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**MAJOR DÁVID**

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Programvezető: Dr. Vingender István, habilitált főiskolai tanár

Témavezető: Dr. Terebessy András, egyetemi adjunktus

Dr. Fazekas-Pongor Vince, egyetemi adjunktus

**IMPACT OF COVID-19-RELATED SCHOOL LOCKDOWNS  
ON ADOLESCENTS' SCREEN TIME, WELL-BEING, AND  
SELF-ESTEEM: A LONGITUDINAL STUDY IN HUNGARY**

**Ph.D thesis**

**David Major, MD**

Semmelweis University Doctoral School

Health Sciences Division



Supervisors:

András Terebessy, MD, Ph.D

Vince Fazekas-Pongor, MD, Ph.D

Official reviewers:

Orsolya Varga, MD, PhD

Tamás Kiss, MD, PhD

Head of the Complex Examination  
Committee:

Helga Feith, JD, habil., Ph.D

Members of the Complex Examination  
Committee:

Gabriella Nagy-Pénzes, Ph.D

Magor Papp, MD, Ph.D

Budapest

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## **List of Abbreviations**

BEP	Balassagyarmat Health Education Program
CI	confidence interval
FDMII	Family Dynamics Measure II
HBSC	Health Behavior in School-aged Children
MD	mean difference
OECD	Organization for Economic Co-operation and Development
RSES	Rosenberg Self-Esteem Scale
WBI	WHO-5 Well-being Index
WHO	World Health Organization

# **1 Introduction**

Adolescence is a unique and sensitive developmental period of life during which experiences can have lasting effects on health attitudes and behaviors. Increasing attention has been directed toward several health issues affecting this age group. There is a growing concern on digital media use since screen time has steadily increased over the past two decades (Bucksch et al., 2016; Qi et al., 2023). The majority of adolescents far exceed the World Health Organization's (WHO) recommended recreational limit of two hours per day (European Commission, 2021). Another concern is the increasing prevalence of mental health conditions among adolescents (Sacco et al., 2024; Twenge et al., 2021), which are influenced by a complex interplay of factors, such as ongoing adversity, peer pressure, identity exploration, media and gender expectations, and strained family or peer relationships (World Health Organization, 2024).

The COVID-19 pandemic only further complicated the already difficult landscape. On March 11, 2020, the World Health Organization officially declared COVID-19 a pandemic (World Health Organization, 2020) that persisted until May 2023, during which over 760 million confirmed cases and nearly seven million deaths were recorded globally (Sarker et al., 2023). Besides the acute illness, several individuals still experience prolonged impact, known as long COVID, which is estimated to affect 36% of people previously diagnosed with COVID-19 globally (Hou et al., 2025). In addition to the direct health burden, the pandemic had wide-ranging effects on society, disrupting education, employment, social relationships, and mental well-being. Students were forced into remote learning, which fundamentally altered their daily routines. All academic and social interactions were moved to digital platforms. In these uncertain times, family interactions can play a major protective role. The present thesis aims to understand these pandemic-related changes in screen time and mental health among adolescents with a particular focus on family-related factors within a Hungarian context.

## **1.1 Effects of Screen Time and Trends Among Adolescents**

Several studies have drawn attention to excessive screen time and its possible consequences on children and adolescents. Too much screen time is often linked to

disruptions in sleep patterns (Hale & Guan, 2015), which in turn can affect cognitive functioning and academic performance (Dutil et al., 2022). Increased screen use may also reduce the time engaging in face-to-face interactions with family and friends, limiting opportunities for social development (Hall & Liu, 2022; Muppalla et al., 2023). Additionally, it can lead to a more sedentary lifestyle, decreasing physical activity and increasing the risk of weight-related health problems (Haghjoo et al., 2022). Beyond physical effects, extended screen exposure is associated with mood disturbances, including increased feelings of anxiety and depression (Liu et al., 2022; Santos et al., 2023), as well as negative impacts on self-esteem (Santos et al., 2023) and body image (Papageorgiou et al., 2022). The constant connectivity can contribute to a fear of missing out, which may intensify stress and anxiety (Bloemen & De Coninck, 2020; Gupta & Sharma, 2021). Furthermore, excessive screen time can interfere with learning alternative, more balanced ways to relax and enjoy free time (Oberle et al., 2020).

Despite many studies reporting negative mental health effects of social media, other ones argue that it might support well-being and social connectedness (Cauberghe et al., 2021; Smith et al., 2021; Thomas et al., 2020). Not all forms of digital media is harmful. Digital technologies, including educational apps, video games, and online learning platforms, have been shown to enhance cognitive skills such as problem-solving, critical thinking, and memory (Haddock et al., 2022). Furthermore, digital interventions can also promote physical activity and healthy diet among adolescents (Navarra et al., 2021; Rose et al., 2017).

Since the effects of digital media and screen time can be both beneficial and detrimental, newer guidelines emphasize the importance of focusing on the quality of content, the context of use, and the individual needs of youth, not merely on the amount of screen time (American Academy of Child & Adolescent Psychiatry, 2025; American Academy of Pediatrics, 2025; Ministry of Health Singapore, 2025). However, research studies still mainly use hours of screen time or percentage of children exceeding two hours screen time per day as outcomes.

Increasing screen time among children and adolescents has been described even before the COVID-19 pandemic (Bucksch et al., 2016; Harvey et al., 2022), which just worsened the trends according to cross-sectional studies (Kovacs et al., 2022; Trott et al., 2022). A

meta-analysis reported an average screen time of 2.7 hours per day before the pandemic, which increased by 1.4 hours during the pandemic based on retrospective or historical pre-pandemic data (Madigan et al., 2022). According to another meta-analysis, 46.6% of schoolchildren exceed the WHO recommendation of two hours per day on average. When comparing studies from before and after the COVID-19 outbreak, this study also reported an increase from 41.3% before to 59.4% after January 2020 (Qi et al., 2023).

While cross-sectional research provides valuable information, it lacks the ability to distinguish between effects related to specific time periods and differences across cohorts. Therefore, longitudinal research that monitors screen time before and throughout the COVID-19 pandemic is essential for accurately capturing how school closures have influenced screen time.

## **1.2 Adolescents' Mental Health**

Adolescence is a particularly sensitive stage of life, during which the combined effects of physical, emotional, and social changes increase vulnerability to mental health problems (Mastorci et al., 2024). Global estimates indicate that approximately one in seven adolescents aged 10–19 is affected by a mental disorder, most commonly anxiety and depression (World Health Organization, 2024). Among individuals aged 15–29, suicide ranks as the third leading cause of death (World Health Organization, 2024). The report of the Health Behaviour in School-aged Children (HBSC) study (Cosma et al., 2023) accompanied by other international studies (Daly, 2022; Marquez et al., 2022; Mazur et al., 2021; Potrebny et al., 2017) indicated a decline in life satisfaction and a rise in psychosomatic complaints among adolescents in several countries even before the COVID-19 pandemic. Hungarian HBSC data also demonstrated a rise in psychosomatic complaints, but contrary to international trends, an increase in life satisfaction between 2006 and 2018 (Várnai & Németh, 2024). The international report also highlighted that girls and older adolescents reported lower levels of mental well-being, and that socio-economic disparities were mirrored in mental health outcomes (Cosma et al., 2023).

Adolescents' sleep quality and duration are also linked to psychological well-being. Insufficient or disrupted sleep is associated with elevated levels of depression, anxiety, emotional dysregulation, and behavioral difficulties (Tarokh et al., 2016). Long sleep

onset latency, frequent night awakenings, and delayed bedtimes on school nights have been shown to predict higher emotional and behavioral risks (Qiu & Morales-Munoz, 2022). Epidemiological research suggests that delaying school start times, thus allowing adolescents to align sleep schedules more closely with their biological rhythms, yields improvements in both sleep duration and psychological health outcomes (Berger et al., 2018).

The COVID-19 pandemic has been reported to have a detrimental impact on adolescents' mental health (Farrell et al., 2023; Pepe & Farina, 2023; Richard et al., 2023), with increasing prevalence of stress, anxiety, depressive symptoms, and loneliness (Cochran et al., 2023; Pepe & Farina, 2023). A review of 156 observational studies found that most investigations reported a decline in adolescents' well-being during the pandemic, although some yielded no change (Zolopa et al., 2022). This review also highlighted a more negative effect on young women ( $\leq 25$  years) compared to men. The possible underlying factors were direct impact of the pandemic (loss of control, heightened fear, insecurity) and indirect impact of social isolation and school closures. While most studies indicated a deterioration in youth mental health, slight improvement has also been described particularly in the early stages of the pandemic (Goto et al., 2022). According to the authors, after major crises, people's mental health often shows a short-lived improvement due to a collective sense of solidarity, known as the "honeymoon effect" (Goto et al., 2022). As for self-esteem, only a limited number of studies investigated it in context with the COVID-19 pandemic, and the results are heterogeneous (Domínguez-Martín et al., 2025; Goto et al., 2022; Ozer, 2024).

Despite the large number of studies focusing on the relationship between the pandemic and adolescents' mental health, longitudinal evidence, which can differentiate between pre-pandemic trends and pandemic-related changes, remains scarce. Furthermore, existing findings, particularly on well-being and self-esteem, are inconsistent. This highlights the need for longitudinal studies that can clarify these associations to understand potential long-term psychological consequences and to strengthen preparedness for future public health emergencies.

### **1.3 Role of Family**

The family is adolescents' closest interpersonal setting and shapes both health-related behaviors and psychological outcomes. Prior work identifies several determinants of screen use, among which family structure seems to be important: youths in single-parent or reconstituted families tend to report longer screen time than peers in two-parent households (Langoy et al., 2019). Beyond structure, the style and quality of parent–adolescent communication also matter for regulating screen time. Autonomy-supportive, explanatory approaches are typically more effective than controlling strategies in shaping duration and content (Bjelland et al., 2015). Although problematic behaviors acquired in adolescence can persist in adulthood, supportive environments within the family, peer network, and school may interrupt this continuity and promote healthier trajectories (Frech, 2012).

These familial influences extend to mental health as well. During the COVID-19 period, it was observed that family togetherness, better family functioning, and higher-quality relationships buffered adverse effects on adolescents' well-being (Zolopa et al., 2022). On the other hand, poorer mental-health outcomes were associated with dysfunctional parenting, negative familial coping, parental irritability, and parent–child conflicts (Zolopa et al., 2022). Similar patterns emerged for self-esteem: stronger family relationships and constructive communication operated as protective factors, whereas familial conflict and harsh discipline predicted lower self-esteem during the pandemic (Maruyama et al., 2023).

Several mechanisms may account for these associations. Families define daily routines (sleep, homework, mealtimes), set and enforce media rules (limits, bedroom devices, co-use), and model coping strategies (Liga et al., 2020; Nagata et al., 2025; Selman & Dilworth-Bart, 2024). Warm, autonomy-supportive communication can reduce conflict around media use, foster adolescents' self-regulation, and guide them toward more adaptive activities, whereas chaotic or punitive climates may increase avoidance, dysregulation, and reliance on screens for mood management (Kroshus-Havril et al., 2024; Niu et al., 2023).

While existing literature underscores the importance of family-related factors in shaping adolescents' screen time and mental health outcomes, much of the evidence is derived

from cross-sectional studies that cannot capture changes over time. Longitudinal investigations that assess how family structure and communication relate to screen use, well-being, and self-esteem, particularly in the context of significant societal disruptions such as the COVID-19 school closures, remain limited.

## 2 Objectives

The overarching aim of the thesis was to understand the effects of COVID-19-related school lockdowns on the digital behaviors and psychological well-being of Hungarian adolescents, with special attention to the role of family structure and family communication. To do so, we conducted secondary analyses of data collected during a regional, school-based health education program, the Balassagyarmat Health Education Program (BEP) (Árva, 2023).

The specific objectives were:

1. To compare changes in overall screen time and its components (watching videos, playing games, doing homework, social media/communication) among adolescents affected and unaffected by school lockdowns.
2. To examine longitudinal changes in well-being (WHO-5 Well-being Index) and self-esteem (Rosenberg Self-Esteem Scale) in adolescents affected and unaffected by school lockdowns.
3. To analyze whether family structure (two-parent, single-parent, stepfamily) and the quality of family communication modify the association between school lockdowns and adolescents' screen time, well-being, and self-esteem.

### **3 Methods**

The following methodological description is based on my works published before (Major et al., 2024; Major et al., 2023).

