 attending children aged 3-5 years, and preschool 2 (F2) attended by 57 children aged 3-5 years, practicing traditional preschool education. The outdoor environment of F1 was graded as good, i.e. triggered active play, whereas F2 was graded lower in this respect. The surface of F1 was three times the size of the one at F2 (3701 m^2 and 1053 m^2 respectively) with a translocation surface of 53m^2/child (F1) and 18m^2/child (F2) respectively.

The mean CARS value of intensity was observed to be significantly higher at F1 (2.51) compared to F2 (2.37) (Tables 2 and 3). In both preschools the intensity of translocation differed significantly between boys and girls. We also studied social interaction along with the registration of CARS values. F1 had significantly lower levels of physical activity during social communication in a group, and the highest intensities were observed during occasions when the child was on its own.

Physical activity, its frequency, duration and intensity, was higher when outdoors compared to indoor stay (Raustorp et al. 2012). At F1 the children's step count amounted at an average to 8490 steps per day, compared to F2 where the children merely obtained an average of 5557 steps per day. The total average step count of all 11 preschools participating in Kidscape I was for girls 7313 (±3017) steps per day, for boys 8385 (±3442) steps per day (Pagels P. et al. 2010). The time of moderate and vigorous physical activity during preschool time also differed (18 at F1 and 15 minutes at F2), in both cases far from the recommended 60 minutes (Raustorp et al. 2012).

For preschool children to obtain 60 minutes of moderate to vigorous physical activity published data have benchmarked 10000 -14000 steps daily (Tudor Locke et al 2011).

Conclusion

The levels of physical activity that have been measured in the Kidscape I project are insufficient. Parents may thus not count on satisfactory levels of physical activity during preschool time for part of their children. However, the design of the outdoors may promote healthy levels of physical activity in preschool children.

References

Blair SN & Morris JN. Healthy Heartstand the Universal Benefits of Being Physically Active: Physical Activity and Health Ann Epidemiol 2009;19:253–256.

Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep. 1985 Mar Apr;100(2):126-31.

Cosco N, Moore R, Islam M. Behavior Mapping: A Method for Linking Preschool Physical Activity and Outdoor Design. Med. Sci. Sports Exerc., Vol. 42, No. 3, pp. 513–519, 2010

Durant RH, Baranowski T, Puhl J, et al. Evaluation of the Children's Activity Rating Scale (CARS) in young children. Med Sci Sports Exerc. 1993;25(12):1415–21.

Ekelund U, Sjostrom M, Yngve A, Poortvliet E, Nilsson A, Froberg K, et al. Physical activity assessed by activity monitorand doubly labeled water in children. Med Sci Sports Exerc 2001; 33: 275–81.

Fairweather SC, Reilly JJ, Grant S, Whittaker A, Paton JY. Using the Computer Scienceand Applications (CSA) activity monitor in preschool children. Pediatr Exerc Sci 1999; 11: 413–20.

Freedson PS, Miller K. Objective monitoring of physical activity using motion sensors and heart rate. Res Q Exerc Sport 2000; 71: 21–9.

Guinhouya BC & Hubert H. Insight into physical activity in combating the infantile metabolic syndrome: Environ Health Prev Med. 2011 May; 16(3): 144–147.

Janz KF. Validation of the CSA accelerometer for assessing children's physical activity. Med Sci Sports Exerc 1994; 26: 369–75.

Kim Y, Beets MW, Welk GJ. Everything you wanted to know about selecting the "right" Actigraph accelerometer cut-points for youth, but. . .: A systematic review. J Sci Med Sport (2012), doi:10.1016/j.jsams.2011.12.001

McClain JJ, Abraham TL, BrusseauTAJr, Tudor-Locke C. Epoch length and accelerometry outputs in children: comparison to direct observation. Med Sci Sports Exerc 2008; 40:2080–7.

Melanson EL, Freedson PS. Validity of the Computer Science and Applications, Inc. (CSA) activity monitor. Med Sci Sports Exerc 1995; 27: 934–40.

O'Keefea JO, Vogelb R, Laviec CJ, Cordaind L. Exercise Like a Hunter-Gatherer: A Prescription for Organic Physical Fitness. Progress in Cardiovascular Diseases: Volume 53, Issue 6, May–June 2011, Pages 471–479

Oliver M, Schofield G, Kolt G. Physical activity in preschoolers: understanding prevalence and measurement issues. Sports Med 2007; 37: 1045–70.

Puhl J, Greaves K, Hoyt M, Baranowski T. Children's Activity Rating Scale (CARS): description and calibration. Res Q Exerc Sport. 1990;61(1):26–36.

Pagels P, Boldemann C, Raustorp A. Comparison of pedometer and accelerometer measures of physical activity during preschool time on 3- to 5-year-old children. Acta Pædiatrica 2010; ISSN 0803–5253.

Raustorp A, Pagels P, Boldemann C, Cosco N, Söderström M, Mårtensson F. Accelerometer measured level of physical activity indoors and outdoors during preschool time in Sweden and the United States. J Phys Act Health. 2012 Aug;9(6):801-8. Epub 2011 Aug 2.

Raustorp A, Boldemann C, Mårtensson F, Sternudd C, Johansson M. Translation of children's cycling into steps: the share of cycling in 10-year-olds' physical activity. Int J Adolesc Med Health. 2013 Jan 17:1-6. doi: 10.1515/ijamh-2013-0026.

Sirard JR, Trost SG, Pfeiffer KA, Dowda M, Pate RR. Calibration and evaluation of an objective measure of physical activity in preschool children. J Phys Act Health 2005; 3: 345–57.

Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, Hergenroeder AC, Must A, Nixon PA, Pivarnik JM, Rowland T, Trost S, Trudeau F. Evidence Based Physical Activity for School- age Youth. J Paediatrics 2005; 146 (6): 732-737.

Telama R, Yang X, Viikari J, Välimäki I, Wanne O, Raitakari O: Physical activity from childhood to adulthood: a 21-year tracking study. Am J Prev Med 2005;28:267–273.

Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of Accelerometer Cut Points for Predicting Activity Intensity in Youth. American College of Sports Medicine 2010.

Tudor-Locke C, Bassett DR Jr. How many steps/day are enough? Preliminary pedometer indices for public health. Sports Med 2004; 34: 1–8.

Tudor-Locke C, Pangrazi RP, Corbin CB, Rutherford WJ, Vincent SD, Raustorp A, et al. BMI-referenced standards for recommended pedometer determined steps/day in children. Prev Med 2004; 38: 857–64.

Tudor-Locke C ,Craig CL, Bassett DR, Beets MW, Belton S, Cardon G, Duncan JS,Hatano Y, Lubans DR, Olds TS, Raustorp A, Rowe DA, Spence JC, Tanaka S, Blair SN. How many steps are enough for children and adolescents? International Journal of Behavioral Nutrition and Physical Activity 2011,8:78 doi:10.1186/1479-5868-8-78.

US Department of Health and Human Services. Physical activity and health: a report from the Surgeon General. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.

Welk GJ, Differding JA, Thompson RW, Blair SN, Dziura J, Hart P. The utility of the Digiwalker step counter to assess daily physical activity patterns. Med Sci Sports Exerc 2000; 32: S481–8.

Welk GJ. Physical Activity Assessments for Health-Related Research. Champaign, IL: Human Kinetics, 2002.