

THE ASSOCIATION BETWEEN PHYSICAL HEALTH CONSEQUENCES OF SMARTPHONE USE AND SUBJECTIVE WELL-BEING IN EARLY ADOLESCENTS

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ABSTRACT

Most research focuses on the emotional and social consequences of smartphone use among adolescents, and there is less evidence about how smartphone use affects the physical health of early adolescents. This study aims to examine and describe the physical health consequences associated with the extended duration of smartphone use in early adolescents and their association with subjective well-being. To address the aim of the study, data from the fourth wave of the longitudinal study (2021–2023) conducted within the project “Digital technology in the family: patterns of behaviour and effects on child development” (D.E.C.I.D.E.) are used. The sample for this paper comprises 204 early adolescents (58.3% girls). Adolescents provided self-assessments of the physical health consequences associated with the extended duration of their smartphone use, as well as their subjective well-being, measured through life satisfaction and both positive and negative affect. The results show four categories of the physical health consequences associated with the extended duration of smartphone use among early adolescents: a) sleep problems and tiredness, b) physical passivity, c) pain in the head, neck, and back, and d) problems with the eyes and pain related to the hands. A higher frequency of different physical health consequences is related to lower life satisfaction, less positive affect, and more negative affect. Duration of smartphone use and physical passivity were

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significant predictors of life satisfaction. Duration of smartphone use and sleep problems and tiredness were significant predictors of negative affect. Physical health consequences of smartphone use did not significantly contribute to positive affect. The findings of the study suggest that smartphone use may have negative effects on the physical health and well-being of early adolescents, and that time-based measures alone should be complemented by an examination of adolescents' subjective experiences of digital engagement.

INTRODUCTION

Smartphone Use Among Adolescents

Data indicate that a significant majority of adolescents own or have access to a smartphone, with usage patterns showing a steady increase (Pew Research Center, August 2022). In the US and Western Europe, the prevalence of smartphone users among the adolescent population is similar (Marciano & Camerini, 2022). In Croatia, almost 8 out of 10 children aged 11 to 15 engage in screen-based activities more than recommended (up to 2 hours per day) (Žulec et al., 2023). On the one hand, adolescents use smartphones to communicate with peers, acquire new information, and seek help online, but on the other hand, excessive smartphone use may result in emotional distress and harm physical health and well-being (Fischer-Grote et al., 2021; Ophir et al., 2020). Brain areas responsible for social media-related behaviours are still developing and changing significantly during adolescence (Crone & Konijn, 2018; Shannon et al., 2022). Thus, adolescence represents a vulnerable period for uncontrolled smartphone use, which can have negative effects on the health of young users. This research aims to explore the association between the physical health consequences of extended smartphone use duration and subjective well-being in early adolescents. This study sheds light on how smartphone use may affect young individuals during a critical developmental period.

Smartphone use, indicated only by the time of use, can predict smartphone dependency in late adolescence (Lapierre et al., 2019). Along with excessive time, for example, not taking breaks from the smartphone, constantly checking for notifications, and having problems concentrating on one's daily assignments because of smartphone use are all smartphone-related addictive behaviours labelled as 'smartphone addiction' (Kwon et al., 2013; Lin et al., 2016), 'problem mobile phone use' (Bianchi & Philips, 2005), 'problematic smartphone use' (Elhai et al., 2017), and 'smartphone dependency' (Lapierre et al., 2019). Although debate exists about whether these behaviours can or should be labelled as 'addiction' (Elhai et al., 2016; Panova & Carbonell, 2018), studies found some evidence for excessive and harmful smartphone use (Fischer-Grote et al., 2021; Ophir et al., 2020). One review showed that excessive smartphone use in adolescents and youth is related to various medical complications in the domains of sleep, physical fitness, eyesight, migraine, and pain (Wacks & Weinstein, 2021). Gender and

age differences emerged in some previous studies regarding problematic smartphone use, with more studies reporting that girls and older adolescents are more vulnerable to problematic smartphone use (Ekşi et al., 2020; Heo & Lee, 2018; Yang et al., 2020).

Although there are currently no official recommendations regarding daily smartphone use specifically for adolescents, general screen time guidelines suggest that more than two hours of recreational screen use per day may be excessive. When considering adolescents' daily commitments to school, sleep, physical activity, and social interaction, it can be inferred that exceeding two hours of smartphone use, particularly when combined with the use of other digital media and devices, may negatively affect their overall subjective well-being. However, it is important to acknowledge that the duration of smartphone use, indicated by time alone, does not sufficiently represent the complexity of adolescent digital engagement. The effects on adolescents' health and well-being also depend on the nature of digital activities, the underlying motivations, and the context in which these activities occur. This study specifically focuses on the physical health consequences associated with the extended duration of smartphone use as self-reported by adolescents, rather than merely examining the time of smartphone use.

Impact of Smartphone Use on Physical Health and Well-being: Research Findings

Studies from various countries, predominantly employing cross-sectional designs, have found that adolescents who engage in extended smartphone use commonly report neck and shoulder discomfort, vision problems, and reduced physical activity. These physical health issues have been negatively associated with health-related quality of life and sleep problems.