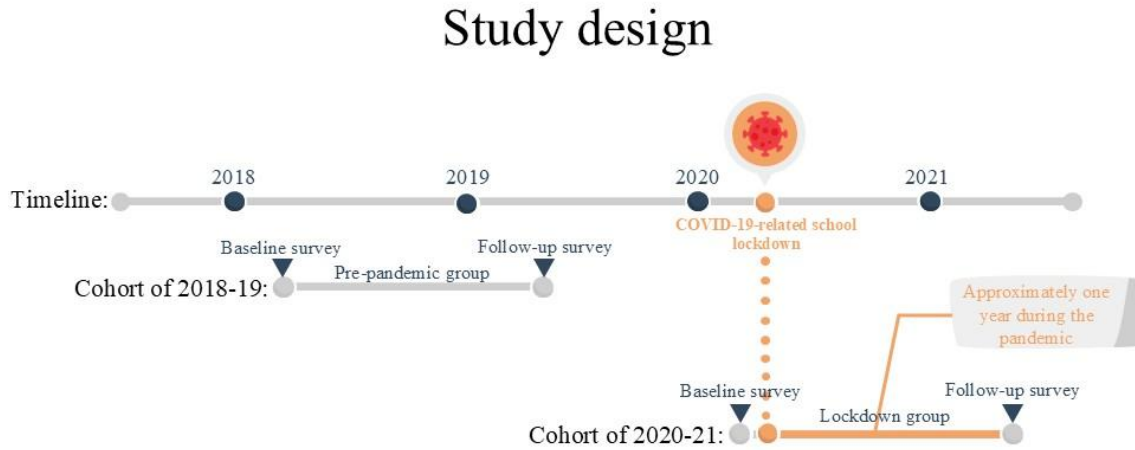
#### **3.1 Study design**

The studies presented in the thesis are secondary analyses of data collected during the BEP (Árva, 2023). BEP was a school-based near-peer health education program that operated between 2018-2021 in Balassagyarmat, a small town in Northern Hungary (Major & Eörsi, 2023). It aimed to improve health literacy, skills and attitudes in the following topics: sexual health, substance use (tobacco, alcohol, drugs), basic life support, infection control, nutrition, and physical activity (Eörsi et al., 2020). The program did not address screen time and mental health directly.

The program invited consecutive ninth graders from all five secondary schools (three grammar schools and two vocational schools) of Balassagyarmat. Students joined the one-year program in March each year. They completed a baseline survey before the health education started, and a follow-up survey after it (approximately one year after the baseline).

For the studies presented in the thesis, only those ninth graders were selected who completed their baseline survey in 2018 or 2020. Students whose baseline assessment was conducted in 2018 formed the pre-pandemic group, as they were unaffected by the COVID-19-related school lockdown. Both their baseline and follow-up surveys were administered in school during regular class hours, supervised by a research assistant and completed without teachers present. Data collection took place between February 22, 2018 and March 9, 2018 for the baseline, and between March 20, 2019 and March 27, 2019 for the follow-up survey. Those assessed in 2020 comprised the lockdown group, as they experienced pandemic-related school closures. Their baseline survey was conducted with the same circumstances between February 17, 2020 and February 19, 2020 (before the outbreak in Hungary), but the follow-up was completed at home during lockdown between April 12, 2021 and April 15, 2021. Students were asked to fill out the questionnaire during designated school hours, and they could consult a research assistant online if they had questions. We excluded students enrolled in 2019 because their follow-

up survey was administered during the early, introductory phase of school lockdowns in Hungary. Figure 1 illustrates the study design.



*Figure 1. Study design*

During the study, school closures in Hungary spanned from March 16, 2020, to June 2, 2020, and again from November 11, 2020, until the end of the study (April 15, 2021). According to the Organization for Economic Co-operation and Development (OECD) report, Hungarian secondary schools were closed for a total of 164 days (excluding holidays and weekends) between January 1, 2020, and May 20, 2021 (OECD, 2021).

Ethical approval was obtained from the Institutional Review Board of Semmelweis University (SE TUKÉB: 276/2017). Passive parental approval (opt-out) consent was sought for every participant.

### **3.2 Participants**

All ninth grader students from all five participating schools were invited to take part in the program. As for the pre-pandemic group, 332 out of 454 eligible students consented to participate at baseline in February 2018, corresponding to a 0.73 sampling fraction. The follow-up survey was completed by 234 students (98 students were lost to follow-up) in March 2019. For the lockdown group, 334 of 446 ninth-grade students participated

at baseline, yielding a 0.75 sampling fraction. Baseline data were collected in February 2020 (about one month prior to the onset of school closures in Hungary), and follow-up surveys were administered in March 2021. In this group, 83 participants were lost to follow-up. Overaged students (mean age + 3 SD) and those living without a biological or stepparent were excluded. The flowchart of participants is illustrated in Figure 2.

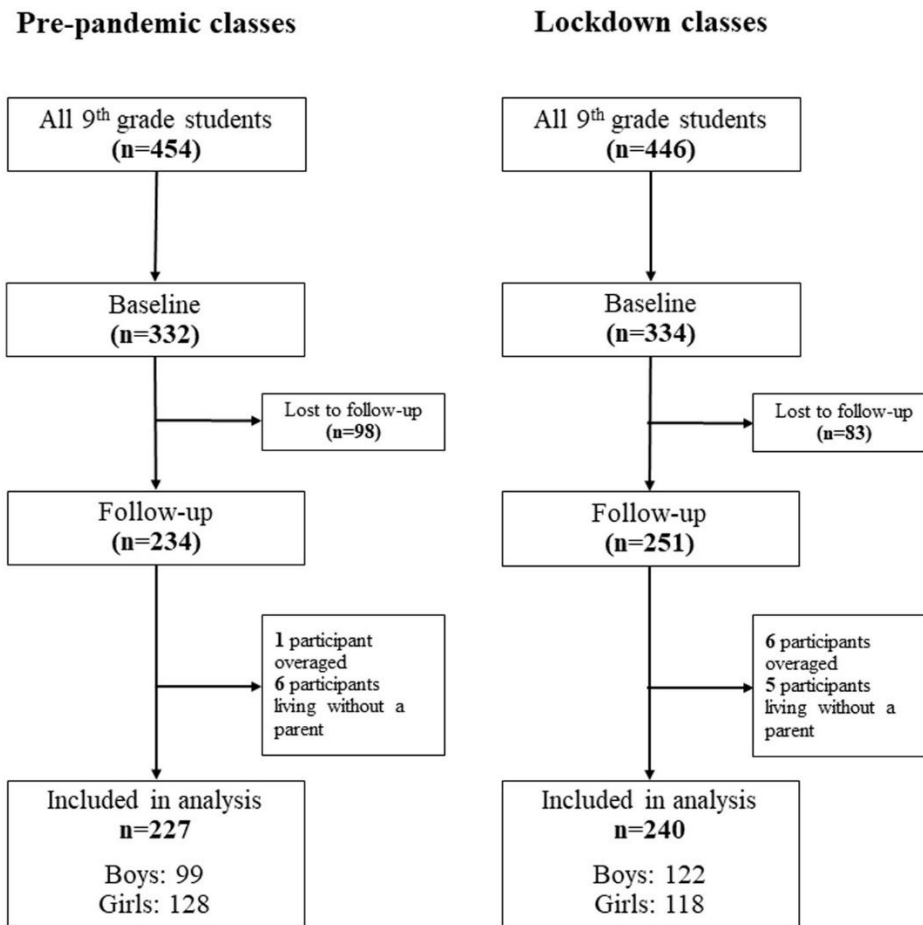


Figure 2. Flowchart of participants. Source: Major et al. (2023)

### 3.3 The survey

The BEP was accompanied by a comprehensive survey which primarily aimed to monitor the impact of the program (Árva, 2023). The survey consisted of detailed questions focusing on demographics, socioeconomic background, family relations, health-related knowledge, sexual health (attitudes and behaviors), health behaviors, self-reported body

and weight, body image, attitudes on family planning and marriage, and mental health (well-being, self-esteem, trait anxiety). The present thesis analyzed only a subset of these questions described below.

### **3.4 Outcomes**

#### **3.4.1 Screen time**

To evaluate screen time, four questions from the Hungarian version of the HBSC study from 2014 (Currie et al., 2014; Németh & Költő, 2016) was adopted: (1) *‘How many hours a day, in your free time, do you usually spend watching TV, videos (including YouTube or similar services), DVDs, and other entertainment on a screen?’* (2) *‘How many hours a day, in your free time, do you usually spend playing games on a computer, games console, tablet (like iPad), smartphone or other electronic device (not including moving or fitness games)?’* (3) *‘How many hours a day, in your free time, do you usually spend using electronic devices such as computers, tablets (like iPad) or smart phones for other purposes, for example, homework, emailing, tweeting, Facebook, chatting, surfing the internet?’* (4) *‘How many hours of this do you spend on doing homework?’*. Students were required to express the amount of time spent on each activity as hours and fractions of an hour. The items resulted in five outcome variables: overall screen time (sum of Question 1, 2 and 3), screen time for watching videos (Question 1), playing games (Question 2), doing homework (Question 4), and screen time for other purposes (derived as the difference between data provided in Questions 3 and 4) representing time spent mainly on social media activities and communication.

#### **3.4.2 Well-being**

Well-being was measured by the validated Hungarian version of the WHO-5 Well-being Index (WBI) (Susánszky et al., 2006; Topp et al., 2015). This instrument consists of five Likert scale items, each ranging from 0 (at no time) to 3 points (all of the time). The items assess whether the participants (1) *‘have felt cheerful in good spirits’*, (2) *‘have felt calm and relaxed’*, (3) *‘have felt active and vigorous’*, (4) *‘woke up feeling fresh and rested’* or (5) *daily life has been filled with things that interest them* in the last 2 weeks. The maximal score is 15. A higher score indicates better well-being.

### 3.4.3 Self-esteem

Self-esteem was measured by the validated Hungarian version of the Rosenberg Self-esteem Scale (RSES) (Rosenberg, 1965; Sallay et al., 2014). The instrument has 10 items (five of these with reverse scoring) with 4-point Likert scales (ranging from strongly agree to strongly disagree). The maximal score is 30. RSES is a unidimensional construct reflecting global self-esteem. A higher score is associated with higher self-esteem. The items read (1) *‘On the whole, I am satisfied with myself’*; (2) *‘At times, I think I am no good at all’*; (3) *‘I feel that I have a number of good qualities’*; (4) *‘I am able to do things as well as most other people’*; (5) *‘I feel I do not have much to be proud of’*; (6) *‘I certainly feel useless at times’*; (7) *‘I feel that I’m a person of worth, at least on an equal plane with others’*; (8) *‘I wish I could have more respect for myself’*; (9) *‘All in all, I am inclined to feel that I am a failure’*; (10) *‘I take a positive attitude toward myself’*.

## 3.5 Covariates

Since family plays an important role in children’s development, health behavior (Frech, 2012), well-being (Gecer & Yildirim, 2023; Han, 2023), and self-esteem (Maruyama et al., 2023), our analyses were adjusted for family structure and family communication.

### 3.5.1 Family structure

Family structure was determined by the participants’ response to the question with whom they lived together. Answers were collapsed into three categories: living with both parents, with one parent, or in a stepfamily (one biological parent and his/her new partner who lives in the same household).

### 3.5.2 Family communication

Family communication was assessed by the Hungarian translation of the short version of the Clear Communication Scale from Family Dynamics Measure II (FDMII) (Lasky et al., 1985) as it was used in the 2014 HBSC study (Németh & Költő, 2016). This instrument consists of four items, each rated on a five-point Likert scale (from 1 = strongly disagree to 5 = strongly agree), resulting in a total possible score of 20. Higher scores reflect more favorable perceptions of communication within the family. The items assess whether in the family (1) *‘I think the important things are talked about’*; (2) *‘When*

*I speak someone listens to what I say*’; (3) *‘We ask questions when we do not understand each other’*; (4) *‘When there is misunderstanding, we talk it over until it’s clear’*.

### **3.6 Statistical analyses**

Gender distribution of pre-pandemic and lockdowns groups were tested by chi-squared test. All further analyses were stratified by gender, since gender differences in screen time and mental health have been described in the literature. Chi-squared test for categorical variable family structure and independent samples t-tests for continuous variables (age and family communication) were used to compare baseline data of pre-pandemic vs. lockdown classes as well as follow-up data of pre-pandemic vs. lockdown classes, respectively. Marginal homogeneity tests for the categorical variable family structure and paired t-tests for continuous variables (age and family communication) were used to compare baseline vs. follow-up data within pre-pandemic and lockdown groups.

