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Original Article

Recreational screen time, sedentary behavior, and moderate to vigorous physical activity in 11-year-old children

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Abstract:
*Problem statement:*Previous research has focused on the multiple effects of physical activity and sedentary behavior. However, the associations between physical activity and sedentary behavioneed more research. Recreational screen time, a part of children's sedentary behavior, has increased rapidly during the last few decades,and threatens to conquer time undertakingphysical activities. *Purpose*: This quantitative case study aimed to examinechildren's recreational screen time, sedentary behavior and moderate to vigorous physical activity, and especially the associations between them. *Approach*: The convenience sample consisted of 33 11-year-old children (20 boys, 13 girls) from a primary school in the capital area of Finland. Sedentary behavior and moderate to vigorous physical activitywere objectively registered for seven consecutive days and nights with wrist-worn accelerometers. Recreational screen time was self-reported. *Main results:* Boys spent three times more hours on recreational screen time than girls did during schooldays, and four times more during the weekend. An increase in sedentary behavior was associated with a decrease in moderate to vigorous physical activity. During the weekend, children accumulated less moderate to vigorous physical activity and more sedentary behavior. Recreational screen time was not associated with sedentary behavior, but a negative association with boys' moderate to vigorous physical activity was found.*Conclusions*: The results suggest that sedentary behavior and especially boys' recreational screen time have a 'tug of war' with their moderate to vigorous physical activity for their shares of children's time use. Atthe school level, these results provide adviceto make schooldays more physically active, and for physical educationteachers to motivate children to engage more in physical activities instead of sedentary behavior during leisure time. Additionally, screen gamesthat aremore physically active need to be developed, because pursuits of strongly limiting recreational screen time may be fighting a losing battle. *Future research*: Sedentary behavior, recreational screen time and different intensity levels of physical activity together with sleep time, should be studied with bigdata andobjectivemeasurements during all seasons of the year, and in at least weeklong periods.
KeyWords*:* ***S*edentary behavior, screen time, physical activity, moderate to vigorous physical activity, children, primary school,**

Introduction

Sufficient moderate to vigorous physical activity (MVPA) has multiple positive effects on children's health, e.g.,cardio metabolic risk factors (Janssen & LeBlanc 2010; Poitras et al. 2016), psychological and sociological well-being (Bangsbo et al. 2016),and attention and academic achievement (Kantomaa et al. 2015; Marques et al. 2018; Watson et al. 2021). Therefore, it is important to promote children's accumulation of MVPA, which refers to the energy expenditure of physical activity that is at least three times higher than when resting (WHO 2020).

However, when sufficient MVPA benefits children in many ways, excessive sedentary behavior (SB) has been found to have many opposite effects (Adelantado-Renau et al. 2019; Carson et al. 2016; Hale & Stanford 2015; Ishii et al. 2020; Rideout et al. 2010; Saunders &Vallance 2017; Stiglic & Viner 2019). Sedentary behavior refers to waking behavior like sitting or lying (WHO 2020).

It has been reported that MVPA decreases, and SB increases during the nine years of basic education (Colley et al. 2011; Steene-Johannessen et al. 2020; Troiano et al. 2008). Steene-Johannessen et al. examined physical activity and sedentary time data from 30 European studies. They found that the amount of MVPA of both sexes started to decrease fromthe start of basic education, and the amount of SB to increase already few years before entering the school.On average,boys accumulated more MVPA and slightly more SB compared to girls.SB increased from 250 minutes per day (4–5 yrs.) to around 400 minutes (12–13 yrs.) in both sexes. The decrease of MVPA was slower, when the boys' MVPA (6–7 yrs.) was over 60 minutes, the amount at the end of primary school (12–13 yrs.) was around 55 minutes. The equivalent MVPA figures for girls were 48 and 38 minutes, respectively.(Steene-Johannessen et al. 2020.) These trendsprovideadviceto continue encouraging children to be physically more active, and to limit their SB. Consequently, in the World Health Organization's new global guidelines (WHO 2020), include the recommendationsboth for SBand MVPA. WHO recommends

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limiting the amount of SB, particularly the amount of screen time (ST):watching television, computer and mobile devices.Recreational screen time (RST) is a part of screen timewhen the screen devices are,instead of school homework,used for entertainment like watching movies, videos, and playing games with a smartphone, tablet, console, or computer (Stiglic & Viner 2019; Tremblay et al. 2017). Additionally, chatting and messaging in social media are fast-growing RST trends. Children's RST has been changing during the last few decades, when watching TV has decreased and the use of computers and mobile devices has increased, especially among boys (Bucksch et al. 2016; Rideout et al. 2010).RST is increasing rapidly due to the fast developing, captivating devices and applications (Rideout 2010). Currently, SB consists mostly of ST, as children use screen devices usually in sitting or lying-down positions. However, the devices may also be used in physically active ways (Tremblay et al. 2017).

