



## Original article

## International Trends in Adolescent Screen-Time Behaviors From 2002 to 2010



Jens Bucksch, Dr.P.H., M.P.H.<sup>a,\*</sup>, Dagmar Sigmundova, Ph.D.<sup>b</sup>, Zdenek Hamrik, Ph.D.<sup>b</sup>, Philip Jay Troped, Ph.D.<sup>c</sup>, Ole Melkevik, Ph.D.<sup>d</sup>, Namam Ahluwalia, Ph.D.<sup>e</sup>, Alberto Borraccino, M.D.<sup>f</sup>, Jorma Tynjälä, Ph.D.<sup>g</sup>, Michal Kalman, Ph.D.<sup>b</sup>, and Joanna Inchley, Ph.D.<sup>h</sup>

<sup>a</sup> Department of Prevention and Health Promotion, School of Public Health, Bielefeld University, Bielefeld, Germany

<sup>b</sup> Faculty of Physical Culture, Palacký University Olomouc, Olomouc, Czech Republic

<sup>c</sup> Department of Exercise and Health Sciences, University of Massachusetts Boston, Boston, Massachusetts

<sup>d</sup> Norwegian Institute of Public Health, Oslo, Norway

<sup>e</sup> Health Scientist, Hyattsville, Maryland

<sup>f</sup> Department of Public Health and Paediatrics, University of Torino, Torino, Italy

<sup>g</sup> Department of Health Sciences, University of Jyväskylä, Jyväskylä, Finland

<sup>h</sup> Child and Adolescent Health Research Unit, School of Medicine, University of St. Andrews, Fife, United Kingdom

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## A B S T R A C T

**Purpose:** Engaging in prolonged screen-time behaviors (STBs) is detrimental for health. The objective of the present analyses was to examine temporal trends in TV viewing and computer use among adolescents across 30 countries.

**Methods:** Data were derived from the cross-national Health Behaviour in School-aged Children study. Data on TV viewing and computer use for gaming and nongaming purposes were collected in 2002 ( $n = 139,725$  [51.4% girls]), 2006 ( $n = 149,251$  [51.3% girls]), and 2010 ( $n = 154,845$  [51.2% girls]). The temporal trends in TV viewing and computer use were each tested for all countries combined and for each individual country by sex-specific univariate analysis of variance.

**Results:** Between 2002 and 2010, TV viewing decreased slightly in most of the 30 countries among both boys and girls. This decrease was more than offset by a sharp increase in computer use, which was consistent across all countries. Overall, boys reported more hours of STBs. They also reported a slightly larger decrease in TV viewing and slightly larger increase in computer use. STBs were generally more frequent on weekend days.

**Conclusions:** The overall cross-national increases in STBs should be a call to action for public health practitioners, policy-makers, and researchers that interventions specifically focused on reducing STBs in youth are sorely needed. Because all countries experienced a trend in the same direction, it might be fruitful to learn more about the determinants of STBs among those countries in which hours of STBs are generally low as compared with other countries.

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IMPLICATIONS AND  
CONTRIBUTION

Within a large cross-national study of 30 countries that used a comparable measurement approach, the time adolescents engaged in overall screen time increased between 2002 and 2010. These findings indicate that a public health call for action is needed to implement interventions to reduce screen-time behaviors in youth on an international scale.

**Conflicts of Interest:** All authors declare that they have no competing interests.

\* Address correspondence to: Jens Bucksch, Dr.P.H., M.P.H., Department of Prevention and Health Promotion, School of Public Health, Bielefeld University, PO Box 100131, D-33501 Bielefeld, Germany.

E-mail address: [jens.bucksch@uni-bielefeld.de](mailto:jens.bucksch@uni-bielefeld.de) (J. Bucksch).

Engaging in screen-time behaviors (STBs) such as TV viewing and computer use is an important indicator for time spent sedentary although it is acknowledged that non-STBs also contribute to the total time being sedentary [1–3]. Numerous reviews have highlighted that STBs are associated with a range of

adverse psychosocial and physical health outcomes independent of moderate-to-vigorous physical activity in children and adolescents [4,5]. However, time spent in STBs is high among children and becomes even more prevalent among adolescents [6]. There is some evidence suggesting that it also tracks moderately from childhood to adulthood [7]. Developing interventions to reduce STBs among children and adolescents is therefore of high priority. From a public health perspective, it is essential to monitor trends in health-related behaviors such as STBs to provide information about the success of appropriate policies and programs to reduce their prevalence [8] and to understand how lifestyle behaviors of adolescents change over time [9].

From an international perspective, information on recent trends in STBs is limited. Studies conducted in various countries have provided an unclear picture of time trends in STBs [10–14]. Recent findings on total screen time using data from 2000 to 2010 among adolescents in the Czech Republic found a decrease in TV viewing that was replaced by an increase in personal computer use [15]. Another study showed that time spent in STBs was more frequent on weekends than weekdays and showed a larger relative increase on weekends [16]. Because only a few national studies have reported on trends in screen time [12,15–18], a cross-national perspective using a comparable measurement approach is important to shed further light on trends in STBs across different policy and cultural contexts.

The aim of the present analyses was therefore to examine temporal trends in leisure time TV viewing and computer use during weekdays and weekend days among girls and boys aged 11–15 years from 2002 to 2010 across 30 countries, using data from the cross-national Health Behaviour in School-aged Children (HBSC) study [19].