Linear mixed models were built to assess the effect of COVID-19-related school lockdowns on overall screen time, its individual components (watching videos, playing games, doing homework, and other purposes), well-being, and self-esteem. *Model 1* included group status (pre-pandemic vs. lockdown) as the sole predictor, while *Model 2* was adjusted for time-varying family structure and family communication. Both models included a random slope and a random intercept with an unstructured covariance matrix.

All statistical analyses were performed using IBM SPSS Statistics (version 28.0.0.0. or 29.0.1.0.). Statistical significance was set at 2-tailed  $p < 0.05$ .

#### **3.6.1 Post hoc analyses**

To better understand the change in well-being observed during the pandemic, we conducted additional analyses by running separate linear mixed models for each individual item of the WHO-5 WBI, using group status as the sole predictor (*Model 1*). These analyses revealed that the only significant difference between the pre-pandemic and lockdown groups pertained to changes in Item 4 (waking up feeling fresh and rested) over the follow-up period. Based on this, we hypothesized that adolescents who typically had difficulty waking up early might have benefited the most from the lockdowns. To investigate this, we categorized students according to their baseline responses on Item 4: those with a low score (0 or 1) and those with a high score (2 or 3). We then expanded

*Model 1* by incorporating this new grouping variable (including the main effect, its interaction with pandemic status, with follow-up, and a 3-way interaction with pandemic status and follow-up). This approach allowed us to examine whether these subgroups, defined by their baseline experiences with waking up, exhibited different trajectories before and during the pandemic.

Given that RSES has a unidimensional structure (Aluja et al., 2007; Rosenberg, 1965), we did not perform any post-hoc analysis.

## 4 Results

Results are described based on my previous works (Major et al., 2024; Major et al., 2023).

### 4.1 Descriptive statistics of pre-pandemic and lockdown groups

In total, 234 students from the pre-pandemic group and 251 from the lockdown group were eligible for inclusion in the analysis. Seven students were excluded due to being overaged, and an additional 11 students due to living without biological or stepparent. As a result, the final sample consisted of 467 participants: 227 pre-pandemic controls (128 girls and 99 boys) and 240 lockdown cases (118 girls and 122 boys), as depicted in Figure 2. The proportion of girls and boys did not differ significantly between the pre-pandemic and lockdown groups ( $\chi^2 = 2.16$ ,  $df = 1$ ,  $p = 0.14$ ). Table 1 (Major et al., 2023) presents the descriptives stratified by gender and group status (pre-pandemic vs. lockdown) at both timepoints (baseline and follow-up).

Among boys, there were no significant differences in age, family structure, or family communication between the pre-pandemic and lockdown groups at either time point (all  $p$ -values  $> 0.05$ ). As for girls, they were 0.22 years older in the lockdown group compared to the pre-pandemic group. In addition, at baseline, there was a significant difference in family structure between pre-pandemic and lockdown groups among girls, with the lockdown group having a greater proportion of stepfamilies. However, by the follow-up assessment, no significant differences in family structure or family communication were observed between the groups.

When analyzing changes from baseline to follow-up within groups, we observed a shift in family structure among pre-pandemic boys, with fewer students living in two-parent families at follow-up. Additionally, family communication significantly declined over this period among them. As for girls, the FDMII score showed a significant decline from baseline to follow-up in both pre-pandemic and lockdown groups.

**Table 1.** Descriptive statistics of pre-pandemic and lockdown groups (Major et al., 2023)

	Pre-pandemic group		Lockdown group	
	baseline	follow-up	baseline	follow-up
<b>Boys</b>				
n		99		122
age, mean±SD	16.08±0.60	-	16.16±0.63	-
family structure, n (%)				
two-parent	71 (71.7%)†	66 (66.7%)†	85 (69.7%)	83 (68.0%)
single-parent	17 (17.2%)†	19 (19.2%)†	20 (16.4%)	21 (17.2%)
stepfamily	11 (11.1%)†	14 (14.1%)†	17 (13.9%)	18 (14.8%)
family communication, mean±SD	17.53±2.61†	16.44±3.56†	16.97±3.26	16.79±3.56
<b>Girls</b>				
n		128		118
age, mean±SD	15.92±0.68*	-	16.14±0.64*	-
family structure, n (%)				
two-parent	94 (73.4%)*	92 (71.9%)	78 (66.1%)*	73 (61.9%)
single-parent	25 (19.5%)*	26 (20.3%)	19 (16.1%)*	27 (22.9%)
stepfamily	9 (7.0%)*	10 (7.8%)	21 (17.8%)*	18 (15.3%)
family communication, mean±SD	17.43±2.56 †	16.02±4.15†	17.00±3.11†	16.38±3.84†

Abbreviation: SD: standard deviation.

\* p<0.05 (Baseline data of pre-pandemic vs. lockdown groups and follow-up data of pre-pandemic vs. lockdown groups were compared with Chi-squared tests for categorical variables and independent samples t-tests for continuous variables.)

† p<0.05 (Baseline vs. follow-up data within pre-pandemic vs. lockdown groups were compared with Marginal Homogeneity tests for categorical variables and paired samples t-tests for continuous variables.)

## 4.2 Changes in screen time

### 4.2.1 Boys

*Model 1* indicated that overall daily screen time was 1.35 (95% confidence interval [CI]: 0.12–2.57) hours higher in the pre-pandemic group than in the lockdown group. However, this difference was no longer statistically significant after adjusting for family structure and family communication (mean difference [MD]: 1.17 hours [–0.06–2.40]; 9.06 [95% CI: 8.03–10.08] vs. 10.23 [95% CI: 9.35–11.09] hours) (Figure 3; Table 2).

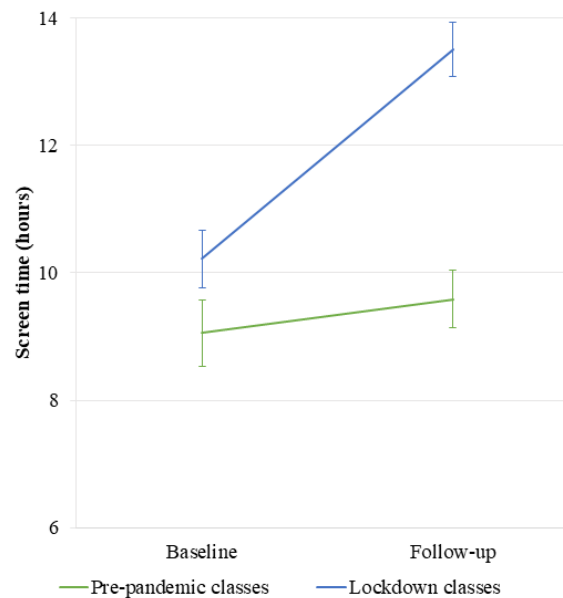


Figure 3. Changes of overall daily screen time of pre-pandemic and lockdown groups for boys (Major et al., 2023).

**Table 2.** Results of liner mixed models for overall screen time of boys expressed in hours per day (Major et al., 2023)

	Model 1		Model 2†	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Intercept	8.46 (7.51 – 9.40)		8.35 (7.34 – 9.36)	
Group				
Pre-pandemic	ref.			
Lockdown	<b>1.35 (0.12 – 2.57)*</b>	<b>0.032</b>	1.17 (-0.06 – 2.40)	0.063
Pre-pandemic*Time				
Baseline	ref.		ref.	
Follow-up	0.81 (-0.32 – 1.93)	0.158	0.53 (-0.59 – 1.66)	0.349
Lockdown*Time				
Baseline	ref.		ref.	
Follow-up	<b>3.27 (2.25 – 4.29)*</b>	<b>&lt;0.001</b>	<b>3.29 (2.29 – 4.29)*</b>	<b>&lt;0.001</b>
Family structure				
Two-parent	–	–	ref.	
Single-parent	–	–	0.66 (-0.69 – 2.01)	0.335
Stepfamily	–	–	1.45 (-0.02 – 2.92)	0.053
Family communication	–	–	<b>-0.78 (-1.32 – -0.24)*</b>	<b>0.005</b>

Abbreviation: 95% CI: 95% Confidence Interval

**\*p<0.05**

†Adjusted for time-varying family structure and family communication

Since the results from *Model 1* and *Model 2* were similar for the individual components of screen time, only results from *Model 2* are described in detail below. At baseline, pre-pandemic students spent an average of 0.79 (95% CI: 0.13–1.45) hours more per day watching videos than lockdown students (3.49 [95% CI: 2.93–4.04] vs. 4.28 [95% CI: 3.80–4.76] hours). The time spent on playing games (3.08 [95% CI: 2.59–3.58] vs. 3.11 [95% CI: 2.68–3.54] hours), doing homework (0.79 [95% CI: 0.53–1.04] vs. 0.91 [95% CI: 0.70–1.12] hours), and other activities (controls: 3.00 [95% CI: 2.41–3.59] vs. cases: 3.63 [95% CI: 3.13–4.14] hours) was similar in the two groups (Figure 4; Table 3).

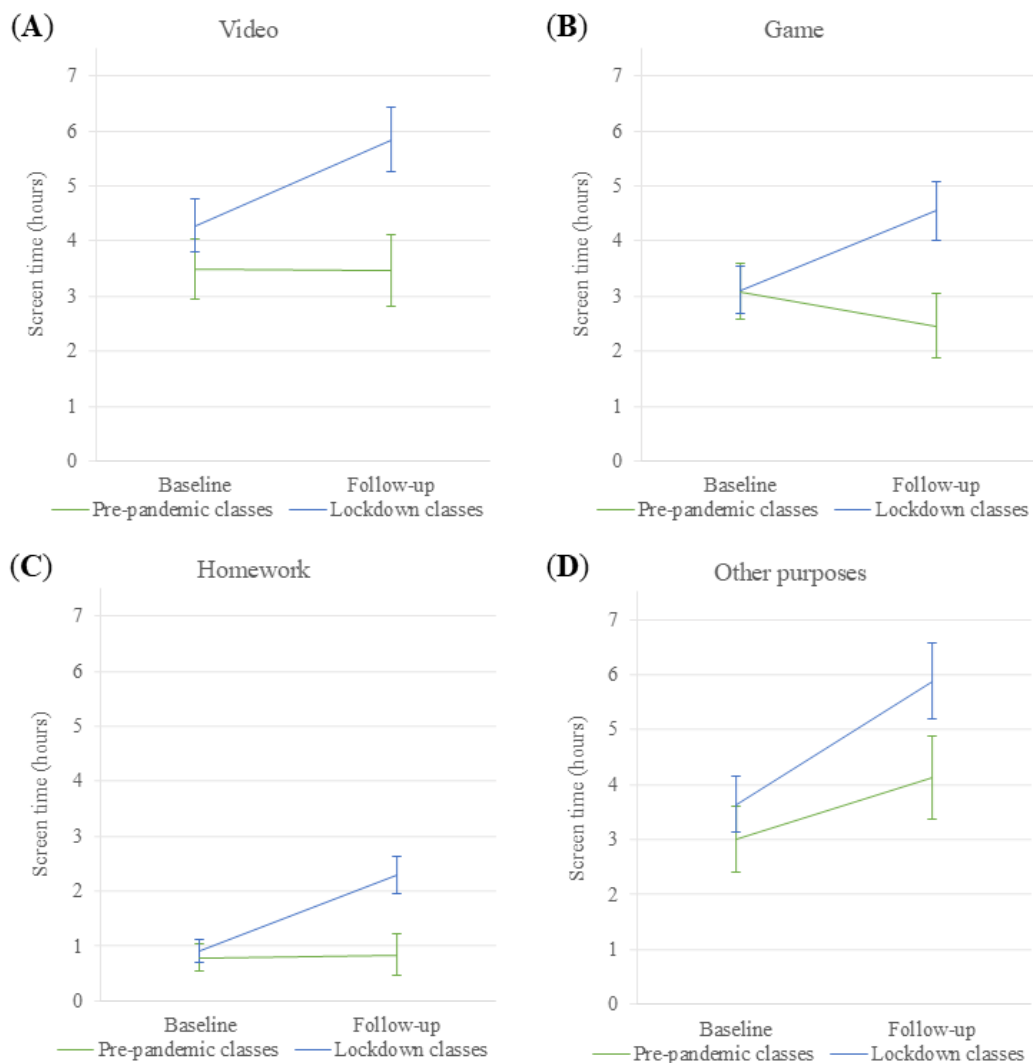


Figure 4. Changes of the individual components of screen time of pre-COVID and COVID classes for boys: daily screen time on watching videos (A), playing games (B), doing homework (C), and other purposes (D) (Major et al., 2023).