The positive outcomes of MVPA (Janssen & LeBlanc 2010; Poitras et al. 2016) and negative outcomes of SB (Carson et al. 2016; Janssen & LeBlanc 2010) have beenquite widely studied. Moreover, Tremblay et al. completed four systematic reviews to combinemore widely the relationships between physical activity (PA), SB and sleep and their associations with health indicators.According to Saunders et al. (2016), the available data suggest that replacing SB with MVPA helps the achievement ofoptimal health benefits. The importance of the associationshas been the focus of some recent national physical activity guidelines (Jago 2019; Okely et al. 2019, Tremblay et al. 2016) and now in the global recommendations of WHO (2020).

Because of the rapid growth of RST, the question if it increases SB and consequently jeopardizes the pursuits of accumulating the recommended MVPA minutes to gain the positive outcomes, need to be studied especially in primary school aged children. Having moredata onthese associations is important for physical education teachers, because according to the main objective of the subject, they havea special role in the development of a physically active lifestyle in children.Kondakov et al. reported (2020) that physical education lessons in their study did not have a physically developing training effect. Physically active lessons and recesses are also good ways of increasing physical activity (Valtonen et al. 2020). However, we need to remember that developing a physically active lifestyle includes many other factors than accumulating MVPA minutes or increasing physical training.

The purpose of this study wasfirstly to explore the amounts of recreational screen time, total sedentary time and moderate to vigorous physical activity during a week-long measurement period. The second purpose was to examine the associations between them. Thirdly, our aim was to study the differences between genders and the differences between schooldays and weekends.

Material & methods

Participants

The participants were the pupils (N=33) of two fourth grade classes comprising 13 girls and 20 boys. The school selection was based on convenience sampling, representing a typical primary school situated in a capital area city in Southern Finland, attended bypupils living in thatschool district. The fourth grade was selected because the age of eleven years seemedto be a starting point for increased ST (Rideout et al. 2010). The mean age of the participants was 10.7 years. Permission was granted bythe pupils, their caregivers, teachers, the principal of the school, and the school administration of the city.

Data collection and procedure

Data were collectedacrossseven consecutive days and nights. Recreational screen time data were collected using self-reports in theform of a structured diary. Physical activity was measured with a Uniaxial Polar Active® (PAC) wrist-worn physical activity monitor (Polar Electro Ltd, Finland). The device records data in thirty seconds epochs and calculates the energy expenditure in METs (metabolic equivalent) hased on auser's sex, age, height and weight. In this study, pupilswere able to view their activity data, but the displays were locked to prevent the settings being changed. According to previous studies, children seem to favor wrist-worn physical activity monitors (Ridgers et al. 2016), finding them more convenient to use compared to waist-worn devices (Fairclough et al. 2016).

Caregivers were provided witha research information sheet explaining the measurements. In addition, they were asked to provide relevant information (date of birth, gender, height, weight) to adjust the children's activity monitors individually. Pupils and their caregivers received written instructions for the use of the activity monitors:"*Keep the device around the wrist of your writing hand continuously for seven days and nights. You may take showers, go swimming or to the sauna and wash as usual. It is very important, that you do not do anything that differs from your normal behavior."*

Physical activity monitors and diaries were given to pupilson a Monday morning at the end of March. The data collection began the following night at 00:00 and continued up to midnight between Monday and Tuesday in the following week, accumulating physical activity data for seven days and nights including the Monday after the weekend. Diaries and activity monitors were collected on the day after the measurement period.

Diaries were used to collect descriptive data of their daily RST. Diaries are suitable for this kind of data collection (Steene-Johannessen et al. 2016). Each day had a similarly structured part in the diary:"*When and for how long time did you do some of the following activities after school?"* The options were watching television,

playing computer and Play Station games. Children couldalso add other screen activities. There were given an example of filling in the diary:"*I watched TV 16:15–17:00 and 18:00–18:30.* Additionally, they were advised to "*ask for the guidance of your teacher or caregiver."* The diary sheets for the weekend were similar, but didnot include the schooldays specifications.

Daily weather during the measurement week was typical for the end of March in Southern Finland. Tuesday; sunshine, 6–8 °C, Wednesday; cloudy, wet snow, -1–1°C, Thursday; sunny, 0–2 °C, Friday; cloudy, rain, 1–3 °C, Saturday; cloudy, rainy 1 °C, Sunday; cloudy 1 °C, Monday; cloudy, wet snow 0 °C.

Data analysis

RST was manually picked up from the diaries. The various RST activities were accumulated to represent the total sum of RST in minutes.The activity monitor data were transmitted to the Polar GoFit net server (https://polargofit.com). Raw data of metabolic equivalent values in 30-second epochs were saved in aMicrosoft Excel spreadsheet and dividedinto seven daily data files. Six pupils out of the 39 were removed due to their insufficient data. Edited data were fed into the IBM SPSS Statistics 24 software package to count the daily amounts of PA and SB in minutes. The intensity of the MVPA was defined as ≥3 MET (metabolic equivalent) according to the consensus report (Tremblay et al. 2017). An example activity of MVPA is brisk walking, but more intensive physical activities are included in MVPA (Hildebrand et al. 2014; Polar 2010; Phillips et al. 2013; Schaefer et al. 2014). SB, like sitting or lying down, was definedas 1–1.5 MET. Thus, sleeping (< 1 MET) was not counted as SB and physical activities of light intensity (1.5–3 MET) were not included (Tremblay et al. 2017.)