## Methods

The HBSC study is a World Health Organization (WHO) collaborative cross-national study with a standardized methodological approach that is used across participating countries. These include countries across Europe and North America as well as Israel. In all participating countries, the HBSC survey is conducted in accordance with the study protocol prepared by the HBSC International Coordinating Centre [20]. Data are collected every 4 years from a nationally representative sample of 11-, 13-, and 15-year-old adolescents within each member country. The primary sampling units are schools and classes. The survey assesses a broad range of self-reported health behaviors and health outcomes. This article presents data from the 2002, 2006, and 2010 HBSC survey waves and includes 30 countries.

## Sample

Each of the three samples was based on a nationally representative randomized cluster (i.e., school level) sampling procedure. In total 443,821 (2002:  $n = 139,725$  [51.4% girls], 2006:  $n = 149,251$  [51.3% girls], 2010:  $n = 154,845$  [51.2% girls]), students with complete data for all STBs variables and covariates were included. Surveys were administered by the classroom teachers, participation was voluntary, and anonymity and confidentiality of the participants were ensured. Ethical approval for the study was obtained at the national or regional level. Response rates varied by country and survey wave both at the school level and individual student level. As an example, in 2010, response rates at the individual level ranged from 44% to 92%. All

survey procedures for each wave were documented and can be downloaded at <http://www.hbsc.org/methods/index.html>.

## Survey items

**Screen time.** Two STBs were assessed in a comparable manner in the last three HBSC surveys across 30 countries and regions: TV viewing and computer use during leisure time. For some analyses, the hours per day of TV viewing and computer use were summed to represent the overall amount of STBs. In previous studies, test-retest reliability of the TV viewing and computer use outcomes was assessed across different countries, and results were acceptable for both STB outcomes [21–24].

**TV viewing.** TV viewing during leisure time was assessed by asking “About how many hours a day do you usually watch television (including DVDs and videos) in your free time?” The DVD wording was added in 2006. Response options were consistent among all the survey waves and ranged from “none at all” to  $>7$  hours/day. Students were asked to report separately on TV viewing during weekdays and weekend days. Responses were recoded as follows: “none at all” = 0, “about half an hour a day” = .5, “about 1 hour a day” = 1, “about 2 hours a day” = 2, and so forth to “more than 7 hours a day” = 7.5.

**Computer use.** In 2002, computer use was measured by asking “about how many hours a day do you usually use a computer (for playing games, e-mailing, chatting, or surfing the Internet) in your free time?” In 2006 and 2010, this single question was subdivided into two questions to be more detailed. The item “about how many hours a day do you usually use a computer for chatting online, Internet, e-mailing, homework, and so forth in your free time?” represents the nongaming part of computer use. The second question is phrased “about how many hours a day do you usually play games on a computer or games console (PlayStation, Xbox, GameCube etc.) in your free time?” and represents the gaming part of computer use. Each question was asked for weekdays and weekends. Responses were recoded as continuous in the same way as for TV viewing. Because a single item measuring computer use for gaming and nongaming was used in 2002, the separate items for gaming and nongaming computer used in 2006 and 2010 were combined to enable trends over time to be examined more accurately. In addition, we also examined changes in nongaming and gaming computer use in isolation by reporting changes in hours per week from 2006 to 2010.

## Covariates

Because STBs differs for boys and girls [25,26], all analyses were stratified by gender. Age and family affluence (proxy for socioeconomic status) have also shown to be correlated with STB [26,27], and therefore we controlled for these variables in our analyses. Because the sampling was based on three specific age groups (i.e., 11-, 13-, and 15-year olds), age was treated as a three-stage categorical variable. The family affluence scale (FAS) provides a valid measure of household material affluence among adolescents [28]. Four items are included to characterize family affluence: number of computers, car ownership, family holidays in the past year, and having one's own bedroom. Responses to these items were summed and treated as a composite sum score. All covariates were collected using the same items in all three survey waves.

## Data analysis

Analyses were conducted with SPSS version 19. Descriptive data are presented as percentages or means for each survey year. The significance of trends over time was tested for all countries combined and for each individual country. Because TwoStep cluster analysis found no indication for clustering by school or by class, we used univariate analysis of variance with hours per day of screen time (TV viewing and computer use for weekdays and weekend days) as the dependent variable and year of the survey (2002, 2006, 2010) as the independent variable. To test the direction of time trends (i.e., significant increase, no change, significant decrease), we computed Least Significant Difference-Bonferroni Test post hoc test of Analysis of Variance (ANOVA) controlling for age and family affluence. The level of significance was .05. In addition, we examined two-way interactions of age and FAS with time to determine if trends varied across subgroups. Results are presented separately for boys and girls and for weekdays and weekend days.

## Results

### Trends for all countries and regions combined

Table 1 shows that mean hours per day of TV viewing decreased significantly from 2002 to 2010 in all subgroups based on age and gender. In contrast, computer use for gaming and

nongaming purposes and total STBs (mean hours/day) showed significant increases in all subgroups over time. Mean hours per day for each STBs were generally higher on weekend days. Computer use was more often used for gaming by boys, whereas girls used computers more often for nongaming activities.