**Table 3.** Results of liner mixed models for the individual components of boys' daily screen time expressed in hours (Major et al., 2023)

	Video				Game				Homework				Other purposes			
	Model 1		Model 2†		Model 1		Model 2†		Model 1		Model 2†		Model 1		Model 2†	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Intercept	3.24 (2.74 – 3.75)		3.10 (2.56 – 3.65)		2.69 (2.24 – 3.15)		2.58 (2.09 – 3.06)		0.79 (0.56 – 1.01)		0.77 (0.52 – 1.03)		2.79 (2.26 – 3.33)		2.71 (2.12 – 3.30)	
Group																
Pre-pandemic	ref.		ref.		ref.		ref.		ref.		ref.		ref.		ref.	
Lockdown	<b>0.83</b> <b>(0.16 – 1.49)*</b>	<b>0.015</b>	<b>0.79</b> <b>(0.13 – 1.45)*</b>	<b>0.019</b>	0.12 (-0.48 – 0.72)	0.685	0.03 (-0.57 – 0.62)	0.931	0.12 (-0.17 – 0.42)	0.413	0.12 (-0.18 – 0.42)	0.425	0.68 (-0.02 – 1.38)	0.055	0.63 (-0.08 – 1.34)	0.081
Pre-pandemic*Time																
Baseline	ref.		ref.		ref.		ref.		ref.		ref.		ref.		ref.	
Follow-up	0.07 (-0.52 – 0.67)	0.811	-0.03 (-0.63 – 0.58)	0.930	-0.46 (-0.95 – 0.03)	0.066	<b>-0.63</b> <b>(-1.12 – -0.14)*</b>	<b>0.012</b>	0.05 (-0.36 – 0.45)	0.827	0.05 (-0.36 – 0.47)	0.800	<b>1.18</b> <b>(0.33 – 2.04)*</b>	<b>0.007</b>	<b>1.11</b> <b>(0.25 – 1.97)*</b>	<b>0.012</b>
Lockdown*Time																
Baseline	ref.		ref.		ref.		ref.		ref.		ref.		ref.		ref.	
Follow-up	<b>1.59</b> <b>(1.07 – 2.10)</b>	<b>&lt;0.001</b>	<b>1.56</b> <b>(1.05 – 2.08)*</b>	<b>&lt;0.001</b>	<b>1.47</b> <b>(1.05 – 1.89)*</b>	<b>&lt;0.001</b>	<b>1.44</b> <b>(1.02 – 1.85)*</b>	<b>&lt;0.001</b>	<b>1.37</b> <b>(1.02 – 1.73)*</b>	<b>&lt;0.001</b>	<b>1.38</b> <b>(1.02 – 1.73)*</b>	<b>&lt;0.001</b>	<b>2.25</b> <b>(1.50 – 3.00)*</b>	<b>&lt;0.001</b>	<b>2.24</b> <b>(1.49 – 2.99)*</b>	<b>&lt;0.001</b>
Family structure																
two-parent	–	–	ref.	–	–	ref.	–	–	–	–	ref.	–	–	–	ref.	–
single-parent	–	–	<b>0.94</b> <b>(0.18 – 1.70)*</b>	<b>0.015</b>	–	–	<b>0.78</b> <b>(0.10 – 1.46)*</b>	<b>0.025</b>	–	–	0.13 (-0.22 – 0.48)	0.479	–	–	0.52 (-0.27 – 1.30)	0.197
stepfamily	–	–	0.22 (-0.63 – 1.07)	0.608	–	–	0.75 (-0.02 – 1.52)	0.057	–	–	-0.09 (-0.47 – 0.29)	0.635	–	–	0.37 (-0.50 – 1.24)	0.404
Family communication	–	–	<b>-0.32</b> <b>(-0.62 – -0.02)*</b>	<b>0.040</b>	–	–	<b>-0.41</b> <b>(-0.66 – -0.15)*</b>	<b>0.002</b>	–	–	0.10 (-0.06 – 0.26)	0.223	–	–	-0.07 (-0.42 – 0.29)	0.722

Abbreviation: 95% CI: 95% Confidence Interval

\***p<0.05**

†Adjusted for family structure and family communication

In the pre-pandemic group, there was no significant change in overall daily screen time with increasing age (9.06 [95% CI: 8.03–10.08] vs. 9.59 [95% CI: 8.55–10.63] hours) (Figure 3). However, the distribution of time spent on different screen-related activities shifted. Time spent watching videos remained largely unchanged (3.49 [95% CI: 2.93–4.04] vs. 3.46 [95% CI: 2.81–4.11] hours), while time spent on playing games decreased by 0.63 (95% CI: -1.12 – -0.14) hours (3.08 [95% CI: 2.59–3.59] vs. 2.45 [95% CI: 1.87–3.04] hours). Time dedicated to homework was stable (0.79 [95% CI: 0.53–1.04] vs. 0.84 [95% CI: 0.46–1.22] hours), whereas screen time for other purposes showed a 1.11 (95% CI: 0.25–1.97) hour increase (3.00 [95% CI: 2.41–3.59] vs. 4.11 [95% CI: 3.36–4.87] hours) (Figure 4; Table 3).

In the lockdown group overall daily screen time increased by 3.29 (95% CI: 2.29–4.29) hours (10.23 [95% CI: 9.35–11.09] vs. 13.51 [95% CI: 12.49–14.53] hours) during the follow-up period (Figure 3; Table 2). This was attributed to an increase in all individual components. Time spent watching videos increased by 1.56 (95% CI: 1.05–2.08) hours (4.28 [95% CI: 3.80–4.76] vs. 5.84 [95% CI: 5.25–6.44] hours). Unlike the pre-pandemic students, the lockdown group increased screen time spent on playing games by 1.44 (95% CI: 1.02–1.85) hours (3.11 [95% CI: 2.68–3.54] vs. 4.55 [95% CI: 4.01–5.09] hours). Furthermore, they showed a 1.38 (95% CI: 1.02–1.73) hour increase in time spent on homework (0.91 [95% CI: 0.70–1.12] vs. 2.29 [95% CI: 1.94–2.62] hours), and a 2.24 (95% CI: 1.49–2.99) hour increase on other purposes (3.63 [95% CI: 3.13–4.14] vs. 5.87 [95% CI: 5.18–6.56] hours) (Figure 4; Table 3).

Additionally, our results showed that boys residing in single-parent households spent more time watching videos and playing games. We also observed that boys with higher family communication scores had less total daily screen time, as well as less time spent on watching videos and playing games (Table 2; Table 3).

#### 4.2.2 Girls

Results from *Model 1* and *Model 2* were consistent for girls, so only results from Model 2 are described in detail below. Based on Model 2, girls in the lockdown group had a 1.53 (95% CI: 0.44–2.62) hour higher baseline for overall daily screen time than the pre-pandemic group (8.50 [95% CI: 7.62–9.38] vs. 10.03 [95% CI: 9.19–10.87] hours) (Figure 5; Table 4).

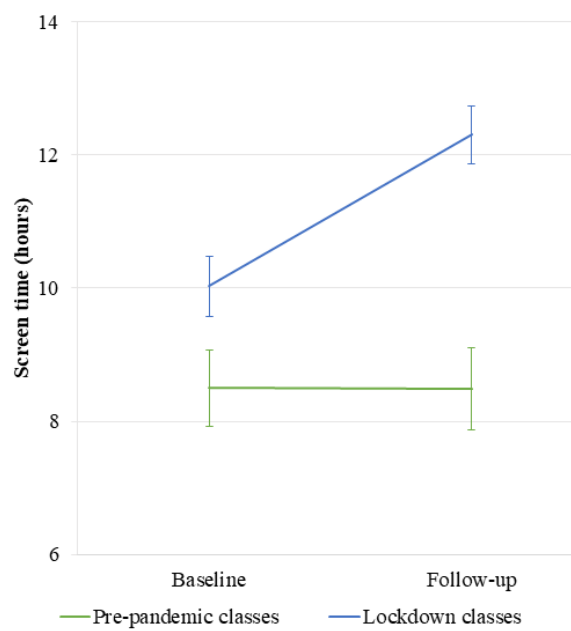


Figure 5. Changes of overall screen time of pre-pandemic and lockdown groups for girls (Major et al. 2023).

**Table 4.** Results of liner mixed models for overall screen time of girls expressed in hours per day (Major et al., 2023)

	Model 1		Model 2†	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Intercept	8.31 (7.55 – 9.07)		8.18 (7.37 – 8.99)	
Group				
Pre-pandemic	ref.		ref.	
Lockdown	<b>1.52 (0.43 – 2.60)*</b>	<b>0.007</b>	<b>1.53 (0.44 – 2.62)*</b>	<b>0.006</b>
Pre-pandemic*Time				
Baseline	ref.		ref.	
Follow-up	0.20 (-0.63 – 1.05)	0.646	-0.02 (-0.88 – 0.84)	0.969
Lockdown*Time				
Group	ref.		ref.	
Pre-pandemic	<b>2.47 (1.57 – 3.38)*</b>	<b>&lt;0.001</b>	<b>2.27 (1.37 – 3.18)*</b>	<b>&lt;0.001</b>
Family structure				
two-parent	–	–	ref.	
single-parent	–	–	<b>1.16 (0.02 – 2.31)*</b>	<b>0.046</b>
stepfamily	–	–	-0.19 (-1.68 – 1.30)	0.804
Family communication	–	–	<b>-0.64 (-1.11 – -0.16)*</b>	<b>0.009</b>

Abbreviation: 95% CI: 95% Confidence Interval

**\*p<0.05**

†Adjusted for time-varying family structure and family communication

Looking at the individual components, girls in lockdown spent 0.62 (95% CI: 0.06–1.17) hours more screen time on watching videos than the pre-pandemic group (3.51 [95% CI: 3.05–3.96] vs. 4.13 [95% CI: 3.69–4.55] hours). No significant differences were observed between groups in time spent playing games (1.51 [95% CI: 1.10–1.93] vs. 1.79 [95% CI: 1.40–2.19] hours) or doing homework (1.08 [95% CI: 0.92–1.24] vs. 1.03 [95% CI: 0.88–1.17] hours). However, girls in the lockdown group also had higher screen time for other purposes by 1.28 hours (95% CI: 0.57–2.00; 3.71 [95% CI: 3.14–4.29] vs. 4.99 [95% CI: 4.45–5.54] hours) (Figure 6; Table 5).