Daily means, standard deviations, and ranges of RST, SB, and MVPA were calculated. Furthermore, they were combinedinto total values of the whole week (Tuesday–Monday), schooldays (Monday–Friday), and weekend (Saturday–Sunday). Due to the small sample size (N = 33), we used the non-parametric Mann-Whitney U test, to analyze the differences between boys and girls. Effect sizes were calculated using the Z and N values of the Mann-Whitney U test. The associations between ST, SB and MVPA were studied with the Pearson product-moment correlation coefficient. We used Cohen's (1988) definition, that correlation (r) can be interpreted to represent an effect size of the relationship, when the correlation .20–.49 represents small, .50–.79 medium, and ≥ .80 large effect size.

Results

Recreational screen time (RST)

The mean of self-reported daily RST for the whole week was 90 minutes (Table 1). During the weekend, the amount of RST was 40minutes higher compared to schooldays. Significant differences between girls and boys were found on every day except Monday.

Table 1. Self-reported recreational screen time (min), and differences between genders.

	All participants				By gender								
	N	*M*	*SD*		n	*M*	*SD*	Range	M-W	Z	*p*	ES	R^2
Whole week	31	93	63	girls	13	43	27.5	0 - 107	14.0	-4.1	< .0005	-.75	.56
				boys	18	129	55.0	34 - 246					
Schooldays	31	82	56	girls	12	43	39.1	0 - 150	25.5	-3.7	< .0005	-.67	.45
				boys	18	110	47.7	36 - 210					
Weekend	30	125	101	girls	13	40	35.5	0 - 110	9.5	-4.2	< .0005	-.76	.58
				boys	18	181	90.5	30 - 390					
Tuesday	31	77	66	girls	13	35	40	0 - 90	39.0	-3.1	.002	-.56	.31
				boys	18	108	51	0 - 240					
Wednesday	31	85	73	girls	13	53	66	0 - 200	60.5	-2.3	.023	-.41	.18
				boys	18	108	64	0 - 240					
Thursday	29	66	66	girls	11	28	37	0 - 85	44.0	-2.5	.012	-.46	.22
				boys	18	88	60	0 - 240					
Friday	29	90	75	girls	13	49	63	0 - 168	44.0	-2.6	.008	-.48	.23
				boys	16	123	75	0 - 270					
Saturday	30	127	100	girls	12	47	54	0 - 150	17.5	-3.9	< .0005	-.71	.51
				boys	18	180	65	60 - 390					
Sunday	27	106	107	girls	12	33	28	0 - 70	16.5	-3.6	< .0005	-.69	.48
				boys	15	164	112	0 - 480					
Monday	27	91	87	girls	11	58	75	0 - 215	51.0	-1.9	ns	-.37	.13
				boys	16	115	84	0 - 255					

ES = Effect Size, M-W = Mann-Whitney U statistic,

R^2 = Proportion of the variance for a dependent variable explained by an independent variable

Acrossthe whole week, boys spent three times more hours on RST than girls. Throughout the weekend, this ratio increased to four. The girls' RST remained stable during the week when that of the boys' increased by more than an hour on the weekend compared to schooldays. Gender explained half of the variance for screen time and the effect sizes were large throughout the week.

Sedentary Behavior and Moderate to Vigorous Physical Activity, and the association between them

Children's daily average spent in sedentary behaviors was 6.5 hours (Table 2). During the weekend, the amount of SB was 30 minutes higher compared to schooldays. MVPA was accumulatedfor 1.5 hours during the whole week. On the weekend, MVPA was 45 minutes less than during the schooldays. Significant differences between boys and girls were not found, but the differences between individuals among boys and girls were remarkably large.

Table 2. Objectively measured SB (1–1.5 MET), MVPA (≥ 3 MET), and associations between them.