Musculoskeletal Impacts and Postural Changes

The studies (e.g., Cheung et al., 2022; Doruk et al., 2023; Toh et al., 2020; Tsang et al., 2022) found that adolescents reporting high smartphone use experienced musculoskeletal discomfort, particularly in the neck and shoulders. The most frequent side effects were upper back pain, wrist/hand pain, and neck/shoulder pain. Other effects included low back pain, arm pain, general bodily pain, and postural changes. Research by Doruk et al. (2023) and Tsang et al. (2022)

associated these effects with two or more hours of daily use. Tsang et al. (2022) reported that prolonged smartphone use was associated with changes in posture.

Visual Health Effects

In a few studies (e.g., Kim et al., 2016; Toh et al., 2020), significant effects on eye health were reported, such as visual symptoms, myopia, blurring, redness, visual disturbance, secretion, inflammation, and dryness. In one study (Kim et al., 2016), visual health effects were associated with more than 2 hours per day use.

Physical Activity Patterns and Sedentary Lifestyle

Physical activity levels were examined in one study (Kim, 2023), which reported lower activity levels among adolescents with smartphone overuse. Using smartphones requires little activity and is usually done while sitting or lying down, which is referred to as sedentary behaviour. There is a clear association between early adolescents' smartphone use and a sedentary lifestyle. According to a study (Tanveer, 2023), adolescents use their smartphones for an average of five hours per day, which leads to a sedentary lifestyle. Kim (2023) found a negative correlation between smartphone use and physical activity levels in adolescents. Higher rates of sedentary behaviour are associated with "smartphone addiction", with research showing that adolescents who exhibit this behaviour are less likely to participate in physical activities (e.g., Yusuf et al., 2023).

Sleep

The studies, including those using self-reported sleep measures and sleep tracking devices, found that increased smartphone use was associated with several sleep issues. For example, most studies reported connections between higher smartphone use and reduced sleep quality (Bruni et al., 2015; Rosdiana et al., 2023), shorter sleep duration (Mireku et al., 2019; Nagata et al., 2024), and difficulties falling asleep (Bruni et al., 2015; Foerster et al., 2019). Nighttime smartphone use appeared particularly relevant, as studies (Mireku et al., 2019; Foerster et al., 2019) found that using phones in darkness and checking phones during the night were linked to sleep disruptions. Studies also found that having phones in bedrooms (Nagata et al., 2024; Bruni et al., 2015) and early social media adopti-

on (Charmaraman et al., 2020) were connected to poorer sleep patterns. Several factors appeared to influence sleep outcomes, including how much the phone was used, what it was used for, and whether it was left on overnight. Studies found that when parents set limits on bedtime phone use (Charmaraman et al., 2021), adolescents typically reported better sleep.

Health-Related Quality of Life

Two studies (Cheung et al., 2022; Karsay et al., 2022) found modest negative correlations between smartphone use and health-related quality of life measures. Cheung et al. (2022) showed that higher smartphone use is associated with lower health-related quality of life, bodily pain, and general health. Karsay et al. (2022) showed that smartphone use is related to physical well-being and daytime tiredness.

Impact of Smartphone Use on Well-being: Theoretical Frameworks and Mechanisms

The studies employ various theoretical frameworks to explain the relationship between smartphone use and subjective well-being in adolescents. Edwards et al. (2022) and Liu et al. (2020) suggest that individuals with heightened anxiety or low self-esteem use smartphones to alleviate negative emotions according to the Compensatory Internet Use Theory. The Uses and Gratification Theory posits that individuals use mass media to fulfil personal desires (Edwards et al., 2022). According to the Interaction of Person-Affect-Cognition-Execution (I-PA-CE) model (Jin et al., 2023), affective and cognitive responses mediate the relationship between personal characteristics and problematic behaviours, including problematic smartphone use. Ecological Systems Theory and Risk-Protective Factor Theory, used by Xiong et al. (2023), explore how cumulative ecological risk factors contribute to smartphone dependence. By integrating these frameworks, Xiong et al. (2023) explored how multiple ecological factors – such as family, school, and peer-related factors – collectively impact smartphone dependence and how individual factors like social anxiety and self-compassion mediate this relationship. The displacement hypothesis posits that time spent on smartphones may replace engagement in physical activities, face-to-face interactions, and other health-promoting behaviours, potentially impacting well-being. For instance, Kus-

hlev and Leita0 (2020) discuss how smartphone use might influence well-being by displacing activities such as sleep, exercise, and direct social interactions. Similarly, Hall and Liu (2022) explore the social displacement hypothesis, which posits that time spent using digital devices replaces face-to-face social interactions with significant others.