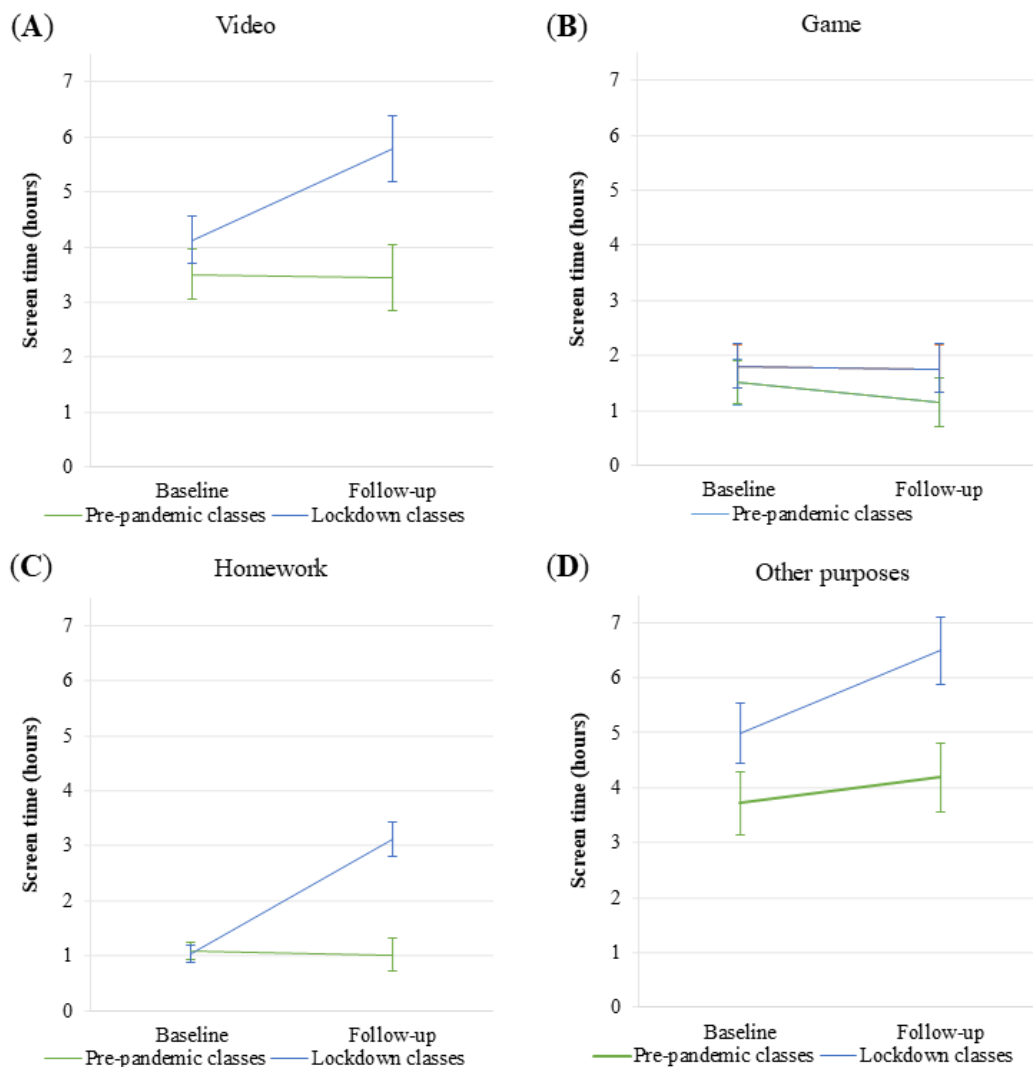


Figure 6. Changes of the individual components of screen time of pre-COVID and COVID classes for girls: daily screen time on watching videos (A), playing games (B), doing homework (C), and other purposes (D) (Major et al., 2023).

**Table 5.** Results of liner mixed models for the individual components of girls' daily screen time expressed in hours (Major et al., 2023)

	Video				Game				Homework				Other purposes			
	Model 1		Model 2†		Model 1		Model 2†		Model 1		Model 2†		Model 1		Model 2†	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Intercept	3.38 (2.99 – 3.76)		3.35 (2.93 – 3.76)		1.54 (1.18 – 1.90)		1.63 (1.25 – 2.02)		1.05 (0.92 – 1.18)		1.04 (0.90 – 1.19)		3.48 (2.97 – 3.99)		3.25 (2.72 – 3.78)	
Group																
pre-COVID	ref.		ref.		ref.		ref.		ref.		ref.		ref.		ref.	
COVID	<b>0.65</b> <b>(0.10 – 1.20)*</b>	<b>0.021</b>	<b>0.62</b> <b>(0.06 – 1.17)*</b>	<b>0.030</b>	0.31 (-0.20 – 0.82)	0.231	0.28 (-0.24 – 0.80)	0.288	-0.04 (-0.23 – 0.14)	0.633	-0.05 (-0.25 – 0.14)	0.593	<b>1.27</b> <b>(0.54 – 2.00)*</b>	<b>&lt;0.001</b>	<b>1.28</b> <b>(0.57 – 2.00)*</b>	<b>&lt;0.001</b>
pre-COVID*Time																
Baseline	ref.		ref.		ref.		ref.		ref.		ref.		ref.		ref.	
Follow-up	0.05 (-0.46 – 0.56)	0.860	-0.06 (-0.58 – 0.46)	0.834	-0.31 (-0.76 – 0.15)	0.183	-0.37 (-0.82 – 0.08)	0.110	-0.06 (-0.33 – 0.21)	0.651	-0.06 (-0.36 – 0.23)	0.677	0.52 (-0.08 – 1.13)	0.090	0.47 (-0.15 – 1.08)	0.135
COVID*Time																
Baseline	ref.		ref.		ref.		ref.		ref.		ref.		ref.		ref.	
Follow-up	<b>1.73</b> <b>(1.20 – 2.26)*</b>	<b>&lt;0.001</b>	<b>1.66</b> <b>(1.13 – 2.19)*</b>	<b>&lt;0.001</b>	-0.03 (-0.49 – 0.43)	0.889	-0.04 (-0.50 – 0.42)	0.862	<b>2.10</b> <b>(1.82 – 2.38)*</b>	<b>&lt;0.001</b>	<b>2.10</b> <b>(1.80 – 2.40)*</b>	<b>&lt;0.001</b>	<b>1.59</b> <b>(0.97 – 2.21)*</b>	<b>&lt;0.001</b>	<b>1.49</b> <b>(0.87 – 2.12)*</b>	<b>&lt;0.001</b>
Family structure																
two-parent	–	–	ref.	–	–	–	ref.	–	–	–	ref.	–	–	–	ref.	–
single-parent	–	–	0.33 (-0.31 – 0.97)	0.310	–	–	-0.23 (-0.77 – 0.31)	0.399	–	–	0.02 (-0.21 – 0.26)	0.842	–	–	<b>0.92</b> <b>(0.16 – 1.67)*</b>	<b>0.017</b>
stepfamily	–	–	0.14 (-0.67 – 0.96)	0.729	–	–	-0.12 (-0.81 – 0.56)	0.720	–	–	0.08 (-0.21 – 0.37)	0.589	–	–	0.47 (-0.49 – 1.42)	0.338
Family communication	–	–	-0.27 (-0.55 – 0.01)	0.059	–	–	-0.12 (-0.35 – 0.11)	0.320	–	–	0.01 (-0.11 – 0.12)	0.972	–	–	-0.29 (-0.61 – -0.03)	0.080

Abbreviation: 95% CI: 95% Confidence Interval; COVID: Coronavirus Disease 2019

\***p<0.05**

†Adjusted for family structure and family communication

Over the follow-up period, overall daily screen time among pre-pandemic girls remained unchanged (8.50 [95% CI: 7.62–9.38] vs. 8.47 [95% CI: 7.56–9.41] hours) (Table 2; Figure 2). In contrast to boys, there were no significant age-related changes in any specific component of screen time for pre-pandemic girls. On average, they spent 3.45 (95% CI: 2.85–4.04) hours watching videos, 1.14 (95% CI: 0.70–1.59) hours playing games, 1.02 (95% CI: 0.71–1.32) hours on homework, and 4.18 (95% CI: 3.56–4.80) hours on other screen-based activities (Figure 6; Table 5).

On the other hand, lockdown girls experienced a 2.27-hour (95% CI: 1.37–3.18) increase in their overall daily screen time during follow-up (10.03 [95% CI: 9.19–10.87] vs. 12.30 [95% CI: 11.35–13.25] hours) (Figure 5; Table 4). Breaking down the components, screen time spent watching videos rose by 1.66 (95% CI: 1.13–2.19) hours (4.13 [95% CI: 3.69–4.55] vs. 5.79 [95% CI: 5.18–6.37] hours), while time spent playing games remained unchanged (1.80 [95% CI: 1.40–2.19] vs. 1.76 [95% CI: 1.32–2.19] hours). Screen time dedicated to homework increased by 2.10 (95% CI: 1.80–2.40) hours (1.03 [95% CI: 0.88–1.17] to 3.13 [95% CI: 2.81–3.43] hours), and screen time for other activities rose by 1.49 (95% CI: 0.87–2.12) hours (4.99 [95% CI: 4.45–5.54] to 6.48 [95% CI: 5.87–7.10] hours) (Figure 6; Table 5).

Girls living in a single-parent household had a higher overall daily screen time and screen time spent on social media. We also observed that girls with higher scores on family communication had less overall screen time, though no significant associations were observed between family communication and the separate components of screen use (Table 4; Table 5).

### 4.3 Changes in the WHO-5 Well-Being Index

#### 4.3.1 Boys

Based on the unadjusted model (*Model 1*), baseline WHO-5 well-being scores were similar among pre-pandemic and lockdown boys. Over the follow-up period, well-being scores in the pre-pandemic group declined by 1.05 points (95% CI:  $-1.72$  to  $-0.38$ ). In contrast, the decline was significantly less pronounced in the lockdown group, resulting in a non-significant but positive point estimate of change (Figure 7; Table 6). Adjusting for family structure and family communication in *Model 2* did not substantially alter these findings. Additionally, higher scores on family communication were significantly associated with better well-being among boys (Table 6).

#### 4.3.2 Girls

Overall, girls had lower WHO-5 well-being scores than boys. The general pattern of change for girls in *Model 1* mirrored that of boys: both the pre-pandemic and lockdown groups had similar baseline scores, but the pre-pandemic group experienced a significant decline over time (MD:  $0.71$ , 95% CI:  $-1.31$  to  $-0.11$ ), while the lockdown group had a significantly different trajectory, showing a non-significant improvement (Figure 7; Table 6). After adjusting for time-varying family structure and family communication (*Model 2*), the decline in the pre-pandemic group was greatly reduced and became non-significant; however, the difference in change between the two groups persisted, resulting in an actual improvement in well-being among girls in the lockdown group (MD:  $0.64$ , 95% CI:  $0.01$  to  $1.72$ ). Living in a single-parent household was linked to lower well-being scores ( $-0.77$ , 95% CI:  $-1.52$  to  $-0.01$ ). As with boys, family communication was positively associated with well-being among girls, with a similar effect size (Table 6).

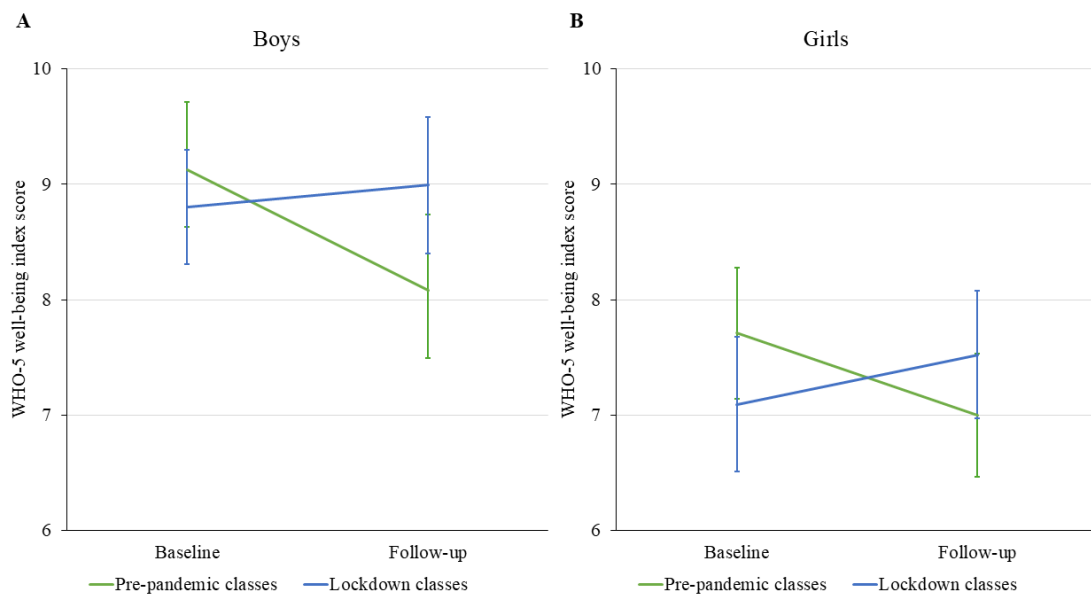


Figure 7. Estimated marginal means (Model 1) of boys' (A) and girls' (B) WHO-5 well-being index score of pre-pandemic and lockdown classes from baseline to follow-up (Major et al. 2024).