		SB (min)			MVPA (min)			Correlations	
	N	*M*	*SD*	Range	*M*	*SD*	Range	*r*	*p*
Whole week	33	392	82	203 - 551	92	30	46 - 158	-.39	.027
Schooldays	33	383	78	197 - 537	104	32	53 - 170	-.41	.017
Weekend	33	414	114	203 - 615	59	36	13 - 163	-.28	ns
Tuesday	33	360	78	194 - 549	124	49	65 - 247	-.45	.008
Wednesday	33	383	85	196 - 548	98	38	32 - 181	-.37	.034
Thursday	32	357	75	221 - 520	127	34	70 - 184	-.13	ns
Friday	32	413	114	209 - 641	87	26	44 - 130	-.42	.016
Saturday	30	455	130	223 - 718	54	33	13 - 141	-.53	.003
Sunday	31	382	107	172 - 615	71	47	13 - 186	-.35	ns
Monday	31	413	108	146 - 584	84	51	19 - 241	-.72	< .001

SB = Sedentary Behaviour, MVPA = Moderate to Vigorous Physical Activity

Saturday was the least physically active day compared to schooldays, in terms of spending more time engaged in sedentary behaviors and less time in MVPA. Friday and Monday in connection with the weekend formed an 'extended physically passive weekend' compared to the middle part of the week. The correlations between SB and MVPA were negative during all weekdays, exceeding the moderate level of the association on most days.

Recreational Screen Time associated with Sedentary Behavior and Moderate to Vigorous Physical Activity

Recreational screen time did not have any significant associations withSB and the correlations werelow on average (Table 3). On Saturday, when children had the most SB, boys' RST correlated moderately negatively to SB. Monday, the first school day after the weekend, was the only day when both girls' and boys' correlations were positive on at least a medium level. A similar connection existed among boys on Sunday. In these cases, RST explained 14–25% of the variance for SB.

Table 3. Recreational screen time associated with SB (1–1.5 MET) and MVPA (≥ 3 MET).

		SB						MVPA					
		girls			boys			girls			boys		
		n	r	*p*	n	r	*p*	r	n	*p*	r	n	*p*
RST	Whole week	13	-.28	ns	18	-.07	ns	.08	13	ns	-.51	18	.031
	Schooldays	13	-.16	ns	18	-.11	ns	-.07	13	ns	-.59	18	.011
	Weekend	12	.13	ns	18	-.08	ns	.08	12	ns	-.35	18	ns
	Tuesday	13	.08	ns	18	.16	ns	-.22	13	ns	-.52	18	.026
	Wednesday	13	-.06	ns	18	-.03	ns	.00	13	ns	-.55	18	.019
	Thursday	11	-.29	ns	18	.06	ns	.42	11	ns	-.14	18	ns
	Friday	13	-.33	ns	16	-.04	ns	-.05	13	ns	-11	16	ns
	Saturday	11	.15	ns	16	-.49	ns	.07	11	ns	-.29	16	ns
	Sunday	12	-.10	ns	15	.39	ns	-.27	12	ns	.04	15	ns
	Monday	11	.37	ns	16	.41	ns	-.46	11	ns	-.58	16	.025

RST = Recreational Screen Time

SB = Sedentary Behaviour

MVPA = Moderate to Vigorous Physical Activity

A significant negative, medium level association between RST and boys' MVPA existed on schooldays and consequently forthe whole week. On the weekend, the association was small, but not significant. Among girls, the associations between RST and MVPA were moderate, but not significant on only two single days.

Discussion

This case study investigated the amounts of recreational screen time (RST), sedentary behavior (SB), moderate to vigorous physical activity (MVPA) and especially, the associations between them, in 11-year-old children. The key findings were: 1) Boys spent three times more hours on RST during the schooldays and four times more during the weekend, compared to girls. 2) An increase in SB was associated with a decrease in MVPA. The weekend, even an 'extended weekend', was physically more passive when children accumulated

less MVPA and more SB compared to schooldays. 3) RST had a negative association with boys' MVPA, but was not associated with SB.

First, our finding that boys spend more RST, especially during weekends, is in line with the previous review byBucksch et al. (2016). However, the amounts of RST in our study are much lower, and difference between girls and boys is farhigher, compared to the results in the review. This difference may partly be explainedbyour narrower focus on RST, instead of counting the total screen time with homework. The participants inour study did not mention doing homework with computers in their diaries. Differing from our study, a recent Finnish national survey did not find differences between girls' and boys' self-reported screen times, when measured with the proportion of children exceeding the screen time recommendation of two hours (Kokko et al. 2019). Girls' low RST in our study may be partly explained by their hobbies and screen-free activities with their friends, siblings, and parents. Girls reported them more often in their diaries, compared with the boys. However, thosedata were not used in this study, due to the small number of participants. In comparison with the other studies (Bucksch et al. 2016; Kokko et al. 2019), the lower number of RSTminutes can be considered to bea good sign, because children still have hobbies and spend screen-free time with their friends and family. However, the much higher RST of the boys, compared to the girls, needs to be noted. Do boys seek excitement from the screen games instead of physically active hobbies or screen-free playing with their friends?