### Trends in TV viewing stratified by countries and regions

Significant declines in time spent watching TV on weekdays from 2002 to 2010 were found in 29 of 30 countries among boys (Table 2) and in 25 of 30 countries among girls (Table 3). For weekend days, significant declines were seen among boys and girls in 24 of 30 and 21 of 30 countries, respectively. Only in case of Greece and the Netherlands, we also observed a significant increase depending on sex and on time of the week (weekday vs. weekend day) in TV viewing from 2002 to 2010. For all countries and age groups combined, the overall absolute difference between 2002 and 2010 in the mean hours per day of TV viewing was  $-.31$  ( $= -18, 6$  minutes) in girls for both weekdays and weekend days. In boys, the absolute difference was  $-.40$  ( $= -24, 0$  minutes) for weekdays and  $-.45$  ( $= -27, 0$  minutes) for weekend days. Relative and absolute changes in TV viewing between countries from 2002 to 2010 show a comparable picture. The largest absolute and relative decreases in TV viewing on weekdays and weekend days were observed in Ukraine, Latvia, Estonia, Russia, Norway, and the United States of America in boys.

**Table 1**

Trends in screen-time behaviors from 2002 to 2010 for all countries and regions combined by age and gender (mean hour per day)

Variable	Age	Weekdays						Weekend					
		Year of survey			Trend			Year of survey			Trend		
		2002	2006	2010	2002/2006	2006/2010	2002/2010	2002	2006	2010	2002/2006	2006/2010	2002/2010
Boys													
TV viewing	11	2.61	2.34	2.24	—	—	—	3.35	3.14	3.03	—	—	—
	13	2.83	2.60	2.38	—	—	—	3.68	3.44	3.20	—	—	—
	15	2.69	2.51	2.31	—	—	—	3.58	3.33	3.06	—	—	—
Nongaming computer use	11	n.a.	1.03	1.31	n.a.	+	n.a.	n.a.	1.28	1.63	n.a.	+	n.a.
	13	n.a.	1.39	1.70	n.a.	+	n.a.	n.a.	1.76	2.16	n.a.	+	n.a.
	15	n.a.	1.69	2.11	n.a.	+	n.a.	n.a.	2.15	2.61	n.a.	+	n.a.
Computer use for gaming	11	n.a.	1.71	1.77	n.a.	+	n.a.	n.a.	2.42	2.51	n.a.	+	n.a.
	13	n.a.	1.92	2.04	n.a.	+	n.a.	n.a.	2.79	2.94	n.a.	+	n.a.
	15	n.a.	1.80	2.04	n.a.	+	n.a.	n.a.	2.66	2.91	n.a.	+	n.a.
Computer use (combining gaming and nongaming purposes)	11	1.32	2.74	3.08	+	+	+	1.79	3.70	4.14	+	+	+
	13	1.55	3.31	3.74	+	+	+	2.21	4.55	5.11	+	+	+
	15	1.62	3.49	4.15	+	+	+	2.33	4.81	5.52	+	+	+
Total screen time	11	3.93	5.09	5.33	+	+	+	5.14	6.87	7.20	+	+	+
	13	4.38	5.92	6.13	+	+	+	5.91	8.02	8.34	+	+	+
	15	4.31	6.01	6.47	+	+	+	5.93	8.16	8.60	+	+	+
Girls													
TV viewing	11	2.36	2.21	2.08	—	—	—	3.03	2.90	2.80	—	—	—
	13	2.67	2.55	2.31	—	—	—	3.50	3.36	3.13	—	—	—
	15	2.48	2.39	2.21	—	—	—	3.40	3.28	3.06	—	—	—
Nongaming computer use	11	n.a.	.95	1.27	n.a.	+	n.a.	n.a.	1.16	1.57	n.a.	+	n.a.
	13	n.a.	1.42	1.95	n.a.	+	n.a.	n.a.	1.80	2.48	n.a.	+	n.a.
	15	n.a.	1.58	2.27	n.a.	+	n.a.	n.a.	2.03	2.88	n.a.	+	n.a.
Computer use for gaming	11	n.a.	.93	1.05	n.a.	+	n.a.	n.a.	1.34	1.51	n.a.	+	n.a.
	13	n.a.	.91	1.11	n.a.	+	n.a.	n.a.	1.37	1.61	n.a.	+	n.a.
	15	n.a.	.67	.90	n.a.	+	n.a.	n.a.	1.03	1.30	n.a.	+	n.a.
Computer use (combining gaming and nongaming purposes)	11	.73	1.88	2.32	+	+	+	.99	2.50	3.08	+	+	+
	13	.85	2.33	3.06	+	+	+	1.20	3.17	4.10	+	+	+
	15	.79	2.25	3.17	+	+	+	1.12	3.06	4.19	+	+	+
Total screen time	11	3.09	4.10	4.41	+	+	+	4.02	5.42	5.90	+	+	+
	13	3.52	4.89	5.38	+	+	+	4.70	6.54	7.24	+	+	+
	15	3.27	4.65	5.38	+	+	+	4.52	6.34	7.26	+	+	+

ANOVA = Analysis of Variance; n.a. = not available; + = significant positive trend (increase); – = significant negative trend (decrease); significance is based on LSD (Least Significant Difference-Bonferroni Test) post hoc test of ANOVA.