**Table 6.** Results of linear mixed models for WHO well-being score (Major et al., 2024)

	Model 1		Model 2 <sup>†</sup>	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
<b>Boys</b>				
Intercept	9.13 (8.54 to 9.72)		9.04 (8.42 to 9.66)	
Group				
Pre-pandemic	ref.		ref.	
Lockdown	-0.33 (-1.10 to 0.45)	0.408	-0.20 (-0.96 to 0.55)	0.594
Time	<b>-1.05 (-1.72 to -0.38)*</b>	<b>0.002</b>	<b>-0.82 (-1.49 to -0.14)*</b>	<b>0.018</b>
Group*Time				
Pre-pandemic	ref.		ref.	
Lockdown	<b>1.24 (0.35 to 2.12)</b>	<b>0.006</b>	<b>1.05 (0.17 to 1.93)</b>	<b>0.020</b>
Family structure				
two-parent	–	–	ref.	
single-parent	–	–	0.03 (-0.81 to 0.86)	0.952
stepfamily	–	–	-0.53 (-1.46 to 0.41)	0.269
Family communication	–	–	<b>0.82 (0.49 to 1.16)*</b>	<b>&lt;0.001</b>
<b>Girls</b>				
Intercept	7.71 (7.14 to 8.28)		7.66 (7.08 to 8.24)	
Group				
Pre-pandemic	ref.		ref.	
Lockdown	-0.62 (-1.44 to 0.20)	0.139	-0.61 (-1.41 to 0.18)	0.131
Time	<b>-0.71 (-1.31 to -0.11)*</b>	<b>0.022</b>	-0.38 (-1.01 to 0.24)	0.225
Group*Time				
pre-pandemic	ref.		ref.	
lockdown	<b>1.14 (0.28 to 2.01)</b>	<b>0.010</b>	<b>1.03 (0.15 to 1.90)</b>	<b>0.022</b>
Family structure				
two-parent	–	–	ref.	
single-parent	–	–	<b>-0.77 (-1.52 to -0.01)*</b>	<b>0.047</b>
stepfamily	–	–	0.68 (-0.29 to 1.64)	0.167
Family communication	–	–	<b>0.89 (0.58 to 1.21)*</b>	<b>&lt;0.001</b>

Abbreviation: 95% CI: 95% Confidence Interval

\*p&lt;0.05

<sup>†</sup>Adjusted for time-varying family structure and family communication

#### 4.3.3 Changes in the individual items of the WHO-5 well-being index during follow-up

Upon observing an improvement in well-being during the pandemic, we decided to explore the underlying cause by conducting separate analyses for each item of the WHO-5 WBI. We ran linear mixed models with group status as the sole predictor. In these *post hoc* item-level analyses, lockdown boys had slightly higher baseline scores (MD: 0.32 [95% CI: 0.09 to 0.54]) for Item 1 (*feeling cheerful and in good spirits*) and Item 3 (*feeling active and vigorous*; MD: 0.27 [95% CI: 0.03 to 0.50]) compared to the pre-pandemic group. The pre-pandemic boys' group did not show any significant change in the items over the follow-up period. However, we experienced an increase in score on Item 4 (*waking up feeling fresh and rested*) in the lockdown group. There were no changes over time for Items 1, 2 (*feeling calm and relaxed*), 3, and 5 (*daily life being filled with interesting things*) (Table 7).

For girls, the only baseline difference was observed for Item 4, with those in the lockdown group reporting a lower score (MD: -0.31, 95% CI: -0.53 to -0.10). Over the follow-up period, pre-pandemic girls showed a decline in their Item 4 score, whereas, similar to the boys, girls in the lockdown group experienced an increase in this item, with an effect size comparable to that seen in boys (Table 7).

**Table 7.** Results of linear mixed models for WHO-5 WBI items (Major et al., 2024)

	Item 1		Item 2		Item 3		Item 4		Item 5	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
<b>Boys</b>										
Intercept	1.89 (1.72 to 2.06)		1.66 (1.49 to 1.83)		1.68 (1.50 to 1.85)		1.15 (0.96 to 1.34)		1.57 (1.39 to 1.74)	
Group										
Pre-pandemic	ref.		ref.		ref.		ref.		ref.	
Lockdown	<b>0.32 (0.09 to 0.54)*</b>	<b>0.006</b>	0.18 (-0.05 to 0.41)	0.131	<b>0.27 (0.03 to 0.50)*</b>	<b>0.028</b>	-0.09 (-0.33 to 0.16)	0.505	0.19 (-0.05 to 0.42)	0.119
Time	0.15 (-0.05 to 0.35)	0.141	0.00 (-0.21 to 0.21)	0.985	0.15 (-0.06 to 0.36)	0.157	-0.17 (-0.39 to 0.05)	0.135	0.01 (-0.21 to 0.22)	0.937
Group*Time										
Pre-pandemic	ref.		ref.		ref.		ref.		ref.	
Lockdown	-0.18 (-0.45 to 0.10)	0.203	0.08 (-0.20 to 0.36)	0.555	-0.18 (-0.46 to 0.11)	0.220	<b>0.42 (0.12 to 0.72)*</b>	<b>0.007</b>	-0.10 (-0.39 to 0.19)	0.498
<b>Girls</b>										
Intercept	1.76 (1.62 to 1.89)		1.42 (1.28 to 1.56)		1.62 (1.47 to 1.77)		1.09 (0.95 to 1.24)		1.53 (1.38 to 1.69)	
Group										
Pre-pandemic	ref.		ref.		ref.		ref.		ref.	
Lockdown	0.18 (-0.01 to 0.38)	0.067	-0.04 (-0.24 to 0.17)	0.723	0.03 (-0.19 to 0.25)	0.790	<b>-0.31 (-0.53 to -0.10)*</b>	<b>0.004</b>	-0.19 (-0.41 to 0.03)	0.089
Time	0.16 (-0.01 to 0.33)	0.053	-0.06 (-0.25 to 0.13)	0.546	-0.14 (-0.32 to 0.04)	0.136	<b>-0.28 (-0.45 to -0.12)*</b>	<b>0.001</b>	-0.11 (-0.29 to 0.07)	0.225
Group*Time										
Pre-pandemic	ref.		ref.		ref.		ref.		ref.	
Lockdown	-0.07 (-0.31 to 0.17)	0.561	0.17 (-0.11 to 0.44)	0.227	0.15 (-0.12 to 0.41)	0.272	<b>0.41 (0.17 to 0.65)*</b>	<b>&lt;0.001</b>	0.20 (-0.05 to 0.46)	0.120

Abbreviation: 95% CI: 95% Confidence Interval, WBI: WHO-5 Well-Being Index

\*p&lt;0.05

†Sum of Items 1, 2, 3, and 5 from WHO WBI

#### 4.3.4 Changes in the WHO-5 well-being score in subgroups based on baseline Item 4 score

As the only significant difference between the pre-pandemic and lockdown groups was observed in the change in Item 4 (*waking up feeling fresh and rested*), our hypothesis was that adolescents who typically had difficulty waking up early might have benefited the most from the lockdown period. To examine this, changes in the WHO-5 well-being score were compared among subgroups defined by their baseline score on Item 4. Among boys who reported waking up feeling fresh and rested (Item 4 score  $\geq 2$ ), the decline in WHO-5 WBI scores was similar in both the pre-pandemic and lockdown groups (MD of changes: 0.33 [95% CI: -1.10 to 1.77]). On the other hand, boys with lower baseline Item 4 scores exhibited divergent patterns: the pre-pandemic group experienced a decrease in total WHO-5 WBI score, while the lockdown group showed an improvement (MD of changes: 1.20 [95% CI: 0.15 to 2.25]) (Figure 8).

The patterns seen in girls mirrored those found in boys. Among girls who reported waking up feeling fresh and rested (Item 4 score  $\geq 2$ ), the decline in WHO-5 WBI scores was similar in both the pre-pandemic and lockdown groups (MD of changes: -0.31 [95% CI: -2.02 to 1.41]). However, for girls with lower baseline scores on Item 4, the two groups diverged: the pre-pandemic group experienced a decrease in overall WHO-5 WBI scores, whereas the lockdown group saw an improvement (MD of changes: 1.20 [95% CI: 0.23 to 2.17]) (Figure 8).

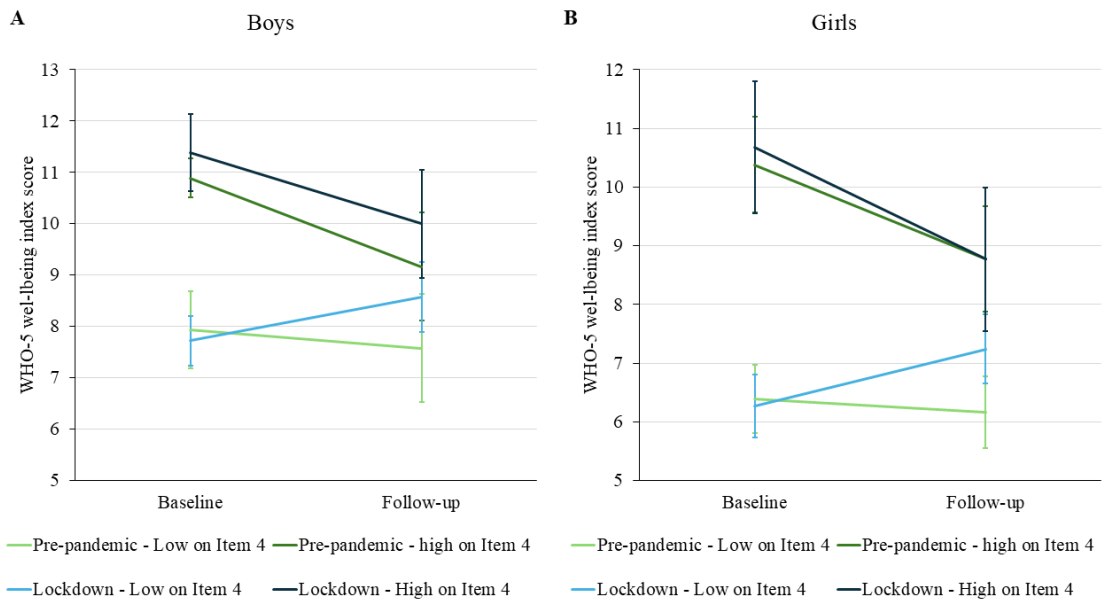


Figure 8. Estimated marginal means (Model 1) of boys' (Panel A) and girls' (Panel B) WHO-5 well-being index score by subgroups based on WHO-5 Item 4 (Major et al. 2024).

## 4.4 Changes in the Rosenberg Self-esteem Scale

### 4.4.1 Boys

Boys in the pre-pandemic and lockdown groups had similar average scores on the Rosenberg Self-esteem Scale, with no significant changes observed over the one-year follow-up in the unadjusted model (*Model 1*). Adjusting for family structure and family communication (*Model 2*) produced similar findings. Additionally, *Model 2* indicated that boys living in stepfamilies had a 2.26 (95%CI: 0.35 to 4.16) points lower self-esteem scores, while higher levels of family communication were significantly linked to higher self-esteem (Figure 9; Table 8).

### 4.4.2 Girls

Girls scored lower on the Rosenberg self-esteem scale than boys. At baseline, there were no significant differences in self-esteem between the pre-pandemic and lockdown groups in either the unadjusted or adjusted models. During the one-year follow-up, self-esteem scores in the pre-pandemic group remained stable, whereas the lockdown group showed a significant increase over time, also confirmed in *Model 2*. Additionally, higher family communication was linked to greater self-esteem among girls, while family structure did not show any association with self-esteem (Figure 9; Table 8).

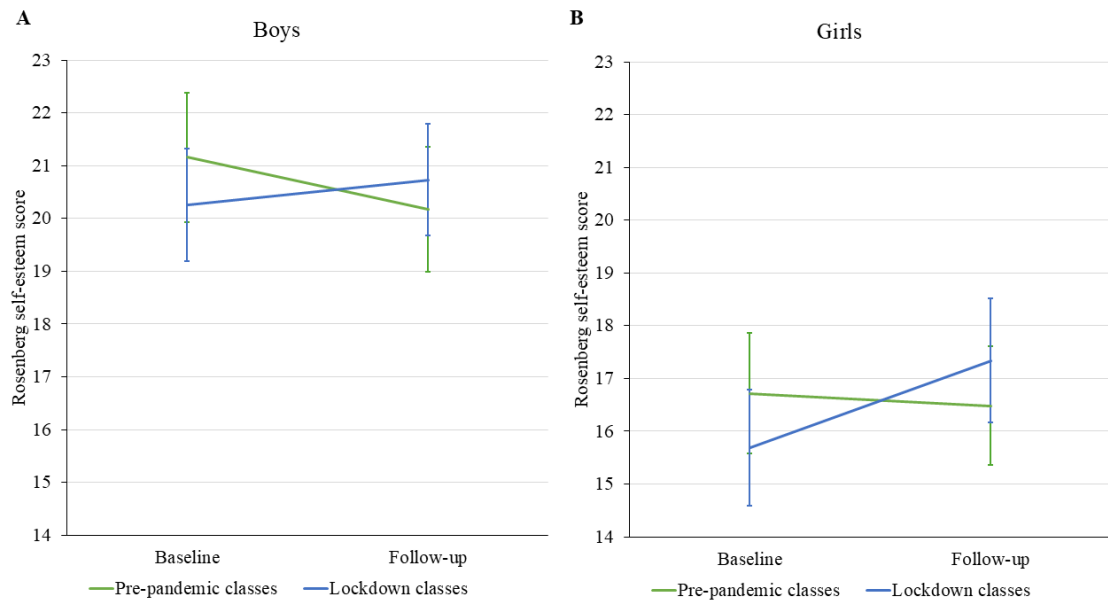


Figure 9. Estimated marginal means (Model 1) of boys' (Panel A) and girls' (Panel B) Rosenberg self-esteem score of pre-pandemic and lockdown classes from baseline to follow-up (Major et al. 2024).