Second, an increase in SB was associated with adecrease inMVPA. Weekends were physically less active when children accumulated less MVPA and more SB, which is in line with the findings of previous studies (Noonan et al., 2016; Owen et al., 2009; Steele et al. 2010). Objectively measured SB and MVPA were only slightly lower than in a national Finnish survey (Husu et al. 2019). Conversely, Owen et al. (2009) reported higher SB and lower MVPA, in their study among British children froma range ofethnic backgrounds (Steele et al. 2010). Our results suggest that pupils' 'weekends' may be extended with two days, in terms of accumulating less MVPA and more SBfrom Friday to Monday. The concept of 'weekend', meaning Saturday–Sunday, is equivocal because Friday differs from the other days of the school week because the next day is not a school day. Respectively, Sunday differs from other days because the next day is a school day. These may be reasons to consider Fridayto be a minor part of the weekend. Instead, on Monday, children may be tired after the weekend, because they mighthave stayed awake longer in the evening and slept longer the next morning. Therefore, Monday may still be a 'consequence' of the weekend or 'landing' at the school week. We did not find differences in SB and MVPA between girls and boys, supporting the Finnish results byHusu et al. (2019). However, studies by Aubert et al. (2018), Nader et al. (2018), Steele et al. (2010), and Steene-Johannessen et al. (2020) showed that boys are physically more active than girls are. Lower accumulated minutes of MVPA in this study may partly be explained by the weather conditions. The week of the measurements at the end of March was chilly and rainy. According to previous studies, weather like this decreases physical activity (Atkin et al. 2016; Harrison et al. 2011 and 2015; Mattocks et al. 2007; Rich et al. 2012) and may have increased SB.

Third, RST did not seem to be associated with the total SB, suggesting that the time for screen time is taken from somewhere else. However, a negative association between RST and MVPA was found among boys, who spent at least times more on RST than girls did. This finding suggests that RST may challenge the pursuits of the PA recommendations. The most likelyreason for this is that screen-based games and social media are mainly used when sitting, lying or standing. According to earlier studies, boys are more likely to be heavy users of screen-based games (Bucksch et al. 2016). The suggestion, that RST reduces MVPA is contradicted by the study byRideout (2010), in which it was concluded that the level of PA does not vary by time spent using media. This view is supported by Tremblay et al. (2017), who reminded us that screen devices can also be used in physically active ways. On the other hand, when screen devices are in sedentary use, they may supersede the moments for PA.

This study had limitations that should be noted. The convenience sample from one school was small; therefore, the results cannot be generalized to Finnish children of this age. However, the school was a typical capital area primary school in Southern Finland, allowing for at least suggestive local generalization. The timing of the study did not favor outdoor activities and reduced MVPA. Our method of applying self-reports did not seem to be a precise way tomeasure RST. More guidance from their caregivers would have helped many children to report the RST minutes more often and more precisely. Even though SB and MVPA were measured objectively, wrist-worn PA monitors may give vague results depending on the type of physical activity (Kim et al. 2014; Noonan et al. 2016). Bicycling is a common physical activity among childrenbut it is underestimated. Additionally, PA monitors have been found to activate children to move more than usual, which may bias the results (Ridgers et al. 2016). Therefore, the PA data fromthe first day were removed. The small number of participants in this study did not allow the use of more sophisticated statistical methods.

Conclusions

The results of this study suggest that sedentary behavior (SB) and moderate to vigorous physical activity (MVPA) are struggling for their shares of children's time use. Recreational screen time (RST) as a growing part of SB seems to reduce MVPA among 11-year-old boys but not among girls.

These results suggest that physical activitiesshould be mademore tempting and easierto reach. Atthe school level, the advice from these results isto make the schooldays physically more active.Physically active

lessons, recesses and school commuting are effective ways of accumulating MVPA. Physical educationteachers may need to raise the intensity of their lessons(Kondakov et al. 2020), teach multiple skills, and enable positive experiences, to motivate children to engage more in physical activities during their leisure time. Even though schools have an important role in making children's days physically more active (Haapala 2017), we need to understand, that the development of screendevices and applications is inevitable. Trying to prevent or strongly limit especially boys' use of screen-based games may be a major challenge. Instead, application developers and the screen game industry should develop physically active screen-based games which can be played indoors and outdoors.

Future research should be directed to study SB, RST and different intensity levels of PA and sleep time, to form a holistic picture of their associations with each other. Large and objectively measured data should be collected during the other seasons of the year, and at least for week-long periods.

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References:

Adelantado-Renau, M., Moliner-Urdiales, D., Cavero-Redondo, I., Beltran-Vall, M.R., Martínez-Vizcaíno, V. &Álvarez-Bueno, C. (2019). Association Between Screen Media Use and Academic Performance Among Children and Adolescents. A Systematic Review and Meta-analysis. *JAMA Pediatrics173*(11), 1058–1067. doi:10.1001/jamapediatrics.2019.3176

Atkin, A. J., Sharp, S.J., Harrison, F., Brage, S. & Van Sluijs, E.M.F. (2016). Seasonal Variation in Children's Physical Activity and Sedentary Time. *Medicine Science in Sports & Exercise*, *48*(3), 449–456. doi: 10.1249/MSS.0000000000000786