**Table 2**

Trends in mean hours per day of TV viewing from 2002 to 2010 for weekdays and weekends among boys

Boys	Weekdays						Interaction	Weekend						Interaction
	Year of survey			Trend				Year of survey			Trend			
	2002	2006	2010	2002/2006	2006/2010	2002/2010		2002	2006	2010	2002/2006	2006/2010	2002/2010	
Vlaamse Gewest (Belgium)	2.64	2.50	2.28	–	–	–		3.66	3.40	3.18	–	–	–	
Wallone, Région (Belgium)	2.22	2.15	2.02	–	–	–	a	3.45	3.40	3.21	o	–	–	
Canada	2.69	2.73	2.40	o	–	–		3.52	3.31	3.04	–	–	–	a
Switzerland	1.81	1.56	1.44	–	–	–		2.86	2.62	2.45	–	–	–	a
Czech Republic	2.77	2.48	2.30	–	–	–		3.23	3.20	2.96	o	–	–	a
Germany	2.40	2.27	2.11	–	–	–	b	3.38	3.45	3.31	o	–	o	b
Denmark	2.61	2.41	2.42	–	o	–	a	3.33	3.17	3.20	–	o	–	
Estonia	3.39	2.75	2.42	–	–	–		4.03	3.51	3.25	–	–	–	a
Spain	2.45	2.23	2.21	–	o	–		3.26	3.02	2.70	–	–	–	
Finland	2.34	1.96	1.95	–	o	–	a	3.25	2.79	2.76	–	o	–	a
France	2.28	2.33	2.10	o	–	–		3.15	3.18	3.03	o	–	–	a, b
Greenland	2.66	2.22	2.06	–	o	–		3.04	3.11	2.98	o	o	o	
Greece	2.49	2.72	2.66	+	o	+		3.53	3.63	3.54	o	o	o	
Croatia	3.03	2.97	2.71	o	–	–		3.91	3.53	3.28	–	–	–	
Hungary	2.41	2.32	2.18	o	–	–		4.01	3.67	3.56	–	o	–	
Israel	3.46	2.97	3.11	–	+	–	a	3.29	3.23	3.29	o	o	o	a, b
Italy	2.34	2.30	2.06	o	–	–		2.64	2.62	2.62	o	o	o	
Latvia	3.43	2.96	2.52	–	–	–		4.41	3.57	3.17	–	–	–	
Macedonia	2.77	2.48	2.40	–	o	–	a	3.50	3.53	3.08	o	–	–	a, b
The Netherlands	2.76	2.96	2.75	+	–	–		3.63	3.40	3.19	–	–	–	
Norway	2.68	2.11	1.99	–	–	–	a	3.60	3.03	2.90	–	–	–	a
Poland	3.01	2.62	2.50	–	–	–	b	4.04	3.78	3.44	–	–	–	a, b
Portugal	2.84	3.00	2.51	+	–	–		3.93	3.96	3.80	o	–	o	
Russia	3.19	2.75	2.46	–	–	–	a	3.94	3.69	3.23	–	–	–	a
Scotland	2.90	2.73	2.46	–	–	–	b	3.40	3.24	3.14	–	–	–	
Sweden	2.32	2.07	2.20	–	+	–		3.19	2.83	2.95	–	+	–	
Slovenia	2.45	2.36	2.13	–	–	–		3.26	3.17	2.94	o	–	–	
Ukraine	3.56	2.87	2.48	–	–	–	b	4.50	3.74	3.19	–	–	–	
United States of America	2.82	2.36	2.17	–	–	–		3.85	3.22	2.99	–	–	–	
Wales	2.90	2.60	2.54	–	o	–	b	3.44	3.20	3.14	–	o	–	
All countries	2.71	2.49	2.31	–	–	–	a, b	3.54	3.31	3.09	–	–	–	a, b

ANOVA = Analysis of Variance; FAS = family affluence scale; Significance is based on LSD (Least Significant Difference-Bonferroni Test) post hoc test of ANOVA controlling for age and family affluence; interaction based on ANOVA F values: a = significant interaction year × age; b = significant interaction year × FAS; + = significant positive trend (increase); o = no changes; – = significant negative trend (decrease).

The largest differences in girls were found in Finland, Norway, Ukraine, Wales, Estonia, Italy, Latvia, Estonia, Spain, and the United States of America (Supplementary Tables 5 and 6).

#### Trends in computer use stratified by countries and regions

We observed a strong increase in computer use including nongaming and gaming activities, from 2002 to 2010. In all 30 countries, significant trends were found in boys (Table 4) and girls (Table 5) on both weekend days and weekdays. For all countries combined, the absolute differences in mean hours per day of computer use were +2.17 (= 130, 2 minutes) for boys and +2.07 (= 124, 2 minutes) for girls on weekdays, and +2.83 (= 169, 8 minutes) and +2.69 (= 161, 4 minutes), respectively, on weekend days. Overall, boys spent about 1 hour more per day using computers, including both gaming and nongaming activities, than girls. When computer use was analyzed separately for nongaming and gaming purposes, we also observed a significant increase in most countries between 2006 and 2010 (Supplementary Tables 1–4).

Among boys, the largest relative and absolute increases in computer use from 2002 to 2010 by country were found in Poland, Israel, Macedonia, Estonia, the Netherlands, and Russia

with only marginal differences between weekdays and weekends. For girls, absolute differences were across all countries generally smaller, and relative differences were higher compared with boys. The smallest increases were observed for girls from the United States of America, Canada, Greenland, and Norway as well as Switzerland (Supplementary Tables 5 and 6).