Understanding the mechanisms underlying the association between smartphone use and subjective well-being involves exploring various individual and contextual factors. However, some findings from the literature suggest that certain individual psychological factors, such as low self-esteem (Edwards et al., 2022), emotion regulation difficulties (Fu et al., 2020), body dissatisfaction (Liu et al., 2020), depression (Fu et al., 2020), anxiety (Jin et al., 2023), and fear of missing out (Jin et al., 2023), increase problematic smartphone use. Furthermore, some social and environmental mechanisms, including parent –child interaction and relationship (Bea & Nam, 2023), peer relationships (Liu et al., 2020), and social support (Fu et al., 2020), possibly influence the relationship between smartphone overuse and subjective well-being. However, most studies relied on cross-sectional data, making it difficult to determine cause-and-effect relationships.

Current Study

Studies primarily conducted in Asian countries confirm the negative contribution of the extended duration of smartphone use to adolescents' health. Despite increasing research on adolescent smartphone use, few studies have directly explored the relationship between physical health outcomes associated with the extended duration of smartphone use and subjective well-being, particularly among early adolescents. Thus, this study aims to examine the physical health consequences associated with the extended duration of smartphone use as well as their relationship with subjective well-being. Adolescents' physical health consequences due to the extended duration of smartphone use are examined with a newly developed self-report scale. In this study, subjective well-being is measured as commonly conceptualised in the literature, comprising three components: life satisfaction, positive affect, and negative affect. This tripartite model (Diener, 1984) has been extensively discussed and accepted in the literature.

Based on the existing literature and the overall aim of the study, the research questions and hypotheses of the paper are:

1. What are the physical health consequences associated with the extended duration of smartphone use among early adolescents?
H1: Early adolescents who engage in the extended duration of smartphone use are likely to experience negative physical health outcomes, such as sleep disturbances, reduced physical activity, and musculoskeletal issues.
2. How do physical health consequences associated with extended duration of smartphone use contribute to subjective well-being in early adolescents?
H2a: More physical health consequences associated with the extended duration of smartphone use will significantly contribute to lower life satisfaction.
H2b: More physical health consequences associated with the extended duration of smartphone use will significantly contribute to more negative affect.
H2c: More physical health consequences associated with the extended duration of smartphone use will significantly contribute to less positive affect.

METHOD

Sample

The sample for this paper consists of 204 adolescents (58.3% girls; $n = 119$) who participated in the fourth wave of the longitudinal study (S2) of the research project UIP-2019-04-7547 “Digital technology in the family: patterns of behaviour and effects on child development” (project D.E.C.I.D.E.). Adolescents came from six schools in the area of the city of Zagreb. In the fourth wave of data collection, they were aged 11 to 16, with a mean age of 13. In the fourth wave, children attended the sixth (32%), seventh (26%), and eighth (35%) grades of primary schools, and 7% attended the first grade of high schools. Most of their mothers had completed high school (58.7%) and were employed (89.2%). Most of their fathers had completed high school (49.1%) and were employed (89.2%). Most adolescents came from two-parent families (86%) with a monthly income of 465–995 EUR per family member (47%).

Since there were dropouts from the study, missing data were screened. Missing data analysis showed that data were not missing at random (Little’s MCAR; $X^2 = 314.92$, $df = 260$, $p = .001$), and missing value analysis showed that 17% of values and 33.1% of cases had incomplete data in the data set for analysis. The missing data were input using the option of multiple imputation (input missing data valu-

es) in IBM SPSS Statistics for Windows (Version 20), and the imputed data set was used in the Results section. The pattern of the findings obtained based on the imputed data set did not differ compared to the raw data set.

Measurement Instruments

Physical health consequences associated with the extended duration of smartphone use

The scale of physical health consequences associated with the extended duration of smartphone use among adolescents (Merkaš et al., 2023) (Table 1) was developed based on the responses of adolescents participating in focus group discussions in Study 1 of the project D.E.C.I.D.E. Transcripts of focus groups were reviewed to identify physical consequences and problems related to physical health by the research team of the project, and 15 items were formulated (Table 1). Although the word “mobile phone” is used in the scale, it pertains to smartphone use since in Croatian these words are used as synonyms among adolescents, and the word mobile phone is used much more frequently in spoken language among adolescents.

Adolescents reported the frequency of different physical health consequences associated with the extended duration of their smartphone use (e.g., “When I use a mobile phone for a long time, I sleep worse.”, “When I use a mobile phone for a long time, I am tired.”) on a 5-point scale (Table 1). The scale showed good psychometric properties (Table 1). The factor analysis¹ yielded four related latent factors: a) sleep problems and tiredness, b) physical passivity, c) pain in the head, neck, and back, and d) problems with the eyes and pain related to the hands (Table 1). Items of each factor were averaged into four scores, indicating four subscales of the scale, with higher scores indicating more frequent physical health problems associated with the extended duration of smartphone use. In this study, results by subscales were used in the analysis, but it is also possible to use the total score on the scale by summing or averaging all 15 items. The mean value of the scale was 1.84 ($SD = 0.60$) in this study.

¹ Oblique rotation was used because the underlying factors were expected to be correlated, which reflects the theoretical assumption that dimensions of adolescents' health are interrelated.