Aubert, S., Barnes, J.D., Abdeta, C., Nader, P.A., Adeniyi, A.F., Aguilar-Farias, N., Tenesaca, D.S.A., Bhawra, J., Brazo-Sayavera, J., Cardon, G., Chang, C-K., Nyström, C.D., Demetriou, Y., Draper, C.E., Edwards, L., Emeljanovas, A., Gába, A., Galaviz, K.I., González, S.A., Herrera-Cuenca, M., Huang, W.Y. . . . Tremblay, M.S. (2018). Global Matrix 3.0 Physical Activity Report Card Grades for Children and Youth: Results and Analysis From 49 Countries. *Journal of Physical Activity and Health15*(2), 251–273. https://doi.org/10.1123/jpah.2018-0472

Bangsbo, J., Krustrup, P., Duda, J., Hillman, C., Andersen, L.B., Weiss, M., Williams, C.A., Lintunen, T., Green, K., Hansen, P.R., Naylor, P-J., Ericsson, I., Nielsen, G., Froberg, K., Bugge, A., Lundbye-Jensen, J., Schipperijn, J., Dagkas, S., Agergaard, S. . . . Elbe, A-M. (2016). The Copenhagen Consensus Conference 2016: children, youth, and physical activity in schools and during leisure time. *Br J Sports Med* (50), 1177–1178. http://dx.doi.org/10.1136/bjsports-2016-096325

Bucksch, J., Sigmundova, D., Hamrik, Z., Troped, P.J., Melkevik, O., Ahluwalia, N., Borraccino, A., Tynjälä, J., Kalman, M. &Inchley, J. (2016). International Trends in Adolescent Screen-Time Behaviors From 2002 to 2010. *Journal of Adolescent Health* 58, 417–425. http://dx.doi.org/10.1016/j.jadohealth.2015.11.014

Carson, V., Hunter, S., Kuzik, N., Gray, C.E., Poitras, V.J., Chaput, J-P., Saunders, T.J., Katzmarzyk, P.T., Okely, A.D. & Connor Gorber, S., Kho, M.E., Sampson, M., Lee, H. & Tremblay, M.S. (2016). Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Applied Physiology, Nutrition and Metabolism*41, 240–265. dx.doi.org/10.1139/apnm-2015-0630

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Colley R.C., Garriguet D., Janssen I., Craig C.L., Clarke J. & Tremblay M.S. (2011). Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 *Canadian Health Measures Survey. Health Reports*, *22*(1). Statistics Canada, Catalogue no. 82-003-XPE.

Fairclough, S.J., Noonan, R., Rowland, A.V., Van Heese, V., Knowles, Z. &Boddy, L.M. 2016. Wear Compliance and Activity in Children Wearing Wrist- and Hip-Mounted Accelerometers. Medicine Science in Sports &Exercise, *48*(2), 245–253.

Haapala, H., Hirvensalo, M.H., Kulmala, J., Hakonen, H., Kankaanpää, A., Laine, K., Laakso, L. & Tammelin, T.H. (2017). Changes in physical activity and sedentary time in the Finnish Schools on the Move program: a quasi-experimental study. *Scand J Med Sci Sports* (27), 1442–1453. doi: 10.111Grgic1/sms.12790

Hale, L. & Stanford, G. (2015). Screen time and sleep among school-aged children and adolescents: A systematic literature review. *Sleep Medicine Reviews* 21, 50–58. http://dx.doi.org/10.1016/j.smrv.2014.07.007

Harrison, F., Jones, A.P., Bentham, G., Van Sluijs, E.M.F., Cassidy, A. & Griffin, S.J. (2011). The impact of rainfall and school break time policies on physical activity in 9-10 year old British children: a repeated measures study. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(47). https://doi.org/10.1186/1479-5868-8-47

Harrison, F., Van Sluijs, E.M.F., Corder, K., Ekelund, U. & Jones, A. (2015). The changing relationship between rainfall and children's physical activity in spring and summer: a longitudinal study. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(41). https://doi.org/10.1186/s12966-015-0202-8

Hildebrand, M., Van Hees, V.T., Hansen, B.H. & Ekelund, U. (2014). Age Group Comparability of Raw Accelerometer Output from Wrist- and Hip-Worn Monitors. Medicine *Science in Sports & Exercise*, *46* (9), 1816–1824. doi: 10.1249/MSS.0000000000000289

Husu, P., Jussila, A-M., Tokola, K., Vähä-Ypyä, H. &Vasankari, T. (2019). Objectively measured amount of sedentary behavior and sleep.Published in Finnish.Objektiivisesti mitatun paikallaanolon, liikkumisen ja unen määrä. In S. Kokko & L. Martin (toim.) *Lasten ja nuorten liikuntakäyttäytyminen Suomessa. LIITU-tutkimuksentuloksia 2018*. Valtionliikuntaneuvostonjulkaisuja 2019:1, 29–40.