**Table 8.** Results of linear mixed models for score on Rosenberg self-esteem scale (Major et al., 2024)

	Model 1		Model 2†	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
<b>Boys</b>				
Intercept	21.16 (19.92 to 22.40)	0.284	21.09 (19.71 to 22.46)	
Group				
Pre-pandemic	ref.		ref.	
Lockdown	-0.89 (-2.54 to 0.75)	0.284	-0.42 (-2.11 to 1.27)	0.627
Time	-0.99 (-2.13 to 0.16)	0.092	-0.33 (-1.50 to 0.85)	0.582
Group*Time				
Pre-pandemic	ref.		ref.	
Lockdown	1.45 (-0.06 to 2.96)	0.060	0.87 (-0.62 to 2.36)	0.249
Family structure				
two-parent	–	–	ref.	
single-parent	–	–	-0.86 (-2.55 to 0.83)	0.318
stepfamily	–	–	<b>-2.26 (-4.16 to -0.35)</b>	<b>0.020</b>
Family communication	–	–	<b>1.15 (0.55 to 1.75)</b>	<b>&lt;0.001</b>
<b>Girls</b>				
Intercept	16.72 (15.57 to 17.87)		16.74 (15.55 to 17.92)	
Group				
Pre-pandemic	ref.		ref.	
Lockdown	-1.03 (-2.63 to 0.57)	0.205	-0.88 (-2.44 to 0.68)	0.269
Time	-0.23 (-1.30 to 0.83)	0.666	0.31 (-0.79 to 1.40)	0.584
Group*Time				
Pre-pandemic	ref.		ref.	
Lockdown	<b>1.89 (0.42 to 3.35)</b>	<b>0.012</b>	<b>1.65 (0.17 to 3.13)</b>	<b>0.029</b>
Family structure				
two-parent	–	–	ref.	
single-parent	–	–	-0.99 (-2.57 to 0.60)	0.223
stepfamily	–	–	-0.56 (-2.57 to 1.45)	0.583
Family communication	–	–	<b>1.61 (1.00 to 2.22)</b>	<b>&lt;0.001</b>

Abbreviation: 95% CI: 95% Confidence Interval

\*p<0.05

†Adjusted for time-varying family structure and family communication

## 5 Discussion

The aim of the thesis was to explore how COVID-19-related school lockdowns influenced adolescents' screen time habits, well-being, and self-esteem in Hungary, with a special focus on the role of family structure and family communication. Our results are based on secondary analyses of longitudinal data collected during the BEP.

### 5.1. Brief summary of results

The baseline overall screen time of our sample averaged about 9-10 hours per day. Among both groups of boys, watching videos accounted for the largest portion of screen time at baseline. In the absence of lockdown, as boys aged, their screen time for playing games decreased, while screen time spent on other activities increased, resulting in stable overall screen time. For girls, the greatest amount of screen time at baseline was dedicated to other activities (primarily social media and communication) and aging had no significant impact on their total screen time or its distribution. Our findings indicate that the COVID-19 pandemic disrupted these age-related patterns. During the pandemic, boys showed increases in overall screen time and its individual components, with the most notable rise in screen time spent on other activities. Girls affected by lockdown also increased overall screen time and across all specific activities except for playing games, which remained unchanged.

Regarding family factors, boys living with a single parent spent more time watching videos and playing games, while for girls, single-parent households were associated with greater overall screen time and increased use of social media. Higher levels of family communication were linked to reduced screen time for watching videos and playing games among boys, and to lower overall screen time among girls. However, these family-related variables did not significantly alter the main patterns or the magnitude of the observed associations.

Our findings indicate that typical, pre-pandemic circumstances were associated with a decline in adolescents' well-being over the course of a year. This decline was much less pronounced, and even showed slight improvement, during the COVID-19 pandemic. The difference in well-being changes between the pre-pandemic and lockdown cohorts remained significant even after adjusting for family structure and family communication. Upon exploring the underlying reasons, we observed that four out of five items changed

similarly across both cohorts, but Item 4 (*waking up feeling fresh and rested*) displayed a notable difference between groups during follow-up. We therefore tested whether there was an interaction between baseline scores on Item 4 and lockdown exposure over time. This analysis revealed that the overall well-being score decreased over time in adolescents with high baseline Item 4 scores, regardless of gender or lockdown status. In contrast, for those with low baseline Item 4 scores, well-being remained stable among those not affected by the pandemic but improved significantly among those who experienced lockdowns.

Regarding self-esteem, there were no substantial differences over time among boys in the two cohorts. However, girls who experienced the pandemic-related lockdown showed a significant increase in self-esteem compared to those in the pre-pandemic group. These findings were not notably influenced by adjustment for family structure and family communication.

Finally, our results consistently demonstrated that higher levels of family communication were associated with greater well-being and self-esteem in both boys and girls.

### **5.1 Adolescents' screen time trends and patterns before and during the pandemic**

Before the COVID-19 pandemic, global estimates indicated that children and adolescents spent approximately 2.7 hours per day engaged with screens (Madigan et al., 2022). During the pandemic studies reported 0.9-1.8 hours/day increase (Madigan et al., 2022; Trott et al., 2022), which is lower than in our sample (3.3 hours/day for boys and 2.3 hours/day for girls). Although adolescents' screen time generally increases with age (Bucksch et al., 2016; Marconcin et al., 2021), this trend was not observed in our pre-pandemic group representing ordinary circumstances. It is important to highlight, however, that our study examined changes in screen time over a relatively brief period. Nevertheless, our results support earlier longitudinal studies reporting a significantly greater rise in screen time during the pandemic compared to periods without such restrictions (McArthur et al., 2021; Plamondon et al., 2023).

Additionally, we expand upon previous research by analyzing the changes of specific components and activities within overall screen time. This is highly important, since the

different types of screen time-associated activities might have different influences on adolescents. In our research, boys spent more time playing games, whereas girls spent more time on other screen-based activities, predominantly involving social media and communication. These findings align with previous studies (Moore et al., 2020; Ng et al., 2021; Vezina-Im et al., 2022). In addition, boys and girls may be affected differently even by the same type of screen activity. For instance, girls are more susceptible than boys to developing mental health issues such as depression, anxiety, loneliness, and physical complaints like headaches and stomachaches resulting from social media usage (Boers et al., 2019; Svensson et al., 2022). Furthermore, social media has been linked to lower overall well-being and a higher likelihood of negative body image among girls (Papageorgiou et al., 2022; Svensson et al., 2022). It has also been proposed that the threshold for mental health risks related to daily screen time differs between genders: approximately two hours for girls versus five hours for boys (Twenge & Farley, 2021). This disparity might be explained by girls' greater sensitivity toward social comparisons, feedback, peer acceptance, and maintaining close relationships (LaFontana & Cillessen, 2010; Nesi & Prinstein, 2015; Skymba et al., 2022).

Contrary to girls, boys were more engaged with playing games, which has been associated with negative outcomes, such as depressive symptoms and reduced life satisfaction (Dong et al., 2018; Twenge & Farley, 2021). These adverse effects typically become prominent following excessive gaming (Twenge & Farley, 2021). A previous study demonstrated that anxiety-like symptoms emerged after six or more hours of gaming per day, specifically among boys but not girls (Chen et al., 2022), reinforcing that adolescents of different gender respond differently to various forms of screen time. This idea is further supported by findings indicating greater neural activation in regions like the medial frontal gyrus, bilateral middle temporal gyri, and thalamus among men compared to women after gaming sessions (Dong et al., 2018). Such neurological differences may explain why males experience stronger cravings related to gaming and have a higher risk of gaming disorders (Dong et al., 2018). Furthermore, a study examining male internet gamers and their motivations (entertainment, social interaction, stress relief, or habitual gaming) found that motivations also play a role in the risk of developing problematic behaviors, namely habitual gamers are at increased risk (Kim et al., 2020).

## **5.2 Changes in adolescents' well-being associated with school lockdown**

Our findings showed that adolescents in the pre-pandemic group experienced a decline in well-being over one year, which aligns with recent findings from the WHO's HBSC Study (Cosma et al., 2023). Unexpectedly, we did not observe this decline in adolescents who experienced pandemic-related lockdowns, despite numerous studies indicating negative mental health outcomes associated with school closures (Chadi et al., 2022; Mazrekaj & De Witte, 2023; Orban et al., 2023; Singh et al., 2020). Our post-hoc analyses revealed that four of the five WHO-5 WBI items changed similarly before and during the pandemic. The notable exception was Item 4, which evaluates feelings of restfulness upon waking: scores on this item decreased significantly less during the pandemic. Based on this observation, we propose that the unexpected stability in overall well-being observed during lockdown might be due to the fact that adolescents (particularly those reporting low baseline score on Item 4) benefited from increased sleep duration and/or later wake-up times during remote learning, since they did not have to commute to school early in the morning (Lukoseviciute & Smigelskas, 2022; Widnall et al., 2022). This interpretation is supported by a recent Austrian study, which also documented improved WHO-5 WBI scores during periods of remote education compared to times when schools reopened, although they did not investigate potential reasons for this finding (Dale et al., 2023). Additionally, qualitative research among Scottish adolescents has indicated positive impacts on mental health and well-being linked to school closures, citing reduced academic stress and workload as contributing factors (Stewart et al., 2023).

The connection between sleep and adolescent mental health is well documented. A recent meta-analysis of longitudinal studies found that better sleep is prospectively associated with improved psychological well-being in adolescents (Bacaro et al., 2024). Another review concluded that sleep disorders and circadian disruption are predictive of depression and anxiety over time (Chai & Bian, 2024). During the COVID-19 pandemic, adolescents' sleep patterns shifted: many reported longer sleep duration and delayed schedules during lockdowns (Rocha & Fuligni, 2023), and one large Swiss study found that sleep gains during school closures were positively associated with better quality of life (Albrecht et al., 2022). These findings support the hypothesis that, under remote schooling, extended sleep opportunity and reduced morning burden may have mitigated the declines in mental health that would otherwise have been expected.

### **5.3 Changes in adolescents' self-esteem during the pandemic**

Self-esteem levels remained generally unchanged among adolescents in our pre-pandemic group, which is consistent with age-related trends based on previous findings (Huang, 2010; Orth et al., 2018). Interestingly, we observed an improvement in self-esteem among girls during the pandemic. Slight increase was also observed among adolescents by Goto et al., however a different assessment tool was used in serial cross-sectional data, instead of a longitudinal study design (Goto et al., 2022). Moreover, the current body of research on the impact of COVID-19-related school closures on self-esteem is limited. Self-esteem, defined as an individual's subjective evaluation of their own worth (Rosenberg, 1965), is shaped by multiple factors, including school expectations and academic achievement (Kiviruusu et al., 2015; Lepp et al., 2021; Metsäpelto et al., 2020). Given that girls are often more sensitive to academic achievement (Stentiford et al., 2023), the reduced pressure and performance demands associated with remote learning may explain the observed increase in their self-esteem during the pandemic.

### **5.4 Role of family structure and family communication**

Our findings highlight the significant influence of both family structure and the quality of family communication on adolescents' screen time activities, psychological well-being, and self-esteem. In terms of screen use, boys living in single-parent households reported spending more time watching videos and playing games, while girls in similar family settings showed higher engagement with social media. These observations are consistent with previous research, which suggests that adolescents in single-parent families are more likely to exhibit unfavorable lifestyle behaviors, including lower physical activity, reduced sports participation, and increased screen time (Gorely et al., 2009; Langoy et al., 2019). One plausible explanation is that single parents may have limited time and fewer resources to monitor and regulate screen time or to provide alternative extracurricular opportunities (Langoy et al., 2019).