#### Moderating effects of age and family affluence

The degree of change over time slightly varied according to age and family affluence with some variation between countries (Tables 1–5). In terms of age, we generally found smaller increases in computer use and decreases in TV viewing among 11-year olds, compared with 13- and 15-year olds. In terms of family affluence, stronger changes were observed among boys and girls from low affluent groups for both decreases in TV viewing and increases in computer use (data not shown).

#### Discussion

Between 2002 and 2010, hours of TV viewing during their leisure time decreased slightly in most of the 30 countries among

**Table 3**

Trends in mean hours per day of TV viewing from 2002 to 2010 for weekdays and weekends among girls

Girls	Weekdays						Interaction	Weekend						Interaction
	Year of survey			Trend				Year of survey			Trend			
	2002	2006	2010	2002/2006	2006/2010	2002/2010		2002	2006	2010	2002/2006	2006/2010	2002/2010	
Vlaamse Gewest (Belgium)	2.26	2.42	2.22	+	–	o	a, b	3.08	3.22	3.09	+	–	o	b
Wallone, Région (Belgium)	2.08	1.87	1.82	–	o	–		3.21	3.07	3.06	–	o	–	b
Canada	2.37	2.38	2.20	o	–	–	a	3.12	3.06	2.87	o	–	–	a
Switzerland	1.65	1.40	1.30	–	–	–	a, b	2.61	2.40	2.35	–	o	–	b
Czech Republic	2.49	2.29	2.15	–	–	–		2.89	2.91	2.68	o	–	–	
Germany	2.21	2.12	2.00	–	–	–		2.98	3.12	2.98	+	–	o	
Denmark	2.45	2.25	2.24	–	o	–		3.09	2.96	3.01	–	o	o	
Estonia	2.97	2.67	2.38	–	–	–		3.87	3.53	3.22	–	–	–	a, b
Spain	2.40	2.09	1.95	–	–	–		3.17	2.77	2.50	–	–	–	
Finland	2.32	1.89	1.83	–	o	–	a	3.14	2.68	2.66	–	o	–	a
France	2.06	2.13	1.95	o	–	–		3.03	2.94	2.89	o	o	–	a, b
Greenland	2.36	2.33	1.98	o	–	–	a	2.88	3.10	2.80	o	–	o	a
Greece	2.09	2.79	2.47	+	–	+		3.27	3.62	3.45	+	–	+	
Croatia	2.73	2.77	2.56	o	–	–	a	3.71	3.41	3.20	–	–	–	a
Hungary	2.15	2.14	2.06	o	o	–		3.88	3.61	3.50	–	o	–	
Israel	3.52	3.23	3.04	–	–	–	a, b	3.25	3.40	3.21	+	–	o	b
Italy	2.51	2.22	1.98	–	–	–		2.55	2.41	2.40	–	o	–	
Latvia	2.94	2.76	2.46	–	–	–	a	4.07	3.51	3.24	–	–	–	a
Macedonia	2.54	2.48	2.36	o	o	–		3.27	3.64	3.24	+	–	o	
The Netherlands	2.44	2.70	2.57	+	–	+		3.25	3.25	3.09	o	–	–	a, b
Norway	2.58	2.17	2.02	–	–	–	a	3.26	2.93	2.85	–	o	–	a
Poland	2.60	2.39	2.34	–	o	–	a	3.74	3.67	3.44	o	–	–	
Portugal	2.88	3.03	2.45	+	–	–		3.83	4.02	3.85	+	–	o	a
Russia	2.82	2.79	2.59	o	–	–		3.68	3.71	3.38	o	–	–	
Scotland	2.80	2.45	2.34	–	–	–	a	3.17	2.84	2.90	–	o	–	
Sweden	2.17	1.95	2.10	–	+	o	a	2.88	2.64	2.82	–	+	o	
Slovenia	2.22	2.11	1.90	–	–	–		2.94	3.01	2.79	o	–	–	a
Ukraine	3.28	2.97	2.55	–	–	–		4.48	3.96	3.34	–	–	–	
United States of America	2.61	2.41	2.13	–	–	–		3.51	3.29	2.97	–	–	–	b
Wales	2.92	2.51	2.32	–	–	–		3.46	3.00	2.90	–	o	–	
All countries	2.51	2.39	2.20	–	–	–	a, b	3.31	3.19	3.00	–	–	–	a, b

ANOVA = Analysis of Variance; FAS = family affluence scale; Significance is based on LSD (Least Significant Difference-Bonferroni Test) post hoc test of ANOVA controlled for age and family affluence; interaction based on ANOVA F values: a = significant interaction year  $\times$  age; b = significant interaction year  $\times$  FAS; + = significant positive trend (increase); o = no changes; – = significant negative trend (decrease).

both adolescent boys and girls. This decrease was more than offset by a sharp increase in leisure time computer use for gaming and nongaming purposes, consistent across all countries and regions. Although these changes were evident for both boys and girls, boys reported more hours of STBs on weekdays and weekend days. They also reported a slightly greater decrease in TV viewing and slightly greater increase in computer use in absolute terms, whereas in girls, the increase for computer use was larger in relative terms. Leisure time STB was generally more frequent on weekend days, and the increase in hours per weekend day was more pronounced compared with weekdays. From a sitting-health perspective and using STBs as one important contributor to sedentary behavior, our findings highlight a clear need to implement interventions aimed at reducing STBs, especially computer use in both boys and girls, to interrupt and reduce long episodes of sedentariness through promoting more physically active leisure choices among adolescents across a wide range of countries. However, we have to point out that diverse types of STBs have different associations with health outcomes [29], and we should be cautious to characterize STBs as only having detrimental effects on health. For example, studies have shown that online communication among adolescents is linked

to enhanced self-esteem, relationship formation, and quality of friendships [30,31].