TABLE 1. *The latent structure and reliability of the Scale of physical health consequences associated with the extended duration of smartphone use among adolescents (N = 204)*

	Extracted factors (Principal Axis Factoring with Oblimin rotation)			
When I use a mobile phone for a long time, ... (Kad dugo koristim mobitel, ...)	Sleep problems and tiredness (Problemi sa spavanjem i umor) (3 items)	Physical passivity (5 items) (Fizička pasivnost)	Pain in the head, neck, and back (Bolovi u glavi, vratu i leđima) (3 items)	Problems with the eyes and pain related to the hands (Problemi s očima i bolovi u šakama) (4 items)
	Factor loadings			
8. My sleep is worse (lošije spavam)	.788			
7. I have difficulty falling asleep (ne mogu spavati)	.754			
9. I am tired (umoran sam)	.534			
14. I am less physically active (manje se krećem)		-.882		
13. I lie down a lot (puno ležim)		-.843		
12. I sit a lot (previše sjedim)		-.681		
15. It's hard for me to move (teško mi je pokrenuti se)		-.504		
11. I get tired faster when I exercise (brže se umorim kad radim tjelovježbu)		-.318		
6. My neck hurts (boli me vrat)			.816	
2. My back hurts (bole me leđa)			.747	
1. My head hurts (boli me glava)			.394	
4. My eyes are dry /red/ swollen (oči su mi suhe/crvene/"natečene")				.913
3. My eyes hurt (bole me oči)				.491

	Extracted factors (Principal Axis Factoring with Oblimin rotation)			
When I use a mobile phone for a long time, ... (Kad dugo koristim mobitel, ...)	Sleep problems and tiredness (Problemi sa spavanjem i umor) (3 items)	Physical passivity (5 items) (Fizička pasivnost)	Pain in the head, neck, and back (Bolovi u glavi, vratu i leđima) (3 items)	Problems with the eyes and pain related to the hands (Problemi s očima i bolovi u šakama) (4 items)
	Factor loadings			
10. My vision is worse (slabije vidim)				.472
5. My hands and fingers hurt (bole me šake i prsti)				.411
% of variance	33.85	8.61	5.86	4.31
Cronbach α	.804	.837	.741	.728
M (SD)	1.75 (0.85)	2.05 (0.90)	1.98 (0.74)	1.60 (0.61)
Mdn	1.33	2.00	2.00	1.50
Note. Croatian original items are in brackets.				

Positive and negative affect

Adolescents' positive and negative affect were measured using the shortened version of the PANAS Scale (Mackinnon et al., 1999). Adolescents rated the frequency of positive and negative affect over the past two weeks on a scale from 1 (not at all or very little) to 5 (very much). Cronbach's alpha coefficient was $\alpha = .78$ for the negative affect (5-items) subscale and $\alpha = .84$ for the positive affect (5-items) subscale. Average scores were computed separately for positive (PA) and negative (NA) affect, with higher scores indicating greater emotional intensity of PA and NA in adolescents.

Life satisfaction

Adolescents' life satisfaction was assessed using the Brief Multidimensional Students' Life Satisfaction Scale (Huebner, 1994; Seligson et al., 2003). The scale comprises five items, each addressing different life domains (family, friends,

school, self, and living environment), as well as one item covering global life satisfaction. Adolescents rated how satisfied they were with each domain and their overall life using a scale from 1 (completely unsatisfied) to 7 (completely satisfied). Cronbach's alpha coefficient for the five items measuring domain-specific life satisfaction was $\alpha = .79$. Scores from these five items were averaged to derive an overall life satisfaction score, with higher scores indicating greater life satisfaction among adolescents.

Duration of smartphone use

Duration of smartphone use was measured using a timeline constructed for the project. Adolescents were asked to circle the number that best represented their average daily smartphone use, with options ranging from 0 to 8 hours, marked in 15-minute increments along a visual scale.

Procedure

Data for this paper come from the fourth wave of the study (Study 2) (wave 4: April–June 2023) of the project D.E.C.I.D.E. The study was conducted in schools during two school years (2021–2022 and 2022–2023). The study received ethical approval from the Ethical Committee of the Catholic University of Croatia and approval to be conducted in schools from the Ministry of Science and Education of Croatia. Participants were recruited from primary schools. A total of 22 schools were contacted via email, six of which agreed to participate, with their principals signing the consent form. A total of 1,096 adolescents were contacted. After parents and children had signed the consent forms ($N = 284$), data were collected partly in schools during regular classes and partly through children and parents filling out the questionnaires at home due to the length of the questionnaires at each wave. The questionnaire was administered by school psychologists and project members, and group administration took approximately 20 to 30 minutes. In the fourth wave of the study, adolescents who completed the eighth grade of primary school during the study (school year 2021–2022) were invited via a message sent to their parents to participate in the fourth wave of data collection. Those who responded completed the questionnaire online. Each adolescent and parent who participated received a gift certificate to visit the zoo.