However, our results also suggest that strong family communication may act as a protective factor. For example, in boys, better family communication was associated with reduced screen time, particularly in activities such as gaming and video watching. This

supports previous findings that an autonomy-supportive communication style (characterized by offering choices, providing rationale, and respecting the adolescent's perspective) is more effective in promoting positive behavioral outcomes than a controlling style, which imposes rules without room for dialogue (Bjelland et al., 2015). These findings underscore the importance of communication quality and style in shaping adolescent screen use patterns.

Beyond behavioral outcomes, our study also found that family communication played a consistent role in adolescents' psychological well-being and self-esteem. Higher levels of family communication were associated with better mental health outcomes in both boys and girls, aligning with existing literature (Birndorf et al., 2005; KavehFarsani et al., 2020). Strong family communication is known to mediate the relationship between family resilience and overall family functioning (Sabah et al., 2023), and it has also been linked to lower distress and improved mental health in adolescents (Zapf et al., 2023). Our data suggest that adolescents with strong family communication skills experienced better well-being and self-esteem, regardless of the external challenges, like the COVID-19 pandemic. One possible explanation is that high-quality communication may include elements of "approach coaching" defined as behavioral, emotional, or cognitive actions aimed at addressing and managing stressors (Dubow & Rubinlicht, 2011). In contrast to avoidant strategies, approach-oriented responses, such as problem-solving and information seeking, may enhance adolescents' ability to cope with crisis situations like the COVID-19 pandemic (Gecer & Yildirim, 2023).

Together, these findings underscore the role of family-related factors: while family structure can shape adolescents' vulnerability to risk behaviors such as excessive screen use, the quality of communication within the family appears to offer a powerful buffer that supports healthier behaviors and better psychological outcomes in both typical and adverse circumstances.

## **5.5 Strengths and limitations**

The present thesis offers several methodological and contextual strengths that enhance the reliability and relevance of its findings. A key strength is the longitudinal design, as the majority of studies addressing similar questions relied on cross-sectional designs or

lacked appropriate control groups. The longitudinal design also allowed for the assessment of within-person changes over time and offered greater statistical power and more accurate estimates of changes in screen time, well-being, and self-esteem. Longitudinal data are also less prone to recall bias than retrospective assessments, which tend to overestimate behaviors such as screen time (Madigan et al., 2022). Moreover, by analyzing cohorts from before and during the COVID-19 pandemic, the study was able to distinguish the effects of normal aging from those associated with lockdowns. The inclusion of multiple domains of screen use (e.g., gaming, videos, social media, homework) adds further depth, enabling a nuanced analysis of how various digital behaviors evolved under differing conditions. Another strength is the comparability of the cohorts: both groups were drawn from the same source population in Balassagyarmat, a typical town in a socioeconomically disadvantaged region of Central Europe. The close timing of data collection (2018 and 2020) and the geographical consistency reduce the potential for cohort bias. This setting also provides external validity for interpreting adolescent behavior in similarly deprived Central European contexts, which are often underrepresented in international literature.

Nevertheless, several limitations must be acknowledged as well. First, although participation and follow-up rates were acceptable, the loss to follow-up may still impact the generalizability of our data. The sample was also ethnically homogenous, limiting the applicability of the results to more diverse populations. In terms of measurement, screen time data were self-reported by adolescents and were not verified by parents or objective tools. However, previous studies have shown good agreement between adolescent and parent reports of screen use (McArthur et al., 2021). Additionally, our survey did not include items that focused specifically on social media, so we had to calculate it indirectly from the HBSC 2014 questions. Furthermore, the study could not account for simultaneous screen activities (e.g., watching videos while browsing social media), nor did it include direct measures of physical activity or other sedentary behaviors, which could influence or interact with screen time patterns. The study also lacks instruments to evaluate problematic internet or social media use specifically. With respect to psychological outcomes, short versions of validated instruments (WHO-5 WBI and RSES) were used. While practical and widely applied, these versions may have limited sensitivity to change. Additionally, Item 4 of the WHO-5 WBI (*waking up feeling fresh*

*and rested*”) may have been particularly susceptible to changes driven by altered school schedules during lockdowns. As students were no longer required to wake early, this item may reflect improved sleep patterns rather than broader well-being. The generalizability of the WHO-5 in adolescent populations is also limited. While it has shown strong associations with psychosocial work factors in adults (Schutte et al., 2014), its link to school-related stressors or the academic environment in adolescents have not been well studied (Cormier & Rossi, 2019). Moreover, the questionnaires were designed before the pandemic, and thus did not include pandemic-specific variables (Voitsidis et al., 2021), such as fear of infection, anxiety related to restrictions, or perceptions of remote learning. Other unmeasured but potentially important factors, such as peer relationships, teacher-student dynamics, and socioeconomic conditions (Chen & Ma, 2023; Ross et al., 2020), were not captured, which may have influenced the observed outcomes. Lastly, because this research is a *post hoc* analysis of data collected as part of a health education program, causal relationships cannot be established. The findings should therefore be viewed as exploratory and hypothesis-generating.

## **5.6 Implications and Recommendations for Future Research**

The findings of this thesis carry several important implications for public health, education, and family-centered interventions targeting adolescents in the context of digital media use and psychological well-being.

From a public health perspective, the high baseline screen time and the observed increase during pandemic-related school closures underscores the need to develop guidelines that go beyond total screen time and consider the type, context, and function of screen-based activities. Future policies and recommendations should emphasize quality of screen use, support digital literacy, and distinguish between passive and interactive screen activities. American recommendations already use this approach (American Academy of Child & Adolescent Psychiatry, 2025; American Academy of Pediatrics, 2025), however we lack a national guideline and strategy to promote healthy digital media use for parents and adolescents.

In terms of education policy, the findings suggest that school-related pressures and early morning schedules may play a role in adolescent well-being, particularly for those who

struggle with waking early. The improvement in well-being among students with low baseline scores on the WHO-5 WBI Item 4 during remote learning calls attention to the potential value of more flexible school start times or hybrid learning models. These adaptations could benefit adolescents' sleep patterns and mental health, even beyond the pandemic context (Biller et al., 2022; Winnebeck et al., 2020).

At the family level, the consistent associations between better family communication and improved well-being, self-esteem, and screen use patterns highlight the importance of family-based interventions. Supporting autonomy-supportive parenting and enhancing communication skills within families may help buffer adolescents against environmental stressors and promote healthier behavioral and emotional development.

Despite these valuable insights, several gaps remain that warrant further exploration. First, longer-term follow-up studies are needed to assess whether the observed changes in screen time and psychological outcomes persist beyond the acute phases of the pandemic. Second, future research should incorporate more diverse samples to enhance generalizability, especially in terms of ethnicity, socioeconomic status, and cultural context. Third, there is a need for multidimensional assessment tools that can simultaneously capture screen use patterns, emotional responses, and the broader psychosocial environment, including factors such as peer relationships, school climate, and digital competence.

Interestingly, our findings suggest that for some adolescents psychological well-being and self-esteem did not deteriorate during the pandemic and, in some cases, even improved. These results indicate that the effects of school lockdowns were not uniformly negative and may have alleviated certain stressors such as early school schedules or academic pressure. Future research should further investigate which contextual or individual factors might have contributed to these outcomes. Understanding such protective mechanisms could help inform future interventions aimed at promoting adolescent resilience during times of disruption.

## 5.7 New Evidence from the Thesis

1. This was the first longitudinal analysis of Hungarian adolescents' screen time, well-being, and self-esteem trajectories across the COVID-19 lockdown. By following two cohorts of pupils before (2018-2019) and during (2020–2021) the pandemic, this thesis isolates lockdown-related change from normal age-related development.
2. The work divides total screen time into four functionally distinct activities (watching videos, playing games, homework, social-media/communication) and shows that each domain followed a different trajectory, with clear gender differences (e.g., gaming surging in boys but not girls; social-media time rising mainly in girls).
3. The thesis provides evidence that well-being did not universally decline during the pandemic and our *post hoc* analysis revealed that adolescents who typically had difficulty waking up early might have benefited the most from the lockdown period. This points to later wake-up times and extra sleep during remote schooling as being a likely protective factor.
4. Adolescent girls' self-esteem improved during the pandemic in our samples, which draws attention to further investigation of possible protective factors of the lockdown period that can be implemented even during ordinary circumstances.
5. Family structure and family communication play important roles in adolescents' screen time use, well-being, and self-esteem.
6. The thesis provides insights from an understudied, socioeconomically deprived Central-European region.

## 6 Conclusions

The present thesis provides evidence on how the COVID-19-related school lockdowns reshaped the changes in Hungarian adolescents' screen time, well-being, and self-esteem compared to pandemic-free age-related changes. A steadier increase in screen time was anticipated, however our results revealed variations in screen-use patterns between pre-pandemic and lockdown cohorts, as well as between boys and girls. This supports current trends to emphasize the quality and context of digital media use as well, not just simply the amount of screen time. Unexpected patterns were also observed, such as the increase in Item 4 on WHO-5 WBI and the improvement of girls' self-esteem. While much of the literature has emphasized the adverse psychological effects of school closures, our study shows that it can also bring beneficial changes in adolescents' lives. Further research is required to understand the mechanisms through which the pandemic might have positively influenced adolescents. These results also highlight a methodological consideration: widely used brief well-being questionnaires may not fully capture context-specific changes, particularly in unusual circumstances like a pandemic. Associations of family structure and family communication with screen time, well-being, and self-esteem point out that health promotion strategies should target families as a whole, and improving communication style within the family might lead to better health outcomes.

## 7 Summary

The present thesis was a secondary analysis of the data collected in the BEP. Our aim was to understand how the COVID-19 pandemic-related school lockdowns affected the changes in screen time, well-being, and self-esteem compared to pandemic-free circumstances with a special focus on family structure and family communication. Two groups of ninth graders were included in the analysis: 227 ‘pre-pandemic’ and 250 ‘lockdown’ students. Linear mixed models were conducted to analyze changes. Our findings indicate that the COVID-19 pandemic disrupted age-related patterns. During the pandemic, boys showed increases in overall screen time and its individual components, with the most notable rise in screen time spent on other activities. Girls affected by lockdown also increased their overall screen time and across all specific activities except for playing games, which remained unchanged. As for well-being, a less pronounced decline was observed during the pandemic, compared to the significant decline before the pandemic. *Post hoc* analysis revealed that only Item 4 from the WBI showed a notable difference between groups. Therefore, we tested the interaction between baseline scores on Item 4 and lockdown exposure over time. Our observation was that well-being of those with low baseline Item 4 score (struggling with waking up) improved significantly during the pandemic. Regarding self-esteem, there were no substantial differences over time among boys in the two cohorts. However, girls who experienced pandemic-related school lockdown showed a significant increase in self-esteem compared to those in the pre-pandemic group. Our study was the first longitudinal analysis of Hungarian adolescents’ screen time, well-being, and self-esteem trajectories across the COVID-19 lockdown. Our results support current trends to emphasize the quality and context of digital media use as well, not just simply the amount of screen time. Furthermore, we provided evidence that well-being and self-esteem did not universally decline during the pandemic, which draws attention to further investigation of possible protective factors of the lockdown period that can be implemented even during ordinary circumstances. Family structure and family communication play important roles in adolescents’ screen time use, well-being, and self-esteem, so health promotion strategies should take this into consideration as well.

## 8 References

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## 9 Bibliography of the candidate's publications

### 9.1 Publications on which the thesis is based

**Major, D.**, Falus, M., Árva, D., Eörsi, D., Terebessy A., Tabák, A. G., & Fazekas-Pongor, V. (2024). The effect of school lockdown on well-being and self-esteem of adolescents during the COVID-19 pandemic in Hungary. *Frontiers in Public Health*, *12*, 1474893. <https://doi.org/10.3389/fpubh.2024.1474893>

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### 9.2 Publications independent of the thesis

Eörsi, D., **Major, D.\***, Árva, D., Bikás, L., Nagy, N., Fazekas-Pongor, V., Horváth, F., & Terebessy, A. (2024). Diverse Sexual Definitions and Their Predictors Among Adolescents: A Multilevel Analysis in Hungary. *SEXUALITY RESEARCH AND SOCIAL POLICY*, *21*(3), 890–898. <https://doi.org/10.1007/s13178-023-00902-3>

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