Ishii, K., Aoyagi, K., Shibata, A., Koohsari, M.J., Carver, A. & Oka, K. (2020) Joint Associations of Leisure Screen Time and Physical Activity with Academic Performance in a Sample of Japanese Children. *Int. J. Environ. Res. Public Health*, 17, 757. doi:10.3390/ijerph17030757

Jago, R. (2019). *UK Chief Medical Officers physical activity guidelines 2019*: *Children and Young People Physical Activity Guidelines*, 24–27. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832868/uk-chief-medical-officers-physical-activity-guidelines.pdf

Janssen, I. & LeBlanc, A.G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity* 2010, *7* (40). https://doi.org/10.1186/1479-5868-7-40

Kantomaa, M., Stamatakis, E., Kankaanpää, A., Kajantie, E., Taanila, A. & Tammelin, T. (2015). Associations of Physical Activity and Sedentary Behavior With Adolescent Academic Achievement. *Journal of Research on Adolescence*, *26*(3), 432–442.Doi: 10.1111/jora.12203

Kim, Y., Lee, J-M., Peters, B.P., Gaesser, G.A. & Welk, G.J. (2014). Examination of Different Accelerometer Cut-Points for Assessing Sedentary Behaviors in Children. *PLoS ONE 9*(4). oi:10.1371/journal.pone.0090630.

Kokko, S., Martin, L., Villberg, J., Ng, K. & Mehtälä, A. (2019). Self-assessed physical activity, screen time and social media, as well as movement monitoring devices and applications. Published in Finnish. Itsearvioitu liikunta-aktiivisuus, ruutuaika ja sosiaalinen media sekä liikkumisen seurantalaitteet ja -sovellukset. In S. Kokko & L. Martin (Eds.) *Lasten ja nuorten liikuntakäyttäytyminen Suomessa. LIITU-tutkimuksen tuloksia 2018*. Valtion liikuntaneuvoston julkaisuja 2019:1, 17–25.

Kondakov, V.L., Voloshina, L.N., Kopeikina, E.N. &Kadutskaya, L. (2020). Daily assessment of physical activity in 6–11-year-old children.*Journal of Physical Education and Sport*. *20*(4), 1673–1680. doi:10.7752/jpes.2020.04227

Marques, A. Santos, D.A., Hillman, C.H. &Sardinha, L. (2018). How does academic achievement relate to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6–18 years.*British Journal of Sports Medicine*52(1039). DOI: 10.1136/bjsports-2016-097361

Mattocks, C., Leary, S., Ness, A., Deere, E.K., Saunders, J., Kirkby, J., Blair, S.N., Tilling, K. &Riddoch, C. (2007). Intraindividual Variation of Objectively Measured Physical Activity in Children. *Medicine Science in Sports & Exercise*,*39*(4), 622–629, 2007. Doi: 10.1249/mss.0b013e318030631b

Nader, P.R., Bradley, R.H., Houts, R.M., McRitchie, S.L. & O'Brien, M. (2008). Moderate-to-Vigorous Physical Activity From Ages 9 to 15 Years. *JAMA, 300*(3), 295–305. Doi:10.1001/jama.300.3.295

Noonan, R.J., Boddy, L.M., Kim, Y., Knowles, Z.R. &Fairclough, S.J. (2016). Comparison of children's free-living physical activity derived from wrist and hip raw accelerations during the segmented week. *Journal of Sports Sciences*, *35*(21), 2067-2072. Doi: 10.1080/02640414.2016.1255347

Okely, A., Olds, T., Jones, R., Cliff, D., Parrish, A-M., Loughran, S., Kervin, L., Eckermann, S., Stanley, R., Shilton, T., Ghersi, D., Tremblay, M., Downieand, S. and Sherring, J. (2019). Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (13-17 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep. Https://www1.health.gov.au/internet/main/publishing.nsf/Content/ti-5-17years.

Owen, C., G., Nightingale, C.M., Rudnicka, A.R., Cook, D.G., Ekelund, U. &Whincup, P.H. (2009). Ethnic and gender differences in physical activity levels among 9–10-year-old children of white European, South Asian and African–Caribbean origin: the Child Heart Health Study in England (CHASE Study). *International Journal of Epidemiology*, 38, 1082–1093. Doi: 10.1093/ije/dyp176

Phillips, L.R.S, Parfitt, G. & Rowlands, A.V. (2013). Calibration of the GENEA accelerometer for assessment of physical activity intensity in children. *Journal of Science and Medicine in Sport* 16, 124–128. doi: 10.1016/j.jsams.2012.05.013

Poitras, V.J., Gray, C.E., Borghese, M.M., Carson, V., Chaput, J-P., Janssen, I., Katzmarzyk, P.T., Pate, R.R., Gorber, S.C., Kho, M.E., Sampson, M., and Tremblay, M.S. (2016). Systematic review of the

relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl. Physiol. Nutr. Metab*., 197–239. Dx.doi.org/10.1139/apnm-2015-0663

Polar (2010). *Lessons for Life. Individualizing Health and Physical Education with Heart Rate and Activity Monitoring. Teachers' Guidebook.* Polar Electro Oy: Kempele, Finland.