RESULTS

Descriptive Statistics and Correlations

The most frequently reported health consequence was physical passivity among adolescents (Table 2). Sleep problems and tiredness also showed a notable presence, though most adolescents reported “Never” or “Rarely”. A similar trend was observed with pain in the head, neck, and back. Eye- and wrist-related problems were reported the least frequently. Across all subscales (Table 2), the mean scores were below the midpoint, indicating that such physical consequences are generally infrequent but present in a meaningful subset of the sample. A significant difference was found between girls and boys only on the subscale pain in the head, neck, and back, with girls ($Mdn = 2.00$) reporting more frequent problems than boys ($Mdn = 1.67$), Mann–Whitney $U = 4,111.00$, $z = -2.084$, $p = .037$, $r = .15$, indicating a small effect.

Adolescents reported that, on average, they used a smartphone for 3.25 hours ($min = 0.25$; $max = 8.00$) a day ($SD = 1.43$).² They also reported that, on average, they were mostly satisfied with their life ($M = 5.69$, $SD = 1.09$), felt a moderate level of positive affect ($M = 3.18$, $SD = 0.80$), and felt little negative affect ($M = 2.13$, $SD = 0.88$). A significant difference was found between girls and boys in life satisfaction, with girls ($Mdn = 5.80$) reporting lower life satisfaction than boys ($Mdn = 6.00$), Mann–Whitney $U = 5,158.50$, $z = 2.006$, $p = .045$, $r = .14$, indicating a small effect size that may be considered negligible within this sample. A significant difference was found between girls and boys in positive affect, with girls ($Mdn = 3.00$) reporting lower positive affect than boys ($Mdn = 3.40$), Mann–Whitney $U = 5,860.50$, $z = 2.916$, $p = .004$, $r = 0.21$, indicating a small to approaching medium effect size. No significant differences between boys and girls were observed for negative affect or the duration of smartphone use.

² The amount of daily time spent using a smartphone showed acceptable normality, with skewness of 0.669 and kurtosis of 0.777, both within the commonly accepted range for parametric analysis. The median and mode values were both 3.

TABLE 2. The descriptives of the Scale of physical health consequences associated with the extended duration of smartphone use among adolescents (N = 204)

	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)	M (SD)
Subscale – Sleep problems and tiredness	53.7	29.6	10.3	6.4	0	1.75 (0.86)
Subscale – Physical passivity	33.8	33.9	23.8	8.5	0	2.05 (0.90)
Subscale – Pain in the head, neck and back	29.7	46.5	20.3	3.5	0	1.98 (0.74)
Subscale – Problems with the eyes and pain related to the hands	45.3	42.3	10.9	1	0.5	1.60 (0.61)
Total score on the scale	34.5	51.8	13.2	0.5	0	1.84 (0.60)

In Table 3, correlations between study variables are presented. Lower adolescents' life satisfaction is significantly related to a higher frequency of sleep problems and tiredness, physical passivity, pain in the head, neck, and back, and problems with the eyes and pain related to the hands. Lower positive affect is significantly related to a higher frequency of sleep problems and tiredness, and physical passivity. Higher negative affect is significantly correlated with higher frequency of sleep problems and tiredness, physical passivity, pain in the head, neck, and back, and problems with the eyes and pain related to the hands. All four categories of physical health consequences associated with the extended duration of smartphone use are moderately and significantly related to each other. The duration of smartphone use is significantly and positively correlated with negative affect and sleep problems and tiredness but negatively correlated with life satisfaction.

TABLE 3. Correlations between life satisfaction, positive affect, negative affect, physical health consequences, duration of smartphone use, adolescents' age, and gender (N = 204)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Life satisfaction	1									
2. Positive affect	.40**	1								
3. Negative affect	-.57**	-.22**	1							

4. Sleep problems and tiredness	-.36**	-.17*	.34**	1						
5. Physical passivity	-.39**	-.17*	.28**	.57**	1					
6. Pain in the head, neck and back	-.22**	-0.11	.16*	.46**	.42**	1				
7. Problems with the eyes and pain related to the hands	-.29**	-0.10	.23**	.50**	.39**	.67**	1			
8. Total score on the physical health consequences scale	-.39**	-.17*	.33**	.81**	.79**	.78**	.76**	1		
9. Duration of smart-phone use (hours)	-.20**	-0.11	.22**	.18**	0.12	-0.06	-0.07	0.07	1	
10. Adolescents' age	0.03	-0.00	-0.08	0.07	0.08	0.05	0.13	0.12	0.08	1
11. Adolescents' gender	0.11	.20**	-0.11	-0.08	-0.13	-0.13	-0.08	-0.13	-0.07	0.12

Note. * $p < .05$, ** $p < .01$. Gender – 1 = girls, 2 = boys.

Regression Analyses

Three hierarchical regression analyses were conducted with duration of smartphone use, age, and gender (entered at the first step) and physical health consequences associated with the extended duration of smartphone use (entered at the second step) as predictor variables and well-being measures, namely life satisfaction, positive affect, and negative affect, as criterion variables (Table 4). The results (Table 4) showed that duration of smartphone use and physical passivity were significant and negative predictors of adolescents' life satisfaction. Duration

of smartphone use and sleep problems and tiredness were significant and positive predictors of negative affect. For positive affect, gender was the only significant predictor, while no significant effects were found duration of smartphone use or physical health variables.