Our findings for trends in TV viewing confirm previous findings from Europe and North and South America within the same age range [15–18,32,33] showing a decrease in time spent watching TV in recent years. Studies which have reported stable [11,14,34] or increasing trends [35] have either examined data before 2000 or up until the mid-2000s when TV viewing was more common as the primary source of screen time. Our findings extend the current evidence base by presenting more recent data on temporal trends. In our study, Greece was the only country in which a significant increase in TV viewing was observed for both boys and girls. This country-specific finding is not easy to explain because trends from other countries in this geographical area are in line with the overall decreasing trends. However, a recent Greek study also found an increase in TV viewing among boys and girls between 1992 and 2007 [13].

Our findings suggest that there have been significant changes in time allocated to different types of STBs. These patterns were found to be largely consistent across a wide range of countries and indicate changes in adolescents' preferences and lifestyle choices. We found a large significant increase in computer use



**Table 4**

Trends in mean hours per day of computer use (gaming and nongaming) from 2002 to 2010 for weekdays and weekends among boys

Boys	Weekdays						Interaction	Weekend						Interaction
	Year of survey			Trend				Year of survey			Trend			
	2002	2006	2010	2002/2006	2006/2010	2002/2010		2002	2006	2010	2002/2006	2006/2010	2002/2010	
Vlaamse Gewest (Belgium)	1.40	3.27	3.15	+	o	+	a	2.29	4.73	4.72	+	o	+	a, b
Wallone, Région (Belgium)	1.38	2.89	2.80	+	o	+	a	2.50	5.07	4.91	+	+ o	+	a, b
Canada	1.69	3.62	3.79	+	+	+		2.36	4.65	4.97	+	+	+	
Switzerland	1.06	2.15	2.27	+	+	+	a	1.85	3.76	4.02	+	+	+	a
Czech Republic	1.60	3.17	4.04	+	+	+	a	1.90	3.96	4.81	+	+	+	a
Germany	1.45	3.18	3.20	+	o	+	a, b	1.97	4.67	4.79	+	o	+	a, b
Denmark	1.85	3.55	4.34	+	+	+		2.32	4.38	5.35	+	+	+	
Estonia	1.78	4.36	4.54	+	o	+	a, b	2.25	5.52	5.70	+	o	+	b
Spain	1.08	2.23	3.17	+	+	+	b	1.83	3.65	4.12	+	+	+	b
Finland	1.44	3.12	3.40	+	+	+	a, b	1.99	4.23	4.70	+	+	+	a, b
France	1.01	2.72	3.28	+	+	+	a, b	1.49	4.06	4.92	+	+	+	a, b
Greenland	1.42	2.07	2.12	+	o	+		1.72	2.57	2.31	+	o	+	
Greece	1.20	2.61	3.66	+	+	+	a, b	1.92	4.24	5.49	+	+	+	a, b
Croatia	1.18	2.74	3.76	+	+	+	b	1.86	3.69	4.97	+	+	+	
Hungary	1.35	3.01	3.71	+	+	+	a, b	2.39	5.16	6.16	+	+	+	a
Israel	2.46	4.64	5.45	+	+	+	b	2.63	4.82	5.70	+	+	+	b
Italy	1.09	2.27	3.05	+	+	+	a	1.25	2.69	3.76	+	+	+	a
Latvia	1.43	3.55	3.93	+	+	+	a, b	2.02	4.32	4.77	+	+	+	a
Macedonia	1.39	2.96	4.34	+	+	+	a, b	1.97	4.87	5.98	+	+	+	a, b
The Netherlands	1.70	4.63	4.46	+	–	+	a, b	2.41	5.06	4.91	+	o	+	a
Norway	1.86	3.12	3.31	+	+	+	a	2.31	4.12	4.07	+	o	+	a
Poland	1.62	4.18	4.77	+	+	+	a, b	2.53	6.02	6.54	+	+	+	a, b
Portugal	1.49	3.82	3.80	+	o	+	b	2.21	5.20	5.85	+	+	+	b
Russia	1.68	2.79	4.34	+	+	+	b	2.39	3.83	5.60	+	+	+	a, b, c
Scotland	2.08	3.87	4.49	+	+	+	a	2.46	4.59	5.64	+	+	+	a
Sweden	1.79	3.61	4.11	+	+	+	a	2.30	4.41	5.13	+	+	+	a
Slovenia	1.34	3.10	3.43	+	+	+	a	2.05	4.21	4.57	+	+	+	a
Ukraine	1.05	2.58	2.82	+	+	+	b	1.55	3.72	3.69	+	o	+	b
United States of America	1.34	2.46	2.36	+	o	+		1.96	3.84	3.95	+	o	+	b
Wales	1.68	3.64	4.21	+	+	+	a, b	2.16	4.44	5.11	+	+	+	a
All countries	1.50	3.19	3.67	+	+	+	a, b	2.10	4.37	4.93	+	+	+	a, b