Rich, C., Griffiths, L.J. and Dezateux, C. (2012). Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(49). http://www.ijbnpa.org/content/9/1/49

Rideout, V.J., Foehr, U.G. & Roberts, D.F. (2010). *Generation M2. Media in the Lives of 8- to 18-Year-Olds.* A Kaiser Family Foundation Study. January 2010

Ridgers, N.D., McNarry, M.A. & Mackintosh, K.A. (2016). Feasibility and Effectiveness of Using Wearable Activity Trackers in Youth: A Systematic Review. *JMIR MhealthUhealth4* (4). doi: 10.2196/mhealth.6540

Saunders, T.J., Gray, C.E., Poitras, V., Chaput, J.-P., Janssen, I., Katzmarzyk, P.T., et al. 2016. Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. Appl. Physiol. Nutr. Metab. **41**: This issue. doi:10.1139/apnm-2015-0626.

Saunders, T.J. &Vallance, J.K. (2017). Screen Time and Health Indicators Among Children and Youth: Current Evidence, Limitations and Future Directions. *Appl Health Econ Health Policy* 15, 323–331. doi 10.1007/s40258-016-0289-3

Schaefer, S.E., Van Loan, M. & German, J.B. (2014). A Feasibility Study of Wearable Activity Monitors for Pre-Adolescent School-Age Children. *Preventive Chronic Disease* 11:130262. doi: 10.5888/pcd11.130262

Steele, R.M., Van Sluijs, E.M.F., Sharp, S.J., Landsbaugh, J.R., Ekelund, U. & Griffin, S.J. (2010). An investigation of patterns of children's sedentary and vigorous physical activity throughout the week. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(88). https://doi.org/10.1186/1479-5868-7-88

Steene-Johannessen, J. Hansen, B.H., Dalene, K.E., Kolle, E., Northstone, K., Møller, N.C., Grøntved, A., Wedderkopp, N., Kriemler, S., Page, A.S., Puder, J.J., Reilly, J.J., Sardinha, L.B., Van Sluijs, E.M.F., Andersen, L.B., Van der Ploeg, H., Ahrens, W., Flexeder, C., Standl, M. . . . Ekelund, U. (2020). Variations in accelerometry measured physical activity and sedentary time across Europe. *International Journal of Behavioral Nutrition and Physical Activity*, *17* (38). https://doi.org/10.1186/s12966-020-00930-x

Steene-Johannessen, J., Anderssen, S.A., Van der Ploeg, H.P., Hendriksen, I.J.M, Donnelly, A.E., Brage, S. &Ekelund, U. (2016). Are Self-report Measures Able to Define Individuals as Physically Active or Inactive? *Medicine Science in Sports & Exercise*, *48*(2), 235–244. doi: 10.1249/MSS.0000000000000760

Stiglic, N. & Viner, R.M. (2019). Effects of screentime on the health and well-being of childrenand adolescents: a systematic review of reviews. *BMJ Open*9:e023191. Doi:10.1136/bmjopen-2018-023191.

Tremblay M.S., Carson V., Chaput J.P., Connor, G.S., Dinh T., Duggan, M., Faulkner, G.,Gray, C.E., Gruber, R., Janson, K., Janssen, I., Katzmarzyk, P.T., Kho, M.E., Latimer-Cheung, A.E., LeBlanc, C., Okely, A.D., Olds, T., Pate, R.R., Phillips, A. . . . Zehr, L. (2016). Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *ApplPhysiolNutrMetab.41*(6). doi: 10.1139/apnm-2016-0151

Tremblay, M.S., Aubert, S., Barnes, J.D., Saunders, T.J., Carson, V., Latimer-Cheung, A.E., Chastin, S.F.M, Altenburg, T.M. &Chinapaw, M.J.M. (2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. International *Journal of Behavioral Nutrition and Physical Activity* 2017, *14* (75), 311–327. https://doi.org/10.1186/s12966-017-0525-8

Troiano, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T. & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise*. *40*(1), 181–188.
doi: 10.1249/mss.0b013e31815a51b3

Valtonen, J., Kyhälä, A-L., Slotte, S. & Reunamo, J. (2019).Fourth Graders' Objectively Measured Week Long Physical Activity. *The European Journal of Social and Behavioural Sciences*. Volume XXIV, 2891–2908.
https://dx.doi.org/10.15405/ejsbs.252

Watson, A., Dumuid, D., Maher, C. & Olds, T. (2021). Associations between meeting 24-hour movement guidelines and academic achievement in Australian primary school-aged children. *Journal of Sport and Health Science*. https://doi.org/10.1016/j.jshs.2020.12.004

WHO (2020). WHO guidelines on physical activity and sedentary behavior. Children and adolescents (aged 5–17 years). Geneva: World Health Organization. https://www.who.int/publications/i/item/9789240015128