TABLE 4. Results of hierarchical regression analyses with duration of smartphone use, age, gender, and physical health consequences associated with the extended duration of smartphone use as predictor variables and well-being measures as criterion variables

Predictor variable	Criterion variable – Well-being indicator		
	Life satisfaction	Positive affect	Negative affect
<i>Step 1</i>	β	β	β
Duration of smart-phone use (hours)	-.19*	-.10	.23**
Age	.01	-.05	-.07
Gender	.09	.19**	-.10
R ²	.05*	.05*	.07*
F (df)	2.85* (3,178)	3.18* (3,184)	4.55** (3,186)
<i>Step 2</i>	β	β	β
Time	-.17*	-.08	.19**
Age	.07	-.03	-.12
Gender	.02	.17*	-.06
Sleep problems and tiredness	-.10	-.06	.20*
Physical passivity	-.26**	-.08	.13
Pain in the head, neck and back	.06	-.02	-.06
Problems with the eyes and pain related to the hands	-.16	.00	.13
R ²	.20**	.07	.18**
R ² change	.15	.02	.11
F (df)	8.21** (4, 171)	.09 (4, 177)	6.00** (4, 179)
F (df)	6.12** (7,178)	1.87 (7, 184)	5.59** (7,186)

Note. * $p < .05$, ** $p < .01$. Gender – 1 = girls, 2 = boys.

DISCUSSION

Physical Health Consequences of Extended Duration of Smartphone Use in Early Adolescents

The first research question concerned the physical health consequences associated with the extended duration of smartphone use among early adolescents. Adolescents provided self-assessments of the physical health consequences associated with the extended duration of their smartphone use. The results confirm H1: early adolescents who engage in extended duration of smartphone use are likely to experience negative physical health outcomes, such as sleep disturbances, reduced physical activity, and musculoskeletal issues. Early adolescents who participated in this study experienced problems related to physical health in four domains: 'Sleep problems and tiredness', 'Physical passivity', 'Pain in the head, neck, and back', and 'Problems with the eyes and pain related to the hands. The developed scale of physical health consequences of the extended duration of smartphone use in early adolescents showed good psychometric characteristics and seems promising for use in future research. However, it is important to note that the duration of daily smartphone use was not significantly related to all consequences or the overall level of physical health consequences but was specifically associated with problems related to sleeping and tiredness among adolescents. This suggests that while daily duration of smartphone use may not be linked to all domains of physical health, it can have a targeted association with adolescents' sleep quality.

The findings regarding adolescents' subjective experiences of the negative effects of extended smartphone use on their health are consistent with previous research (Cheung et al., 2022; Karsay et al., 2022). For example, previously noted musculoskeletal impacts and postural changes related to smartphone use (e.g., Cheung et al., 2022; Doruk et al., 2023; Toh et al., 2020; Tsang et al., 2022), effects on eye health (Kim et al., 2016), physical activity patterns and sedentary lifestyle (Kim, 2023; Tanveer, 2023; Yusuf et al., 2023), and various sleep problems (e.g., Foerster et al., 2019; Mireku et al., 2019; Nagata et al., 2024) have been reported in previous studies.

These findings can be explained by the displacement hypothesis, namely that excessive smartphone use may displace engagement in other activities (Kushlev & Leitao, 2020). Early adolescents who engage in excessive smartphone use probably lack time for other activities, among which are physical activities and

other health-promoting behaviours, potentially impacting well-being. The most common explanation for sleep problems is that blue light from screens disrupts the production of melatonin, a hormone that controls sleep, resulting in a delayed onset of sleep and lower-quality sleep (e.g., Silvani et al., 2022). Musculoskeletal issues arise from prolonged poor posture and repetitive strain associated with device use (İnal & Serel Arslan, 2021). These results highlight the need for practical guidelines and educational interventions aimed at helping adolescents develop balanced digital habits related to smartphone use that support their physical health.

Gender and age differences have been noted in previous studies regarding problematic smartphone use, with findings showing that girls and older adolescents may be more vulnerable to excessive or problematic smartphone use patterns (Ekşi et al., 2020; Heo & Lee, 2018; Yang et al., 2020). In the present study, a significant gender difference was observed only on the subscale ‘Pain in the head, neck, and back’, with girls reporting more frequent discomfort than boys. This difference may reflect both behavioural and physiological factors. For example, girls may spend more time in static postures during smartphone use (e.g., texting), increasing their risk of physical strain. Additionally, adolescent girls may exhibit greater sensitivity to physical discomfort and be more likely to report such issues. These findings highlight the importance of considering differences in smartphone use patterns between boys and girls, as well as the related health outcomes, when developing preventive strategies and educational interventions. Although adolescents’ age was included in the analyses, no significant correlations were found between age and the studied health variables, likely due to the specific age range of the sample.