ANOVA = Analysis of Variance; FAS = family affluence scale; Significance is based on LSD (Least Significant Difference–Bonferroni Test) post hoc test of ANOVA controlled for age and family affluence; interaction based on ANOVA F values: a = significant interaction year  $\times$  age; b = significant interaction year  $\times$  FAS; + = significant positive trend (increase); o = no changes; – = significant negative trend (decrease).

over time for gaming and nongaming purposes in all countries and regions. The increases in computer use are compensated for the decline in TV viewing so that overall time spent with STBs was about 2 hours per day more in 2010 compared with 2002 in both girls and boys. Taking health-related guidelines for total media use and sedentary behavior into account the increase is as high as the recommended level of no more than 2 hours per day of recreational screen time [36,37]. Our findings are in line with results from recent studies around the globe that found divergent trends for TV viewing and computer use for different purposes and an overall increase in STBs [11,12,15–18,32,35]. Comparing our findings directly to non-HBSC studies in terms of change in time allocated to STBs is often not possible because these studies have used different questions and different data collection methods to assess STBs and often operationalize STBs as a categorical variable (e.g.,  $\geq 4$  hours per day) [12,16,35].

Clearly, STBs form an important part of young people's leisure time. With continuous technological advances, the choice of innovative and attractive devices supports high levels of screen time. Our study is limited to the period from 2002 to 2010, but it is likely that the observed increase in time spent in STB in recent years will continue to increase even more. The availability of screens,

ready access to the Internet, and the increasing importance of social media in young people's lives has normalized STBs across the world [31]. Recent statistics from the International Telecommunication Union suggest that around 80 per 100 inhabitants in developed countries have a computer and/or internet access at home and that this figure is increasing year by year (<http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>, accessed June 18, 2015). From a scientific and surveillance point of view, rapid technological changes in screen-based opportunities (e.g., smart TVs, streaming TV channels by computers/tablets) lead to challenges in defining media use and measuring STBs. Analyzing current and future trends might therefore become more problematic in terms of applicability of standardized items over time.

Overall, we found relatively small differences between boys and girls in terms of trends in STBs over time, supporting findings from previous studies [12,16,34,35]. In general, boys engaged in more STB than girls and had slightly greater changes from 2002 to 2010 compared with girls. By combining computer use for gaming and nongaming purposes for country-specific analyses, we might have overlooked differences in gender-specific motivations for computer use. Indeed, when examining computer use for social and academic purposes only, girls show a clear increase

**Table 5**

Trends in mean hours per day of computer use (gaming and nongaming) from 2002 to 2010 for weekdays and weekends among girls

Girls	Weekdays						Interaction	Weekend						Interaction
	Year of survey			Trend				Year of survey			Trend			
	2002	2006	2010	2002/2006	2006/2010	2002/2010		2002	2006	2010	2002/2006	2006/2010	2002/2010	
Vlaamse Gewest (Belgium)	.89	2.49	2.48	+	o	+	a	1.39	3.44	3.53	+	o	+	a
Wallone, Région (Belgium)	.68	2.37	2.44	+	o	+	a, b	1.23	4.03	4.20	+	+	+	a, b
Canada	1.37	2.98	3.17	+	+	+	a, b	1.88	3.65	3.95	+	+	+	a
Switzerland	.56	1.37	1.79	+	+	+	a	.96	2.40	3.06	+	+	+	a, b
Czech Republic	.65	1.90	2.99	+	+	+	a, b	.76	2.36	3.59	+	+	+	a
Germany	.70	2.19	2.62	+	+	+	a	.96	3.02	3.69	+	+	+	a, b
Denmark	.71	2.14	2.87	+	+	+	a, b	.79	2.50	3.41	+	+	+	a, b
Estonia	.86	3.03	3.50	+	+	+	a	1.07	3.82	4.40	+	+	+	a, b
Spain	.70	1.62	2.82	+	+	+	a, b	1.13	2.48	3.67	+	+	+	a
Finland	.57	1.95	2.47	+	+	+	a	.77	2.74	3.45	+	+	+	a, b
France	.57	1.88	2.58	+	+	+	a, b	.91	2.88	3.91	+	+	+	a, b
Greenland	.91	1.60	1.27	+	–	+	b	.92	1.84	1.45	+	–	+	b
Greece	.48	1.05	2.32	+	+	+	a	.83	1.77	3.72	+	+	+	a
Croatia	.54	1.56	2.93	+	+	+	a	.88	2.18	3.92	+	+	+	a
Hungary	.68	1.81	2.64	+	+	+	a, b	1.21	3.17	4.54	+	+	+	a, b
Israel	1.44	3.94	4.78	+	+	+	b	1.56	4.05	4.70	+	+	+	a, b
Italy	.67	1.36	2.69	+	+	+	a	.77	1.59	3.34	+	+	+	a
Latvia	.73	2.35	2.78	+	+	+	a	1.03	2.90	3.49	+	+	+	a
Macedonia	.80	2.05	3.37	+	+	+		1.16	3.59	5.24	+	+	+	a, b
The Netherlands	.97	3.22	3.42	+	+	+	a, b	1.36	3.67	3.63	+	o	+	a, b
Norway	.77	2.24	2.50	+	+	+	a	.97	2.77	2.79	+	o	+	a
Poland	.84	2.23	3.18	+	+	+	a, b	1.28	3.44	4.67	+	+	+	a, b
Portugal	.71	2.56	2.76	+	+	+	a, b	1.01	3.44	4.29	+	+	+	a, b
Russia	.71	1.80	3.55	+	+	+	a, b	1.02	2.61	4.66	+	+	+	a, b
Scotland	1.17	2.79	3.48	+	+	+	a	1.34	3.24	4.15	+	+	+	a
Sweden	.88	2.31	3.09	+	+	+		1.11	2.74	3.65	+	+	+	
Slovenia	.62	1.88	2.48	+	+	+	a, b	1.06	2.69	3.31	+	+	+	a, b
Ukraine	.39	1.17	2.07	+	+	+	b	.52	1.80	2.85	+	+	+	a, b
USA	1.22	1.93	2.19	+	+	+	b	1.77	2.82	3.17	+	+	+	a
Wales	1.03	2.75	3.54	+	+	+	a	1.33	3.26	4.24	+	+	+	a
All countries	.79	2.16	2.86	+	+	+	a, b	1.11	2.92	3.80	+	+	+	a, b