Contribution of Physical Health Consequences of Extended Duration of Smartphone Use to Subjective Well-being in Early Adolescents

The second aim was to examine the association of physical health consequences associated with the extended duration of smartphone use with subjective well-being in early adolescents. The results partially confirm H2a: more physical health consequences associated with extended duration of smartphone use will significantly contribute to lower life satisfaction. Only ‘Physical passivity’ was shown to be a significant and negative predictor of adolescents’ life satisfaction. The results also partially confirm H2b: more physical health consequences associated

with extended duration of smartphone use will significantly contribute to more negative affect. Only 'Sleep problems and tiredness' was shown to be a significant and positive predictor of negative affect. Furthermore, the results do not confirm H2c: more physical health consequences associated with extended duration of smartphone use will significantly contribute to less positive affect. None of the four types of consequences proved to be a significant predictor of positive affect. In sum, 'Physical passivity' and 'Sleep problems and tiredness' contributed to the explanation of poorer subjective well-being, namely more negative affect and lower life satisfaction among early adolescents in this study. These results suggest that preventive efforts aimed at improving adolescents' well-being should particularly target reducing physical passivity and addressing sleep-related problems associated with smartphone use.

The results obtained are in line with previous research. Physical passivity has been linked to negative psychological outcomes in early adolescents (Rodriguez-Ayllon et al., 2019). Lack of movement reduces the release of endorphins and other neurochemicals that promote positive emotions and reduce stress (Hossain et al., 2024). Sleep problems negatively impact emotional regulation, cognitive function, and overall well-being (e.g., Baum et al., 2024; Vandekerckhove & Wang, 2017). The literature shows that emotional regulation difficulties underlie the link between smartphone overuse and subjective well-being (e.g., Fu et al., 2020). Adolescents who experience passivity and sleep problems often report higher levels of negative emotions, which can make it challenging to engage in daily activities and social interactions. When passivity and sleep problems coexist, their effects may combine and be even more detrimental to the well-being of adolescents.

As adolescents struggle with increased health issues and mental distress, their ability to find fulfilment in daily activities decreases (Ding & Li, 2017). Smartphone overuse is correlated with various psychological problems, including anxiety, depression, and stress (Kim et al., 2021). These problems can negatively affect the emotional states of adolescents, leading to a decrease in positive feelings and a rise in negative ones. Furthermore, as the social displacement hypothesis posits (Hall & Liu, 2022), time spent on smartphones can reduce meaningful face-to-face interactions, leading to feelings of social isolation. Adolescents can find themselves spending more time on their devices instead of engaging in social activities and face-to-face interactions with significant others, which may promote healthy connections and experiences. Feelings of happiness and belonging, which

are critical for preserving a healthy emotional state, might be diminished by this lack of face-to-face social interaction (Alotaibi et al., 2022).

The daily duration of smartphone use makes a small but significant contribution to the emotional state, namely negative affect, and life satisfaction of early adolescents, and should not be overlooked in research and practical work with adolescents. However, when comparing the pattern of association between subjective well-being indicators and the daily duration of smartphone use with those involving self-reported physical health consequences of the extended duration of smartphone use, it becomes evident that adolescents' subjective physical experiences are more closely related to well-being than the number of daily hours spent using a smartphone. These findings suggest that smartphone use duration, as a time-based measure, does not fully capture the complexity of adolescents' digital engagement. The effects of smartphone use on adolescents' health and well-being depend not only on the duration of use but also on the type of digital content accessed, the underlying motivations for use, and the individual and broader social and contextual factors in which digital engagement occurs.

Limitations and Suggestions for Future Research

The research results should be considered in the context of the limitations of the study, which can serve as guidelines for future research. The data used are cross-sectional, so no conclusion about the direction of effects can be drawn. It is possible that adolescents with poorer well-being are more inclined to use smartphones for longer periods, which contributes to the physical health consequences. The newly developed scale of physical health consequences associated with the extended duration of smartphone use should be tested on new samples of adolescents, and probably new consequences should be added, such as weight-related problems and knee problems. Cross-validation of the findings using culturally and demographically diverse samples of adolescents from different family arrangements is needed. Studies on between- and within-person differences in the patterns of associations between physical health and subjective well-being are needed.

The focus of this study was specifically on smartphone use because it is the most commonly used device among adolescents, with the primary aim of examining its association with adolescents' physical health and well-being. It was not the intention of the study to explore in detail the specific activities, motives for use, or the content adolescents consume via smartphones. Rather, the goal was to explore the

potential physical and psychological consequences associated with the duration of smartphone use as reported by adolescents. Future research should include a more comprehensive analysis of usage patterns, including the nature of digital content, underlying motivations, and the use of other digital devices beyond smartphones among early adolescents.

Based on the results, some practical implications can be made, but it should be considered that they may apply to some, but not all, adolescents or groups of adolescents. The use of smartphones among adolescents should be monitored and given attention by various parties, such as parents, educators, and governments. Using smartphones for good purposes can easily turn into a bad habit for adolescents since studies have shown that low self-control or self-regulation is related to problematic smartphone use in adolescents (Ekşi et al., 2020). Overall, the findings warn us about the importance of teaching and supporting adolescents in healthy and “smart” smartphone use. Although adolescents may possess a certain level of media literacy, considering the developmental capacities of children entering and experiencing adolescence, greater attention should be directed towards identifying and promoting healthy ways of smartphone use to prevent the development of problematic smartphone use. .

The findings highlight the importance of addressing the physical health consequences associated with the extended duration of smartphone use in early adolescents, particularly sleep problems, physical passivity, and musculoskeletal discomfort. Given the observed association between these physical issues and lower life satisfaction, reduced positive affect, and increased negative affect, schools, parents, and healthcare professionals should consider implementing targeted interventions to promote healthy smartphone habits. Educating adolescents about the risks of excessive use and encouraging regular physical activity and screen-time breaks may help mitigate the negative impact on their overall well-being. Furthermore, monitoring smartphone use and sleep hygiene could be essential components of school-based health promotion programs. In this context, reducing or restricting the daily time spent using smartphones can open up time and space during the day for physical activities and reduce passive time spent sitting among early adolescents. Special attention should be paid to smartphone use during late evenings and nights among adolescents, considering appropriate boundaries for their age. Thus, promoting healthy smartphone use habits along with the encouragement of physical activity and healthy sleep habits may help improve the subjective well-being of early adolescents.

CONCLUSION

The study identified four categories of physical health consequences associated with the extended duration of smartphone use among early adolescents: (a) sleep problems and tiredness, (b) physical passivity, (c) pain in the head, neck, and back, and (d) problems with the eyes and pain related to the hands. A higher frequency of these physical consequences was associated with lower subjective well-being. Specifically, physical passivity emerged as a significant negative predictor of life satisfaction, while sleep problems and tiredness significantly predicted higher levels of negative affect. In contrast, none of the physical health consequences were found to significantly predict positive affect. Additionally, the duration of smartphone use was a significant predictor of both lower life satisfaction and higher negative affect. These findings suggest that aspects of physical health affected by smartphone use, especially physical passivity and sleep disturbances, are more strongly linked to well-being than others. Future research should explore the directionality and strength of these associations across diverse adolescent populations, as the patterns observed in this study may not generalise to all adolescents. The findings underscore the need to move beyond time-based measures and adopt a more nuanced approach to studying adolescent smartphone use that includes their subjective experiences of digital engagement.

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POVEZANOST IZMEĐU FIZIČKIH ZDRAVSTVENIH POSLJEDICA KORIŠTENJA PAMETNIH TELEFONA I SUBJEKTIVNE DOBROBITI U MLADIH ADOLESCENATA

SAŽETAK

Većina istraživanja usmjerena je na emocionalne i socijalne posljedice korištenja pametnih telefona među adolescentima, dok postoji manje dokaza o tome kako korištenje pametnih telefona utječe na tjelesno zdravlje mladih adolescenata. Cilj ovog istraživanja je ispitati i opisati fizičko zdravstvene posljedice povezane s dužim korištenjem pametnog telefona u ranoj adolescenciji te njihovu povezanost sa subjektivnom dobrobiti. U svrhu ostvarivanja cilja istraživanja korišteni su podaci iz četvrtog vala longitudinalne studije (2021.-2023.) provedene u sklopu projekta "Digitalna tehnologija u obitelji: obrasci ponašanja i učinci na razvoj djece" (D.E.C.I.D.E.). Uzorak u ovom radu čini 204 mlada adolescenta (58,3 % djevojčica). Adolescenti su procjenjivali učestalost fizičko zdravstvenih posljedica povezanih s dužim trajanjem korištenja pametnog telefona, kao i svoju subjektivnu dobrobit, mjereno procjenom zadovoljstva životom te pozitivnim i negativnim afektom. Rezultati pokazuju četiri kategorije fizičkih zdravstvenih posljedica povezanih s dužim korištenjem pametnog telefona kod mladih adolescenata: a) problemi sa spavanjem i umorom, b) fizička pasivnost, c) bol u glavi, vratu i leđima te d) problemi s očima i bol u šakama. Veća učestalost različitih fizičkih zdravstvenih posljedica povezana je s nižim zadovoljstvom životom, manje pozitivnog i više negativnog afekta. Dnevno trajanje korištenja pametnog telefona i fizička pasivnost pokazali su se značajnim prediktorima zadovoljstva životom. Dnevno trajanje korištenja pametnog telefona te problemi sa spavanjem i umorom značajni su prediktori negativnog afekta. Fizičko zdravstvene posljedice povezane s dužim korištenjem pametnog telefona nisu pridonijele objašnjenju pozitivnog afekta. Nalazi istraživanja impliciraju da korištenje pametnih telefona može imati negativne učinke na tjelesno zdravlje i dobrobit mladih adolescenata, ali i da je mjere temeljene isključivo na vremenu korištenja potrebno nadopuniti ispitivanjem subjektivnog doživljaja digitalnog angažmana kod adolescenata.

KLJUČNE RIJEČI:

adolescencija, fizičko zdravlje, korištenje pametnog telefona, dobrobit