ANOVA = Analysis of Variance; FAS = family affluence scale; Significance is based on LSD (Least Significant Difference-Bonferroni Test) post hoc test of ANOVA controlled for age and family affluence; interaction based on ANOVA F values: a = significant interaction year  $\times$  age; b = significant interaction year  $\times$  FAS; + = significant positive trend (increase); o = no changes; – = significant negative trend (decrease).

over time, whereas in boys, we observed more variation across countries and a smaller increase in the mean hours per day. In boys, the main driver of more computer use appears to be gaming activities. This should be considered when designing gender-sensitive approaches to reduce computer-based STBs.

Data from our cross-national study consistently showed that both TV viewing and computer use were greater on weekend days compared with weekdays at each survey year. In addition, there was a more pronounced increase in computer use on weekend days compared with weekdays, as found by others [16]. These findings suggest that weekend days might be a more optimal target for interventions designed to reduce STBs.

As almost all countries and regions experienced a trend in the same direction, it might be fruitful to closely examine the determinants of STBs among countries in which hours of STBs are generally low, such as Switzerland, Finland, Lithuania, and Greenland, to inform the development of new interventions.

Furthermore, we found a few indications that the trends in STBs are moderated by age and family affluence. It appears that

11-year-old boys and girls have less pronounced changes over time in computer use and TV viewing. This moderating effect and the finding that the duration of STBs is greater with increasing age for all survey waves underpin the conclusion that 15-year-old girls and boys are a high priority group for interventions. In relation to family affluence, although there were again no divergent patterns in trends for different family affluence subgroups at the aggregated international level, we observed some differences within countries underpinning the point that further country-specific investigation is warranted.

Our analyses also showed some interesting differences between countries and regions. We observed large decreases in TV viewing in absolute and relative terms in countries such as the Ukraine, Latvia, Estonia, or the United States of America. Largest increases in computer use for gaming and nongaming purposes in absolute and relative terms were additionally found in Poland, Israel, or Estonia for boys. In Canada, United States of America, or Norway, we observed the lowest increases for girls. It might be fruitful to closely examine the determinants of STBs among the described countries and regions as a starting point for more international and country-specific research.

## Strengths and limitations

A major strength of our study is the large sample size with a cross-national approach. The HBSC study is based on a standardized international protocol and uses the same survey items in all participating countries. Furthermore, we report on trends across countries from different parts of the world, thus representing a diverse range of sociocultural, political, geographic, and economic contexts.

Our data and findings have several limitations that should be kept in mind. First, we used self-reported measures of STBs which might lead to misclassification or have some measurement error, although previous studies have reported acceptable reliability and validity for these measures [21,22]. We may have overestimated time for overall STBs or combined measures of computer use due to simultaneous use of different screens at one occasion [38]. Second, some variations in STBs over time might be attributable to changes in wording of the outcome variables. However, changes were made in each of participating countries in the same way so that the internal validity/comparability of the observed temporal trends between countries was high. With respect to the computer use variables, a more substantial change in wording occurred between 2002 and 2006. In 2006 and 2010, two separate items were used to assess nongaming and gaming computer use. These were summed to allow direct comparison to a reference item in 2002 that was more general and did not differentiate between computer use for playing and for nongaming purposes. Thus, information about trends for different types of computer use from 2002 to 2010 is not available. However, separate changes between 2006 and 2010 in nongaming and gaming computer use are presented in supplementary tables.

In summary, we found that the amount of STBs among adolescents has increased in many parts of Europe and North America during the last decade. Our data showed a consistent trend in 30 countries and regions among both boys and girls. The most important driver for this increase is computer use for gaming and nongaming purposes. Although almost all countries and regions experienced a trend in the same direction, we identified a few differences between countries in terms of absolute, relative, and overall levels of STBs which highlighted the need for further international research on the specific determinants of STBs at national level. The findings also suggest that the weekend may be a critical target for interventions aimed at reducing screen time because TV viewing and computer use are particularly high on weekend days. From a public health and sedentary behavior perspective, the overall increases in STBs found in the HBSC countries from 2002 to 2010 should be a call to action for public health practitioners, policy-makers, and researchers that interventions specifically focused on STBs in youth are sorely needed.

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## Supplementary Data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jadohealth.2015.11.014>.

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